STANDARD SPECIFICATIONS FOR CONSTRUCTION OF ROADS AND BRIDGES ON FEDERAL HIGHWAY PROJECTS

FP-24

U.S. Department
of Transportation

Federal Highway
Administration
Federal Lands
Highway

Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects

FP-24

UNITED STATES DEPARTMENT OF TRANSPORTATION

Federal Highway Administration

PREFACE

These Standard Specifications for the Construction of Roads and Bridges on Federal Highway Projects are issued primarily for constructing roads and bridges on Federal Highway projects under the direct administration of the Federal Highway Administration. These specifications are cited as "*FP-24*" indicating "*Federal Project*" Standard Specifications issued in 2024.

When designated in a contract, the FP-24 becomes part of the contract and binding upon all parties to the contract. Construction contracts of the Federal Highway Administration are also governed by the following regulations:

- Federal Acquisition Regulation (FAR), Title 48, Code of Federal Regulations, Chapter 1; and
- Transportation Acquisition Regulation (TAR), Title 48, Code of Federal Regulations, Chapter 12.

The FAR and TAR regulations are not included in the FP-24. A complete copy of the FAR is available from the Superintendent of Documents, Congressional Sales Office, U.S. Government Publishing Office, Washington, DC 20402.

U.S. Customary units of measure are used in the FP-24. The references to Metric or Metric units apply only where standardized testing requires Metric units of measure.

METRIC TO U.S. CUSTOMARY CONVERSION FACTORS (approximate)				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
LENGTH				
μm	micrometers	3.9×10^{-5}	inches	in
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.31	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.2046	pounds	lb
Mg	megagrams	1.1023	short tons	T
(or "t")	(or "metric ton")		(2000 lb)	
TEMPERATURE (exact)				
°C	Celsius temperature	1.8C +32	Fahrenheit temperature	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
MISCELLANEOUS				
J	joule	0.7376	foot·poundforce	ft·lbf
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	Poundforce per square inch	lbf/in^2

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DIVISION 100
GENERAL REQUIREMENTS

Section 101. — TERMS, FORMAT, AND DEFINITIONS

101.01 Meaning of Terms. These specifications are generally written in the imperative mood. In sentences using the imperative mood, the subject, "*the Contractor*", is implied. Also implied in this language are "*shall*", "*shall be*", or similar words and phrases. In material specifications, the subject may also be the supplier, fabricator, or manufacturer supplying material, products, or equipment for use on the project. Wherever "*directed*", "*required*", "*prescribed*", "*requested*", or "*ordered*" are used, the "*direction*", "*requirement*", "*prescription*", or "*order*" of the Contracting Officer is intended. Wherever something is to be "*submitted*" or "*submitting to*", the Contracting Officer is intended. Similarly, wherever "*approved*", "*acceptable*", "*suitable*", "*satisfactory*", or similar words are used, the words mean "*approved by*", "*acceptable to*", or "*satisfactory to*" the Contracting Officer.

The word "*will*" generally pertains to decisions or actions of the Contracting Officer.

101.02 Specifications Format. These specifications are divided into 10 Divisions. Division 100 consists of general contract requirements for which no direct payment is made. The requirements contained in Division 100 apply to all contracts.

Division 150 consists of project contract requirements that apply to all contracts. Work under Division 150 is paid for directly or indirectly according to Subsection 109.05. If there is no pay item in the bid schedule, no direct payment is made.

Divisions 200 through 600 consist of construction contract requirements for specific items of work. Work under these Divisions is paid for directly or indirectly according to Subsection 109.05. If there is no pay item in the bid schedule, no direct payment is made.

Division 700 contains the material requirements for Divisions 150 through 600. No direct payment is made in Division 700. Payment for material is included as part of the work required in Divisions 150 through 600.

The first three digits of the pay item number in the bid schedule identify the Section under which the work is performed.

101.03 Abbreviations. When these abbreviations are used, they represent the following:

(a) Acronyms.

3D — Three-Dimensional

AASHTO — American Association of State Highway and Transportation Officials

ACI — American Concrete Institute

AISC — American Institute of Steel Construction

AITC — American Institute of Timber Construction

AMG — Automated Machine Guidance

ANSI — American National Standards Institute

ASR — Alkali-Silica Reactivity

ASTM — American Society for Testing and Materials (ASTM International)

ATSSA — American Traffic Safety Services Association

AWG — American Wire Gauge

AWPA — American Wood Protection Association

AWS — American Welding Society

AWWA — American Water Works Association

BMP — Best Management Practice

CFR — Code of Federal Regulations

CO — Contracting Officer and authorized representatives

CPM — Critical Path Method

CRSI — Concrete Reinforcing Steel Institute

CTSM — Contingent Sum

EPA — Environmental Protection Agency

FAR — Federal Acquisition Regulations (48 CFR Chapter 1)

FHWA — Federal Highway Administration

FLH — Federal Lands Highway

FRP — Fiber-Reinforced Polymer

GPS — Global Positioning System

GRS — Geosynthetic Reinforced Soil

GSA — General Services Administration

HDPE — High Density Polyethylene

HPC — High-Performance Concrete

HPS — High-Performance Steel

HMA — Hot Mix Asphalt

HMWM — High Molecular Weight Methacrylate

IMSA — International Municipal Signal Association

ISO — International Organization for Standardization

ISSA — International Slurry Surfacing Association

IWRC — Independent Wire Rope Core

JMF — Job-Mix Formula

LPSM — Lump Sum

LRFD — Load and Resistance Factor Design

MASH — Manual for Assessing Safety Hardware

MPI — Master Painters Institute

MSE — Mechanically-Stabilized Earth

MTV — Material Transfer Vehicle

MUTCD — Manual on Uniform Traffic Control Devices for Streets and Highways

NACE — National Association of Corrosion Engineers

NCHRP — National Cooperative Highway Research Program

NEMA — National Electrical Manufacturers Association

NIST — National Institute of Standards and Technology

NMSA — Nominal Maximum Size Aggregate

NPCA — National Precast Concrete Association

NTP — Notice to Proceed

OSHA — Occupational Safety and Health Administration

PCI — Precast/Prestressed Concrete Institute

PPC — Polyester Polymer Concrete

PTFE — Polytetrafluoroethylene

PTI — Post-Tensioning Institute

PVC — Polyvinyl Chloride

QA — Quality Assurance

QC — Quality Control

QCM — Quality Control Manager

QCP — Quality Control Plan

RAP — Recycled Asphalt Pavement

RECP — Rolled Erosion Control Product

RSS — Reinforced Soil Slope

SDS — Safety Data Sheet

SF — Standard Form

SRWU — Segmental Retaining Wall Unit

SSPC — The Society for Protective Coatings

SWPPP — Storm Water Pollution Prevention Plan

S4S — Surfaced four sides (lumber)

TAR — Transportation Acquisition Regulations (48 CFR Chapter 12)

TSR — Tensile Strength Ratio

UL — Underwriter's Laboratory

U.S. — United States

U.S.C. — United States Code

UV — Ultraviolet

VFA — Voids Filled with Asphalt

VMA — Voids in Mineral Aggregate

VOC — Volatile Organic Compounds

WMA — Warm Mix Asphalt

(b) Unit abbreviations and symbols.

°F	—	degree Fahrenheit	temperature
ft	—	feet	length

ft^2	—	square feet	area
ft^3	—	cubic feet	volume
gal	—	gallon	volume
in	—	inches	length
in^2	—	square inches	area
in^3	—	cubic inches	volume
kip	—	1000 pounds	mass
ksi	—	kilopound per square inch	pressure
lb	—	pound	mass
lbf	—	pound-force	force
mi	—	mile	length
min	—	minute	time
oz	—	ounces	mass
ppm	—	parts per million	concentration
psi	—	pounds per square inch	pressure
sec	—	second	time
V	—	volt	electric potential
yd	—	yards	length
yd^2	—	square yards	area
yd^3	—	cubic yards	volume

(c) Slope notation. Slopes are expressed as the ratio of vertical to horizontal (V:H).

101.04 Definitions. Unless otherwise specified, the following terms are defined as follows:

Automated Machine Guidance — An application that can be applied to highway construction projects to provide construction efficiencies through enhanced location referencing. AMG involves using construction equipment mounted with onboard computers. Using a combination of 3D modeling data along with GPS technology, AMG provides horizontal and vertical guidance in real time to construction equipment operators.

Award — The written acceptance of a bid by the CO.

Backfill — Material used to replace or the act of replacing material removed during construction. Material placed or the act of placing material adjacent to structures.

Base — The lift or lifts of material placed on a subbase or subgrade to support a surface course.

Bid — A written offer by a bidder to perform work at a quoted price.

Bidder — An individual or legal entity submitting a bid.

Bid Guarantee — A form of security assuring that the bidder will not withdraw a bid within the period specified for acceptance and will execute a written contract and provide required bonds.

Bid Schedule — The prepared schedule included with the bid forms, containing the estimated quantities of pay items for which unit bid prices are invited.

Bridge — A structure including supports erected over a depression or an obstruction (such as water, highway, or railway), having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes. It may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening.

Clear Zone — The portion of the roadside, including the shoulder, available for the safe use by an errant vehicle.

Commercial Certification — See Subsection 106.03.

Completion Date — The date by which all contract work is to be complete.

Construction Limits — The limits that establish the area disturbed by construction operations and beyond which no disturbance is allowed.

Contract — The written agreement between the Government and the Contractor setting forth the obligations of the parties for the performance of and payment for the prescribed work.

Contracting Officer — An official of the Government with the authority to execute, administer, and terminate contracts, and make related determinations and findings. The term includes authorized representatives of the CO acting within the limits of their authority as delegated by the CO.

Contract Modification — A written change in the terms of the contract. Contract modifications are of the following forms:

(a) Administrative change. A unilateral contract change, in writing, that does not affect the substantive rights of the parties (such as a change in the paying office or the appropriation data).

(b) Change order. A written order, signed by the CO, directing the Contractor to make a change that FAR Clause 52.243-4 Changes authorizes the CO to order without the Contractor's consent.

(c) Supplemental agreement. A contract modification that is accomplished by the signature of the CO (unilateral contract modification) or by the signature of the CO and the Contractor (bilateral contract modification).

Contractor — The individual or legal entity contracting with the Government for performance of prescribed work.

Contract Time — The specified time allowed for completion of the contract work.

Crashworthy — A highway feature that has been successfully crash tested under applicable standards defined in MASH, the NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, or approved through analysis by FHWA based on similarity to other crashworthy features.

Cross-Section — A vertical section of the ground or structure at right angles to the centerline or baseline of the roadway or other work.

Culvert — A structure, not classified as a bridge, that provides an opening under the roadway.

Day — A calendar day starting and ending at midnight.

Density — Mass per unit volume of material. Specific gravity multiplied by the density of water.

Detour — A temporary rerouting of public traffic onto alternate existing roadways to avoid the work or part of the work.

Dewatering — Lowering and controlling water levels to allow excavation and construction to be performed.

Drawings — Design sheets or fabrication, erection, shop drawing, or construction details submitted to the CO by the Contractor according to FAR Clause 52.236-21 Specifications and Drawings for Construction. Also refers to submissions and submittals.

Federal Land Management Agencies — Federal agencies including, but not limited to, the National Park Service, U.S. Forest Service, U.S. Fish & Wildlife Service, U.S. Army Corps of Engineers, Bureau of Land Management, and Bureau of Reclamation.

Final Acceptance — The point at which the Government formally accepts the work and relieves the Contractor of further responsibility for the maintenance of the project. This excludes warranties, which remain in effect until they expire. See FAR Clause 52.246-21 Warranty of Construction.

Government — The Government of the United States of America.

Highway, Street, or Road — A general term denoting a public way primarily designed for purposes of multimodal travel.

Lane Mile — An area of pavement 1 mile long and 1 lane wide; not including turn lanes, turnouts, parking area lanes, or other auxiliary lanes.

Lift — When placing and compacting soils, aggregates, or pavement; a lift is a single, continuous layer of material that is uniformly compacted.

Material — Substances specified or necessary to complete the contract work.

Measurement — The process of identifying the dimensions, quantity, or capacity of a pay item. See Section 109 for measurement methods, terms, and definitions.

Neat Line — A line defining the proposed or specified limits of excavation or structure element for purposes of calculating quantities.

Notice to Proceed — Written notice to the Contractor to start the contract work.

Offeror — An individual or legal entity submitting a bid.

Pavement Structure — The combination of subbase, base, paving geotextiles, and surface courses placed on a subgrade to support and distribute the traffic load to the roadbed.

Pay Item — A specific item of work consisting of a unit, quantity, and method of measurement furnished by the Government and a price established by the contract.

Payment Bond — The security executed by the Contractor and surety or sureties and provided to the CO to ensure payments as required by law to persons supplying labor or material according to the contract.

Performance Bond — The security executed by the Contractor and surety or sureties and provided to the CO to guarantee completion of the contract work.

Plans — The contract plans furnished by the Government showing the location, type, dimensions, and details of the work.

Production Certification — See Subsection 106.03.

Professional Engineer — Engineers holding valid state licenses permitting them to offer engineering services directly to the public. Engineers that are experienced in the work for which they are responsible, take legal responsibility for their engineering designs, and are bound by a code of ethics to protect the public health.

Profile Grade — The trace of a vertical plane intersecting a particular surface of the proposed road construction located according to the plans, usually along the longitudinal centerline of the roadbed. Profile grade means either elevation or gradient of the trace according to the context.

Project — The specific section of the highway or other property on which construction is to be performed under the contract.

Right-of-Way — Real property necessary for the project, including roadway, buffer areas, access, and drainage areas.

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

Roadside — The area between the outside shoulder edge and the right-of-way limits. The area between roadways of a divided highway may also be considered roadside.

Roadway — In general, the portion of a highway, including shoulders, primarily for vehicular use. A divided highway has two or more roadways. In construction specifications, the portion of a highway within the construction limits.

Roadway Prism — The area between the original and the final design cross-section.

Roller Pass — One trip of a roller in one direction over one spot.

Shop Drawings — See "Drawings"

Shoulder — A portion of the roadway contiguous with the traveled way that accommodates pedestrians, bicycles, stopped vehicles, and emergency use; and is used for lateral support of the subbase, base, and surface courses.

Sieve — See AASHTO M 92.

Solicitation — The complete assembly of documents (whether attached or incorporated by reference) furnished to prospective bidders.

Special Contract Requirement — An addition or revision to the Standard Specifications applicable to an individual project.

Specifications — The written requirements for performing work.

Standard Form — Numbered form issued by the GSA for use as contract documents.

Standard Specifications — *Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects* approved for general application and repetitive use. Also referred to as the FP.

Station — A precise location along a survey line.

Structures — Bridges, culverts, catch basins, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, sewers, service pipes, underdrains, foundation drains, and other constructed features that may be encountered in the work.

Subbase — The lift or lifts of material placed on a subgrade to support a base.

Subcontract — The written agreement between the Contractor and an individual or legal entity setting forth the obligations of the parties for the performance of and payment for a specific portion of the work to be performed by the subcontractor.

Subcontractor — An individual or legal entity with which the Contractor sublets part of the work. This includes subcontractors and material suppliers in all tiers.

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

Substantial Completion — The point at which the project is complete and can be safely and effectively used by the public without further delays, disruption, or other impediments. For conventional bridge and highway work, the point at which bridge deck, parapet, pavement structure, shoulder, drainage, sidewalk, major demolition, roadway obliteration, permanent signing and markings, traffic barrier, safety appurtenance, utility, and lighting work is complete.

Substructure — Components of a bridge below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames including backwalls, wingwalls, and wing protection railings.

Suitable Material — Rock or earth material that will provide stable foundations, embankments, or roadbeds, and is without organic matter, muck, frozen lumps, roots, sod, or other deleterious material. Suitable material may require drying or adding water, and other methods of manipulation before use. Suitable material includes the classifications of material for which the project was designed.

Superintendent — The Contractor's on-site representative who has authority to act for the Contractor and is responsible for directing and supervising construction operations on behalf of the Contractor.

Superstructure — The entire bridge, except the substructure.

Surety — An individual or corporation legally liable for the debt, default, or failure of a Contractor to satisfy a contract obligation.

Surface Course — The top lift or lifts of a pavement structure designed to accommodate the traffic load and resist skidding, traffic abrasion, and weathering.

Target Value — A number established as a center for operating a given process. Once established, adjustments should be made in the process as necessary to maintain a central tendency about the target value. Test results obtained from a well-controlled process should cluster closely around the established target value and the mean of the test results should be equal to, or nearly equal to, the established target value.

Temporary Stormwater Diversion — A temporary rerouting of stormwater runoff in a controlled, non-erosive manner.

Temporary Stream Diversion — A temporary rerouting of water into a temporary channel or through a system of structures within the construction limits to maintain water flow through or around the project.

Temporary Traffic Diversion — A temporary rerouting of public traffic onto a temporary alignment within the construction limits to bypass the work or part of the work.

Traveled Way — The portion of the roadway designated for the movement of vehicles, not including the shoulders.

Unsuitable Material — Material that cannot create stable foundations, embankments, or roadbeds. Unsuitable material includes muck, sod, and soils with high organic contents.

Well-graded — Graded from coarse to fine with a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

Work — The providing of labor, material, equipment, and other incidentals necessary to complete the project according to the contract.

Section 102. — BID, AWARD, AND EXECUTION OF CONTRACT

102.01 Acquisition Regulations. Bid, award, and execution of the contract is governed by the FAR and TAR.

102.02 Preparation of Bids. Follow the requirements of FAR Provision 52.214-18 Preparation of Bids-Construction.

Insert a numeric unit bid price for each pay item for which a quantity appears in the bid schedule. Multiply the unit bid price by the quantity for each pay item and show the amount bid. If mathematical checks made by the Government show a mistake in the amount bid, the corrected unit price extension governs.

If "*LPSM*" appears as a unit of measure in the bid schedule, insert an amount bid for each lump sum pay item.

If "*CTSM*" appears as a unit of measure in the bid schedule, include the Government inserted amount for the pay item in the total bid amount.

Total the amounts bid for each pay item and show the total bid amount.

The quantities listed in the bid schedule are approximate, unless designated as a contract quantity, and are used for the comparison of bids. Payment will be made for the actual quantities of work performed and accepted or material provided according to the contract. The scheduled quantities may be increased, decreased, or deleted. Bid schedule quantities are considered the original contract quantities.

102.03 Bid Guarantee. Follow the requirements of FAR Clause 52.228-1 Bid Guarantee.

102.04 Individual Surety. Follow the requirements of FAR Clause 52.228-11 Individual Surety-Pledge of Assets.

Complete and date the SF 28, *Affidavit of Individual Surety* after the solicitation date. The individual surety shall personally sign the SF 28. Bidders cannot serve as their own surety. See FAR 28.203 Individual Sureties.

After reviewing the SF 28, the CO may request the surety to submit further documentation with respect to its assets, debts, or encumbrances. The information may be required to be provided under oath. Failure of the surety to respond with the requested documentation within 7 days of receipt of the request is cause for rejection of the surety.

Any material misstatement by the surety, overstatement of assets (either as to ownership or value), or understatement of liabilities is cause for rejection of the surety. Substitution of individual sureties to support a bid bond after the bid opening will not be allowed.

Provide documentary evidence as to the ownership and value of the assets pledged in support of the bond and details of the security interest in the assets by the individual sureties for the apparent low bidder within 14 days after the opening of bids. Failure to submit evidence within the time required will be grounds for declaring the surety unacceptable.

After reviewing the SF 28 and documentary information on the security interest and the assets pledged, the CO may request the surety to submit further information and documents with respect to the documents submitted. The information may be required to be provided under oath. Failure of the surety to respond with the requested information or documents within 7 days of receipt of the request is cause for rejection of the surety.

102.05 Public Opening of Bids. Bids will be publicly opened at the time specified in the SF 1442, *Solicitation, Offer, and Award*. All bid openings will be conducted according to FAR Part 14 – Sealed Bidding.

102.06 Performance and Payment Bonds. Follow the requirements of FAR Clause 52.228-15 Performance and Payment Bonds – Construction.

Use SF 25, *Performance Bond* and SF 25A, *Payment Bond* for submitting the bonds.

Follow the requirements of Subsections 102.03 and 102.04.

Submit the documentary evidence for individual sureties at the same time as the Affidavit of Individual Surety and security interest in assets pledged. A Contractor submitting an unacceptable individual surety in satisfaction of a performance or payment bond before the issuance of the NTP will be allowed one opportunity to substitute an acceptable surety or sureties within 7 days of receipt of notification that the surety is unacceptable.

The Government’s right to direct the substitution of sureties to ensure the continuing acceptability of the bonds during the performance of the contract according to FAR Clause 52.228-2 Additional Bond Security is not restricted.

The requirements of this Subsection are in addition to the requirements in FAR 28.203, except where in conflict with the requirements in the FAR, in which case the FAR supersedes the requirements of this Subsection.

Section 103. — SCOPE OF WORK

103.01 Intent of Contract. The intent of the contract is to provide for the construction and completion of the work described in the contract documents. The precise details of performing the work are not described, except as considered essential for the successful completion of the work. Provide labor, material, equipment, tools, transportation, and supplies necessary to complete the work according to the contract.

103.02 Disputes. Follow the requirements of FAR Clause 52.233-1 Disputes (Alternate I).

103.03 Value Engineering. Follow the requirements of FAR Clause 52.248-3 Value Engineering - Construction.

Before undertaking significant expenditures, submit a written description of the value engineering change proposal (VECP) concept. Within 14 days, the CO will inform the Contractor as to whether the concept appears to be viable or if the concept is unacceptable. If the CO indicates that the concept appears to be viable, then the Contractor can prepare and submit the formal VECP.

103.04 Contractor Records. Follow the requirements of FAR Clause 52.222-8 Payrolls and Basic Records.

Upon request, provide records related to the contract to the Government for up to 3 years after final payment or for longer periods as provided by law.

Include a provision in subcontracts at all tiers giving the Government the same rights as provided above with respect to the subcontractor's records.

103.05 Partnering. To facilitate the contract, the CO offers to participate in a partnership with the Contractor. This partnership draws on the strengths of each organization to identify and achieve reciprocal goals. Partnering strives to resolve problems in a timely, professional, and non-adversarial manner. If problems result in disputes, partnering encourages, but does not require, alternative dispute resolution instead of the formal claim process. The objective is effective and efficient contract performance to achieve a quality project within budget and on schedule.

Acceptance of this partnering offer by the Contractor is optional, and the partnership is bilateral.

If the partnering offer is accepted by the Contractor, mutually agree with the CO on the level of organizational involvement and the need for a professional to facilitate the partnering process. Engage the facilitator and other resources for key Contractor representatives and the CO to attend a partnership development and team-building workshop. Hold additional progress meetings upon mutual agreement.

The direct cost of partnering facilities, professional facilitation, copying fees, and other miscellaneous costs directly related to partnering meetings will be shared by the Contractor and Government. Secure and pay for facilities, professional fees, and miscellaneous requirements. Submit invoices to the CO. The Government will reimburse the Contractor for 50 percent of the agreed costs incurred for the partnering process. The Government's share will not exceed $5,000.

Each party is responsible for making and paying for its own travel, lodging, and meal arrangements. No time extension for the completion of the project will be made for the use of partnering. No changes to the contract can result from discussions during partnering sessions.

Section 104. — CONTROL OF WORK

104.01 Authority of the Contracting Officer. As stated in FAR 1.602-1(a), the CO has authority to execute, administer, or terminate contracts and make related determinations and findings. The CO may delegate authority to representatives to decide on acceptability, progress, and suspension of work, interpretation of the contract, and acceptable fulfillment of the contract.

104.02 Authority of Contracting Officer's Representative. As stated in FAR 1.602-2(d), CORs will be designated in writing by the CO to act on behalf of the CO to administer the contract. The COR will administer the contract according to the contract documents and the FAR. The COR lacks authority to make commitments outside of the terms of the contract; issue changes that affect price, quality, quantity, delivery, or other terms and conditions of the contract; or direct the Contractor or its subcontractor to operate in conflict with the contract terms and conditions.

104.03 Authority of Inspectors. Inspectors are authorized to inspect work, including the preparation, fabrication, or manufacture of material for the project. Inspectors are not authorized to alter or waive contract requirements, issue instruction contrary to the contract, act as foreperson for the Contractor, or direct the Contractor's operations. Inspectors have the authority to identify non-conforming work until the issue can be referred to and decided by the CO. An inspector is permitted to stop work in circumstances of imminent and substantial risk of death or injury.

104.04 Electronic Documentation. After award of the contract, provide documents in an approved electronic format.

Provide documents in their native file format (the format produced by the software that the document was created in) upon request.

Provide a resolution quality with color, text, and lines clearly discernible. Submit each document in an individual file. Name files with a unique document name that includes the document date, document description, and project number, or as requested.

Deliver electronic documents to the email address identified at the preconstruction conference or otherwise amended in writing by the CO. Documents delivered on removable media will not be accepted. Documents delivered after 5:00 p.m. local time will be considered received on the following business day.

In addition to electronic documents, provide paper copies of the following documents and other documents as directed:

- **(a)** Documents required under Section 102;
- **(b)** Weight records required under Subsection 109.03;
- **(c)** Receiving records required under Subsection 109.04; and
- **(d)** Concrete batch tickets required under Subsection 552.04.

Provide one paper copy of each document upon request, unless more paper copies are specified.

The CO will reject without review documents that are unreadable, corrupted, illegible, or include malicious content.

104.05 Signatures for Electronic Documentation. Sign documents requiring a signature by electronic signature or by wet signature.

(a) Definitions.

(1) Electronic signature. A computer data compilation of symbols or series of symbols executed, adopted, or authorized by an individual to be the legally binding equivalent of the individual's handwritten signature.

(2) Wet signature. A signature of ink from pen, or a scanned copy of an actual signature of ink from pen.

(b) Electronic signature. Unless the CO requests a wet signature, an electronic signature may be provided. Assume responsibility for the validity of electronic signatures. The Government will assume that the authorized individual's electronic signature is authentic.

Provide electronic signatures in the following formats:

(1) A digital signature from an encryption application;

(2) A digitized image of a paper signature; or

(3) A unique form or individual identification that can be used as a means of authenticating a record, record entry, or document.

(c) Wet signature. After signing a document by wet signature, scan the complete document into an electronic format.

104.06 Specifications and Drawings. Follow the requirements of FAR Clause 52.236-21 Specifications and Drawings for Construction.

(a) General. Submittals include both documents and drawings required to construct the work. Review submittals for accuracy, completeness, and compliance with the contract. Submittals that do not include evidence of Contractor review and verification may be returned for resubmission.

Time for approval starts over when submittals are returned for revision or when additional information is requested. Perform work related to submitted documents or drawings only after they are approved. Obtain written approval before changing or deviating from the approved submittals.

Submit documents and drawings according to Subsection 104.04.

(1) Drawings. Drawings include:

(a) Layouts that show the relative position (vertical and horizontal as appropriate) of work to be performed;

(b) Fabrication details for manufactured items and assemblies;

(c) Installation and erection procedures;

(d) Details of post-tensioning and other systems;

(e) Detailed trench and excavation procedures that conform to OSHA standards;

(f) Traffic control implementation drawings;

(g) Methods for performing work near existing structures or other areas to be protected; and

(h) Calculations that support each drawing.

Show drawing dimensions in the same units as shown in the plans. Limit drawings to a maximum size of 24 by 36 inches. Include the project number, name, and other identification as shown in the contract on each drawing and calculation sheet.

Drawings will be reviewed in the order they are received. Allow 30 days for approval of drawings and 40 days for approval of railroad structure drawings unless otherwise specified. Submit additional drawings for unique situations to clarify layout, construction details, or method if requested.

(2) Documents other than drawings. Documents other than drawings include descriptive literature, illustrations, schedules, performance and test data, certifications, and similar material submitted to certify or explain specific portions of the work required by the contract. Allow 14 days for approval unless otherwise specified.

(b) Specific requirements for concrete and miscellaneous structures.

(1) Submit drawings for the following:

(a) Site-specific layouts and installation procedures for all wall types;

(b) Site-specific layouts and installation procedures for gabion and revet mattress installations;

(c) Forms and falsework for cast-in-place non-bridge concrete structures and retaining walls less than or equal to 6 feet in height;

(d) Shoring systems and cofferdams less than 6 feet in height;

(e) Fabrication drawings for railings and parapets;

(f) Fabrication drawings for prestressed members;

(g) Fabrication and installation drawings for expansion joint assemblies;

(h) Fabrication drawings for bearing assemblies;

(i) Construction joint location and concrete deck placement sequences not according to the plans;

(j) Erection diagrams for structural plate structures (multi-plate structures);

(k) Steel fabrication and assembly drawings;

(l) Wood structure fabrication and assembly drawings;

(m) Utility hanger details;

(n) Fabrication and installation drawings for precast items other than precast bridge elements;

(o) Details and installation procedures for guardrail, guardrail terminal systems, and crash cushions; and

(p) Site-specific layouts for rockeries.

(2) Submit drawings and supporting calculations that bear the seal and signature of a professional engineer proficient in the applicable design field for the following:

(a) Forms and falsework for cast-in-place concrete structures greater than 6 feet in height;

(b) Forms and falsework for all cast-in-place bridge elements;

(c) Shoring systems and cofferdams greater than 6 feet in height;

(d) Shoring systems that support traffic loadings;

(e) Bridge concrete forms;

(f) Containment system for bridge work;

(g) Girder erection plans;

(h) Partial or full demolition of structural bridge elements;

(i) Post-tensioning systems;

(j) Precast bridge elements;

(k) FRP bridges and structural components;

(l) Concrete box culvert details;

(m) Concrete headwall and wingwall details;

(n) Reinforced soil slopes details;

(o) Ground anchors, soil nail, rock bolt, driven pile, drilled shaft, and micropile assembly details, layout, and installation and testing procedures;

(p) MSE and tie back wall details;

(q) Alternate retaining wall details;

(r) Details and installation procedures for proprietary wall systems; and

(s) Stream diversions.

(3) Submit drawings and supporting calculations that bear the seal and signature of a professional engineer who is proficient in the applicable design field and licensed in the state where the project will be constructed for the following:

(a) Falsework for structures with spans exceeding 16 feet;

(b) Falsework for structures with heights exceeding 14 feet;

(c) Falsework for structures if traffic, other than workers involved in constructing the structure, will travel under the structure;

(d) Temporary bridge structures and load ratings for temporary bridge structures;

(e) New or existing bridges structures to be used as temporary work platforms and load ratings for new or existing bridges to be used as temporary work platforms conforming to AASHTO, *The Manual for Bridge Evaluation* (MBE);

(f) New prefabricated bridges or prefabricated bridge superstructures and load ratings for new prefabricated bridge superstructures conforming to AASHTO, *MBE*;

(g) Helical piles; and

(h) Contractor-designed retaining structures including walls, reinforced soil slopes, and rockeries.

(c) As-built drawings. Maintain a separate set of plans exclusively for as-built drawings. Use the color "red" to identify changes. Use approved methods to record changes accurately and neatly. Include details and notes on additional information discovered during construction. Note additions or revisions to the location, character, and dimensions of work. Strikeout details shown that are not applicable to the completed work.

Retain as-built drawings at the project site or an alternate location as approved.

Keep as-built drawings current and maintain a revision log of changes made. Check and initial plan sheets that were incorporated in the completed work without change. Meet with the CO to jointly review as-built drawings and log for accuracy, completeness, and legibility before submission of each monthly invoice. The CO may retain a portion of the progress payment if as-built drawings are not current.

Submit as-built drawings and revision logs before the final inspection. Correct errors and omissions found during the final inspection and resubmit as-built drawings for approval within 7 days after the final inspection.

When as-built drawings are approved, submit the final as-built drawings according to Subsection 104.04.

Include the following in the final as-built drawings:

(1) Title sheet.

(a) "AS-BUILT DRAWINGS" (bold text);

(b) Name of Contractor;

(c) Project completion date;

(d) Revisions to project length;

(e) Revisions to begin and end stations of project;

(f) Revisions to index to sheets;

(g) Strikeout schedules or options not awarded;

(h) Plan notes; and

(i) A note stating, "Work was constructed as designed unless otherwise noted."

(2) Typical section sheets.

(a) Revisions in dimensions;

(b) Revisions in material;

(c) Revisions in station range;

(d) Revisions to curve widening table;

(e) Revisions to begin and end stations of project; and

(f) Strikeout schedules or options not awarded.

(3) Summary of quantities and tabulation sheets.

(a) Revisions to quantities, locations, notes, remarks, including totals;

(b) Strikeout unused pay items;

(c) Revisions to application rates; and

(d) Revisions to location, type, end treatments, riprap, and skew on the drainage summary.

(4) Plan and profile sheets. Note additions or revisions to the location, character, and dimensions of the following items:

(a) Plan.

(1) Alignment and curve and spiral information;

(2) Equations;

(3) Construction limits;

(4) Right-of-way;

(5) Road approaches;

(6) Subexcavation and roadway obliteration;

(7) Underdrains;

(8) Trenches and drains;

(9) Channels and ditches;

(10) Cut and fill slopes;

(11) Monuments and permanent references, including revised or new Control Points;

(12) Guardrail, guardwall, and end treatment;

(13) Constructed, relocated, or encountered utilities;

(14) Structures and obstructions abandoned in the roadbed; and

(15) Walls.

(b) Profile.

(1) Grades, elevations, and stationing of points of intersection;

(2) Equations;

(3) Culvert diameter, length, type, skew, and stationing;

(4) Culvert extension and length of existing culvert;

(5) Walls;

(6) Limits of reinforced soil slopes, rock embankment; and

(7) Guardrail, guardwall, and end treatment.

(5) Bridge sheets. Note additions or revisions to the location, character, and dimensions of the following items:

(a) Stationing of bridge ends;

(b) Elevations including footing, bearing pads, deck, and top of walls;

(c) Pile records with pile length, size, type, and tip elevation;

(d) Modifications or repairs to drilled shafts or micropiles;

(e) Micropile installation records with drilling duration and observations, drill log, final location and inclination, final tip elevation, cut-off elevation, modification or repairs, grout pressures and quantities, and test records;

(f) Post-tensioning records including stressing sequence, jacking force, theoretical and actual tendon elongation measurements, and duct size and layout;

(g) Construction and concrete placement sequences;

(h) Bearing details with orientation;

(i) Expansion joints including actual clearance with atmospheric temperature at time of setting joints;

(j) Changes in plan or dimensions including changes in reinforcing;

(k) Location of construction joints; and

(l) Bridge railing.

(6) Miscellaneous sheets. Note additions or revisions to the location, character, and dimensions of the following items:

(a) Parking areas and turnouts;

(b) Curbs and sidewalks;

(c) Fencing;

(d) Landscaping and planting;

(e) Pavement markings;

(f) Signs;

(g) Permanent erosion control measures;

(h) Rock bolts and dowels;

(i) Draped rockfall protection;

(j) Midslope rockfall attenuator;

(k) Roadside rockfall protection;

(l) Anchored wire mesh;

(m) Drain holes in rock;

(n) Horizontal drains; and

(o) Plan notes.

(7) Standard and detail sheets. Note the additions or revisions to the character and dimensions of details.

104.07 Coordination of Contract Documents. The FAR, TAR, Special Contract Requirements (SCR), plans, and Standard Specifications are contract documents. A requirement in one document is binding as though occurring in all the contract documents. The contract documents are intended to be complementary and to describe and provide for a complete contract. In case of discrepancy, calculated and shown dimensions govern over scaled dimensions. The contract documents govern in the following order:

(a) FAR;

(b) TAR;

(c) SCR;

(d) Plans; and

(e) Standard Specifications.

104.08 Load Restrictions. Follow the requirements of FAR Clause 52.236-10 Operations and Storage Areas.

Comply with legal load restrictions while hauling material and equipment on public roads and bridges to and from the project. Regardless of the legal or posted load limit, control loads to prevent damage to existing and new infrastructure within the project limits.

Obtain necessary oversize or overweight vehicle permits and escorts for moving oversized or overweight loads. Provide a copy of the permits and associated loading calculations for roads and bridges within the project limits. A special permit does not relieve the Contractor of liability for damage resulting from moving or using material or equipment to or within the job site.

Unless otherwise permitted, do not operate equipment or vehicles that exceed the legal load limits over new or existing structures, or pavements within the project. Ensure loads do not damage subgrade or utilities.

Replace or restore infrastructure damaged during operations to original condition.

104.09 Construction Loading of Structures. Protect new and existing structures within the project limits from construction loads.

Construction loads include, but are not limited to, the weight of cranes, trucks, paving equipment, other heavy construction, or material delivery equipment, as well as the delivery or storage of materials placed on or adjacent to the structure or parts thereof during the various stages (phases) of the work.

If construction loads are planned to be located on or adjacent to a structure to be protected, determine the anticipated construction load, the construction loading capacity of the structure, and the effects the construction load will have on the structure. Consider the sequencing of the work, including construction phasing.

If the loading capacity of the structure is not provided, determine the appropriate loading capacity information.

Submit drawings and calculations for approval according to Subsection 104.06(a)(1) that bear the seal and signature of a professional engineer who is proficient in the applicable design field before starting work.

104.10 Inspection at the Plant. Work may be inspected at the point of production or fabrication. Manufacturing plants may be inspected for compliance with specified manufacturing methods. Material samples may be obtained for laboratory testing for compliance with quality requirements. Allow entry at all times to the parts of the plant producing the work.

104.11 Other Contracts. Follow the requirements of FAR Clause 52.236-8 Other Contracts.

Section 105. — CONTROL OF MATERIAL

105.01 Source of Supply and Quality Requirements. Follow the requirements of FAR Clause 52.236-5 Material and Workmanship. Select sources and submit acceptable material. Notify the CO of proposed sources before delivery to the project to expedite material inspection and testing. Do not incorporate material requiring submittal into the work until approved.

Material may be approved at the source of supply before delivery to the project. Provide source quality test results dated within 12 months from NTP. Approval of a material source does not constitute acceptance of material submitted from the source. If an approved source fails to supply acceptable material during the life of the project, further use of that source may be denied.

Submit samples of material for source quality verification testing for material if requested.

105.02 Material Sources.

(a) Government-furnished sources. The Government will acquire the permits and rights to remove material from furnished sources identified in the contract and to use such property for a plant site and stockpiles. Comply with permits and written agreements acquired by the Government.

Test reports and available historical material data will be provided to the Contractor upon request.

Do not perform work within a source until a source development plan is approved. Allow 7 days for approval. Include the following as applicable:

(1) Source development details. Include requirements in Sections 107, 157, 204, and 205;

(2) Restoration details. Include requirements in Sections 624, 625, and 626; and

(3) Abandonment details. Perform work necessary to produce acceptable material including work required by the approved source development plan.

The quality of material is generally acceptable. Variations in quality should be expected as it is not feasible to ascertain the quality of material for an entire deposit from exploratory samples. Determine the quantity, type of equipment, and work necessary and produce acceptable material to be incorporated in the work. Do not perform aggregate source quality tests when using Government-furnished sources. Perform QC sampling and testing according to the approved Contractor QCP in Section 153 and acceptance testing for the required Section of work. Allow the CO the opportunity to witness sampling and splitting of the test material.

(b) Government-furnished material stockpile. The quality of the material in the stockpile has been preapproved unless otherwise noted and is considered acceptable for the application for which it has been designated. Perform QC sampling and testing according to the approved Contractor QCP in Section 153 and acceptance testing for the required Section of work. Allow the CO the opportunity to witness sampling and splitting of the test material.

(c) Contractor-located sources. The Contractor is responsible for Contractor-located material sources, including established commercial material sources. Use sources that fulfill the contract quantity and quality requirements. Determine the quantity, type of equipment, and work necessary to select and produce an acceptable material. Secure permits and clearances for use of the source and submit copies of the documents to the CO. Follow the environmental requirements of Subsection 107.10(d). Submit available historical data indicating acceptable material can be produced from the source. Perform QC sampling and testing according to the approved Contractor QCP in Section 153, aggregate source quality tests, and acceptance testing for the required Section of work. Allow the CO the opportunity to witness sampling and splitting of the test material.

105.03 Material Source Management. Notify the CO at least 14 days before starting operations in the source. Develop and operate according to the approved source development plan for Government-furnished sources or written agreement for Contractor-located sources.

Before developing a material source, measure the sediment content of bodies of water adjacent to the work area that will receive drainage from the work area. Perform erosion and sediment control according to the source development plan and Section 157.

Do not remove material measured in-place from borrow sources or Government-furnished stockpiles until initial ground survey measurements have been taken according to Subsection 152.05(j) and approved. Perform final ground survey measurements according to Subsection 152.05(j).

Dispose of rejected material in an approved manner.

105.04 Handling and Storing Material. Handle and store material to preserve its quality and fitness for the work. Stored material approved before storage may again be inspected before use in the work. Locate stored material to facilitate prompt inspection.

Use only approved portions of the right-of-way for storing material or equipment. Provide additional space as needed. Do not use private property for storage without written permission of the owner or lessee. Submit copies of agreements and documents.

Provide security for stored material.

Restore Government-furnished storage sites to their original condition.

105.05 Use of Material Found in the Work. Stone, gravel, sand, or other material found in the excavation may be used for another pay item, if approved. If material found in the excavation is used for another pay item, material will be paid both as excavation and as the other pay item for which it is used. Replace excavation used with acceptable material at no additional cost to the Government. Excavate or remove material only from within the grading limits, as indicated by the slope and grade lines.

The right to use and process material found in the work excludes the use and processing of material for nongovernment contract work, except for the disposal of waste material. If the Contractor produces or processes more material from Government lands than the quantities required for the contract, the Government may:

(a) Take possession of the excess material and direct its use, paying the Contractor only for the cost of production; or

(b) Require removal of the material and restoration of the land to a satisfactory condition at no additional cost to the Government.

105.06 Material Source Restoration. Restore Government-furnished sources according to the approved source development plan. Restack the unused portion of the Government-furnished stockpiles upon completion of the work at no additional cost to the Government. Do not measure restoration of material sources for payment.

Section 106. — ACCEPTANCE OF WORK

106.01 Conformity with Contract Requirements. Follow the requirements of FAR Clause 52.246-12 Inspection of Construction.

References to standard documents and test methods of AASHTO, ASTM, GSA, and other recognized standard authorities refer to the documents and methods in effect on the date of the Invitation for Bids (IFB) or Request for Proposal (RFP).

Use the FLH Testing Forms for reporting materials test results unless otherwise approved. Use the FLH Test Methods in effect on the date of the IFB or RFP for testing materials, when applicable.

Use ASTM E29, Absolute Method, for test results and related calculations.

Perform work to the lines, grades, cross-sections, dimensions, and processes or material requirements shown in the contract.

Incorporate manufactured material into the work according to the manufacturer's recommendations or to these specifications, whichever is stricter.

If standard manufactured items are specified (such as fence, wire, plates, rolled shapes, and pipe conduits that are identified by gauge, density, or section dimensions) the tolerances for masses or dimensions will be established manufacturing tolerances unless otherwise noted.

Plan dimensions and contract specification values are the values to be strived for and complied with as the design values from which deviations are allowed. Perform work and provide material that is uniform in character and reasonably close to the prescribed value or within the specified tolerance range. The purpose of a tolerance range is to accommodate occasional minor variations from the median zone that are unavoidable for practical reasons.

Perform process control testing as required. Do not rely on the availability of Government test results for process control.

The Government may inspect, sample, or test any work, at any time before acceptance of the entire work. If the Government tests work, copies of test reports will be provided to the Contractor upon request. Government tests may or may not be performed at the work site.

Work will be evaluated for conformance to contract requirements and will be designated as follows:

(a) Conforming work. Acceptable work conforming to the Contract will be paid for at the contract price per unit of measurement. Four methods of determining conformity and accepting work are described in Subsections 106.02 through 106.05. The primary method of acceptance is specified in the Acceptance Subsection of each Section, but work may be rejected if it is found not to comply with the contract.

(b) Nonconforming work. Remove, repair, or replace work at no additional cost to the Government that does not conform to the contract or to prevailing industry standards where no specific contract requirements are noted. Provide temporary traffic control and perform other related work to correct nonconformities at no additional cost to the Government.

As an alternative to removal and replacement, the Contractor may submit a written request for approval that includes the following:

(1) Alternatives.

(a) Have the work accepted at a reduced price; or

(b) Perform corrective measures to bring the work into conformity.

(2) Supporting rationale and documentation. Include references or data justifying the proposal based on an evaluation of test results, effect on service life, value of material or work, quality, aesthetics, and other tangible engineering basis.

The CO will determine disposition of the nonconforming work.

106.02 Visual Inspection. Acceptance is based on visual inspection of the work for compliance with the contract. Use prevailing industry standards in the absence of specific contract requirements or tolerances.

Material accepted by visual inspection may be sampled and tested for conformance.

106.03 Certification. For material manufactured off site, use a manufacturer with an ISO 9000 certification or an approved testing and inspection system. Require the manufacturer to clearly mark the material or packaging with a unique product identification or specification standard to which it is produced.

Other than references in or to the FAR or Federal Law, when the Standard Specifications or Special Contract Requirements reference certifications, certificates, certified documents, equipment, or individuals; the references refer to documentation of non-regulatory, peripheral contract requirements that are required to be validated by an individual or organization having unique knowledge or qualifications to perform such validation.

Check certifications before incorporating the material into the work to ensure that the requirements of the contract have been met. Mark the certifications with the following information: project number and name; pay item number and description; contractor’s signature; and date.

Material accepted by certification may be sampled and tested for conformance.

Provide a commercial certification unless a production certification is identified in the Acceptance Subsection.

(a) Commercial certification. A commercial certification is a manufacturer’s or Contractor’s representation that the material complies with the contract. The representation may be labels, catalog data, stamped specification standards, or supplier’s certifications indicating the material is produced to a commercial standard or specification.

Submit one commercial certification for similar material from the same manufacturer.

(b) Production certification. A production certification is a supplier’s certification that the material has been produced to a specific standard and is accompanied by test data performed within the past

12 months and other information as described below to support that the material complies with the contract.

Submit a production certification from the manufacturer for each shipment of material. Include the following:

(1) Date and place of manufacture;

(2) Lot number or other means of cross-referencing to the manufacturer's inspection and testing system; and

(3) Substantiating evidence that the material conforms to the contract as required by FAR 46.105(a)(4), including the following:

(a) Test results on material from the same lot and documentation of the inspection and testing system;

(b) A statement from the manufacturer that the material complies with the contract; and

(c) Manufacturer's signature or other means of demonstrating accountability for the certification.

106.04 Measured or Tested Conformance. Perform necessary measurements and tests to ensure work complies with the contract.

Use prevailing industry standards in the absence of contract requirements or tolerances.

Submit measurements, tests, and supporting data for acceptance.

If Government testing is performed on work, the results may be used for acceptance purposes.

106.05 Statistical Evaluation of Work and Determination of Pay Factor. Statistical evaluation of work is a method of analyzing inspection or test results to determine conformity with the contract.

Use the computer program, QL-Pay, to determine percent within limits and pay factors. The work will be accepted as follows:

(a) General. For work evaluated based on statistical evaluation, both the Government and Contractor assume some risk.

The Government's risk is the probability that work of a rejectable quality level is accepted. The Contractor's risk is either the probability that work produced at an acceptable quality level (AQL) is rejected (α) or the probability that the work produced at the AQL is accepted at less than the contract unit price.

Acceptable quality level is the lowest percentage of work within the specification limits that is considered acceptable for payment at contract unit price. There are two categories: category I is based on an AQL of 95 percent and category II is based on an AQL of 90 percent.

In both cases, the Contractor's risk is 5 percent and the risk of rejection is significantly lower.

As an incentive to produce uniform quality work and to offset the Contractor's risk, a final payment greater than the contract unit price may be obtained under certain conditions.

The quality characteristics to be evaluated, sampling frequency, sampling location, test methods, and category are listed in the Acceptance Subsection of each Section. The following applies:

(1) Lot size. A lot is a discrete quantity of work to which the statistical evaluation procedure is applied. A lot normally represents the total quantity of work produced. More than one lot may occur if changes in the target values, material sources, or JMF are requested in writing and approved.

(2) Sampling frequency. The frequency rate shown normally requires at least 5 samples. The minimum required to perform a statistical evaluation is 3 samples. The maximum obtainable pay factor with 3, 4, or 5 samples is 1.01. At least 8 samples are required to obtain a 1.05 pay factor.

If the sampling frequencies and quantity of work would otherwise result in fewer than 8 samples, submit a written request to increase the sampling frequency to provide for at least 8 samples. Submit the request to increase the sampling frequency at least 48 hours before starting production. An increase in the sampling frequency may result in a reduced pay factor.

(3) Sampling location. The exact location of sampling will be determined by the CO based on random numbers.

(4) Specification limits. The specification limits for the quality characteristics are listed in the contract for the work in question.

If Contractor testing and inspection are verified by the Government, the Contractor's results may be used by the Government to evaluate work for acceptance. Contractor data will be verified using the F- and t-test statistics in comparison to Government test results at a significance level of 0.01. If the Contractor's data is not verified and the CO determines it to be appropriate, the Government will perform tests associated for that discrete portion of work. In this situation, the Government test results will control in determining the acceptability and pay factor of the work.

(b) Acceptance. The final pay factor for the work in a lot will not be determined until inspections and test results are completed and evaluated.

Before determining the final pay factor, the work may be incorporated in the project provided the current pay factor does not fall below 0.90. If a lot is concluded with fewer than 3 samples, the material will be evaluated under Subsection 106.04.

If the current pay factor of a lot falls below 0.90, stop production. Resume production after effective and acceptable actions to improve quality have occurred.

A lot containing an unsatisfactory percentage of non-specification material (less than 1.00 pay factor) is accepted provided the lowest single pay factor has not fallen into the reject portion shown in Table 106-2.

A lot containing an unsatisfactory percentage of non-specification material with the lowest single pay factor falling into the reject portion shown in Table 106-2 is rejected. Remove rejected material from the work.

If approved, it is permissible to voluntarily remove non-specification material and replace it with new material to avoid or minimize a pay factor of less than 1.00. Sample and test new material according to this Subsection. New material will be evaluated according to this Subsection.

Any quantity of material may be rejected based on visual inspection or test results. Do not incorporate rejected material in the work. The results of tests run on rejected material will be excluded from the lot.

(c) Statistical evaluation. The estimated percentage of work that is within the specification limits for each quality characteristic will be determined as follows:

(1) Calculate the arithmetic mean ($\bar{x}$) of the test values:

$$\bar{x} = \frac{\sum x}{n}$$

where: $\sum$ = summation of:

x = individual test value

n = total number of test values

(2) Calculate the standard deviations:

$$s = \sqrt{\frac{n\sum(x^2) - (\sum x)^2}{n(n-1)}}$$

where: $\sum(x^2)$ = summation of the squares of individual test values

$(\sum x)^2$ = summation of the individual test values squared

(3) Calculate the upper quality index (Q_U):

$$Q_U = \frac{USL - \bar{x}}{s}$$

where: *USL* = upper specification limit

The *USL* is equal to the contract specification limit or the target value plus the allowable deviation.

(4) Calculate the lower quality index (Q_L):

$$Q_L = \frac{\bar{x} - LSL}{s}$$

where: *LSL* = lower specification limit

The *LSL* is equal to the contract specification limit or the target value minus the allowable deviation.

(5) From Table 106-1, determine P_U (the estimated percentage of work within the *USL*). P_U corresponds to a given Q_U. If a *USL* is not specified, P_U is 100.

(6) From Table 106-1, determine P_L (the estimated percentage of work within the lot within the *LSL*). P_L corresponds to a given Q_L. If an *LSL* is not specified, P_L is 100.

(7) Calculate the total estimated percentage of work within the *USL* and *LSL*:

$$P_U + P_L - 100$$

(8) Repeat steps 1 through 7 for each quality characteristic listed for statistical evaluation.

Table 106-1
Estimated Percent of Work Within Specification Limits

Estimated Percent within Specification Limits (P_U or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L								
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14
100	1.16	1.49	1.72	1.88	1.99	2.07	2.13	2.20	2.28
99	–	1.46	1.64	1.75	1.82	1.88	1.91	1.96	2.01
98	–	1.43	1.58	1.66	1.72	1.75	1.78	1.81	1.84
97	1.15	1.40	1.52	1.59	1.63	1.66	1.68	1.71	1.73
96	–	1.37	1.47	1.52	1.56	1.58	1.60	1.62	1.64
95	1.14	1.34	1.42	1.47	1.49	1.51	1.52	1.54	1.55
94	–	1.31	1.38	1.41	1.43	1.45	1.46	1.47	1.48
93	1.13	1.28	1.33	1.36	1.38	1.39	1.40	1.41	1.41
92	1.12	1.25	1.29	1.31	1.33	1.33	1.34	1.35	1.35
91	1.11	1.22	1.25	1.27	1.28	1.28	1.29	1.29	1.30
90	1.10	1.19	1.21	1.23	1.23	1.24	1.24	1.24	1.25
89	1.09	1.16	1.18	1.18	1.19	1.19	1.19	1.19	1.20
88	1.07	1.13	1.14	1.14	1.15	1.15	1.15	1.15	1.15
87	1.06	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.11
86	1.04	1.07	1.07	1.07	1.07	1.06	1.06	1.06	1.06
85	1.03	1.04	1.03	1.03	1.03	1.03	1.02	1.02	1.02
84	1.01	1.01	1.00	0.99	0.99	0.99	0.99	0.98	0.98
83	0.99	0.98	0.97	0.96	0.95	0.95	0.95	0.95	0.94
82	0.97	0.95	0.93	0.92	0.92	0.92	0.91	0.91	0.91
81	0.95	0.92	0.90	0.89	0.88	0.88	0.88	0.87	0.87
80	0.93	0.89	0.87	0.86	0.85	0.85	0.84	0.84	0.84
79	0.91	0.86	0.84	0.82	0.82	0.81	0.81	0.81	0.80
78	0.88	0.83	0.81	0.79	0.79	0.78	0.78	0.77	0.77
77	0.86	0.80	0.77	0.76	0.75	0.75	0.74	0.74	0.74
76	0.83	0.77	0.74	0.73	0.72	0.72	0.71	0.71	0.70
75	0.81	0.74	0.71	0.70	0.69	0.69	0.68	0.68	0.67
74	0.78	0.71	0.68	0.67	0.67	0.65	0.65	0.65	0.64
73	0.75	0.68	0.65	0.64	0.63	0.62	0.62	0.62	0.61
72	0.73	0.65	0.62	0.61	0.60	0.59	0.59	0.59	0.58
71	0.70	0.62	0.59	0.58	0.57	0.57	0.56	0.56	0.55
70	0.67	0.59	0.56	0.55	0.54	0.54	0.53	0.53	0.52
69	0.64	0.56	0.53	0.52	0.51	0.51	0.50	0.50	0.50
68	0.61	0.53	0.50	0.49	0.48	0.48	0.48	0.47	0.47
67	0.58	0.50	0.47	0.46	0.45	0.45	0.45	0.44	0.44
66	0.55	0.47	0.45	0.43	0.43	0.42	0.42	0.42	0.41
65	0.51	0.44	0.42	0.40	0.40	0.39	0.39	0.39	0.38
64	0.48	0.41	0.39	0.38	0.37	0.37	0.36	0.36	0.36
63	0.45	0.38	0.36	0.35	0.34	0.34	0.34	0.33	0.33
62	0.41	0.35	0.33	0.32	0.32	0.31	0.31	0.31	0.30
61	0.38	0.30	0.30	0.30	0.29	0.28	0.28	0.28	0.28
60	0.34	0.28	0.28	0.25	0.25	0.25	0.25	0.25	0.25
59	0.31	0.27	0.25	0.23	0.23	0.23	0.23	0.23	0.23
58	0.30	0.25	0.23	0.20	0.20	0.20	0.20	0.20	0.20
57	0.25	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.20	0.18	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.15	0.13	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.10	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: If the value of Q_U or Q_L does not correspond to a value in the table, use the next lower Q value. If Q_U or Q_L are negative values, P_U or P_L is equal to 100 minus the table value for P_U or P_L.

Table 106-1 (continued)
Estimated Percent of Work Within Specification Limits

Estimated Percent within Specification Limits (P_U or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L					
	n=15 to n=17	**n=18 to n=22**	**n=23 to n=29**	**n=30 to n=42**	**n=43 to n=66**	**n=67 to ∞**
100	2.34	2.39	2.44	2.48	2.51	2.56
99	2.04	2.07	2.09	2.12	2.14	2.16
98	1.87	1.89	1.91	1.93	1.94	1.95
97	1.75	1.76	1.78	1.79	1.80	1.81
96	1.65	1.66	1.67	1.68	1.69	1.70
95	1.56	1.57	1.58	1.59	1.59	1.60
94	1.49	1.50	1.50	1.51	1.51	1.52
93	1.42	1.43	1.43	1.44	1.44	1.44
92	1.36	1.36	1.37	1.37	1.37	1.38
91	1.30	1.30	1.31	1.31	1.31	1.31
90	1.25	1.25	1.25	1.25	1.26	1.26
89	1.20	1.20	1.20	1.20	1.20	1.20
88	1.15	1.15	1.15	1.15	1.15	1.15
87	1.11	1.11	1.11	1.11	1.11	1.11
86	1.06	1.06	1.06	1.06	1.06	1.06
85	1.02	1.02	1.02	1.02	1.02	1.02
84	0.98	0.98	0.98	0.98	0.98	0.98
83	0.94	0.94	0.94	0.94	0.94	0.94
82	0.91	0.90	0.90	0.90	0.90	0.90
81	0.87	0.87	0.87	0.87	0.87	0.87
80	0.83	0.83	0.83	0.83	0.83	0.83
79	0.80	0.80	0.80	0.80	0.80	0.79
78	0.77	0.76	0.76	0.76	0.76	0.76
77	0.73	0.73	0.73	0.73	0.73	0.73
76	0.70	0.70	0.70	0.70	0.70	0.70
75	0.67	0.67	0.67	0.67	0.67	0.66
74	0.64	0.64	0.64	0.64	0.64	0.63
73	0.61	0.61	0.61	0.61	0.61	0.60
72	0.58	0.58	0.58	0.58	0.58	0.57
71	0.55	0.55	0.55	0.55	0.55	0.54
70	0.52	0.52	0.52	0.52	0.52	0.52
69	0.49	0.49	0.49	0.49	0.49	0.49
68	0.47	0.46	0.46	0.46	0.46	0.46
67	0.44	0.44	0.43	0.43	0.43	0.43
66	0.41	0.41	0.41	0.41	0.41	0.40
65	0.38	0.38	0.38	0.38	0.38	0.38
64	0.36	0.35	0.35	0.35	0.35	0.35
63	0.33	0.33	0.33	0.33	0.33	0.32
62	0.30	0.30	0.30	0.30	0.30	0.30
61	0.28	0.28	0.28	0.28	0.28	0.28
60	0.25	0.25	0.25	0.25	0.25	0.25
59	0.23	0.23	0.23	0.23	0.23	0.23
58	0.20	0.20	0.20	0.20	0.20	0.20
57	0.18	0.18	0.18	0.18	0.18	0.18
56	0.15	0.15	0.15	0.15	0.15	0.15
55	0.13	0.13	0.13	0.13	0.13	0.13
54	0.10	0.10	0.10	0.10	0.10	0.10
53	0.08	0.08	0.08	0.08	0.08	0.08
52	0.05	0.05	0.05	0.05	0.05	0.05
51	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00

Note: If the value of Q_U or Q_L does not correspond to a value in the table, use the next lower Q value. If Q_U or Q_L are negative values, P_U or P_L is equal to 100 minus the table value for P_U or P_L.

Table 106-2
Pay Factors

PAY FACTOR		Minimum Required Percent of Work Within Specification Limits for a Given Pay Factor $P_U + P_L - 100$														
Category																
I	II	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to ∞
1.05	–	–	–	–	–	–	100	100	100	100	100	100	100	100	100	100
1.04	–	–	–	–	–	100	99	97	95	96	96	96	97	97	97	97
1.03	–	–	–	–	100	98	96	94	92	93	93	94	95	95	96	96
1.02	–	–	–	–	99	97	94	91	89	90	91	92	93	93	94	94
1.01	–	100	100	100	98	95	92	89	87	88	89	90	91	92	92	93
1.00	–	69	75	78	80	82	83	84	85	86	87	88	89	90	91	92
0.99	–	66	72	76	78	80	81	82	83	84	85	86	87	89	90	91
0.98	–	64	70	74	76	78	79	80	81	82	84	85	86	87	88	90
0.97	–	63	68	72	74	76	77	78	79	81	82	83	84	86	87	88
0.96	–	61	67	70	72	74	75	76	78	79	81	82	83	84	86	87
0.95	1.00	59	65	68	71	72	74	75	76	78	79	80	82	83	84	86
0.94	0.99	58	63	67	69	71	72	73	75	76	78	79	80	82	83	85
0.93	0.98	57	62	65	67	69	71	72	73	75	76	78	79	80	82	84
0.92	0.97	55	60	63	66	68	69	70	72	73	75	76	78	79	81	82
0.91	0.96	54	59	62	64	66	68	69	70	72	74	75	76	78	79	81
0.90	0.95	53	57	61	63	65	66	67	69	71	72	74	75	77	78	80
0.89	0.94	51	56	59	62	63	65	66	68	69	71	72	74	75	77	79
0.88	0.93	50	55	58	60	62	64	65	66	68	70	71	73	74	76	78
0.87	0.92	49	53	57	59	61	62	63	65	67	68	70	71	73	75	77
0.86	0.91	48	52	55	58	59	61	62	64	66	67	69	70	72	74	76

Note: If the value of $P_U + P_L - 100$ does not correspond to a $P_U + P_L - 100$ value in this table, use the next smaller $P_U + P_L - 100$ value.

Table 106-2 (continued)
Pay Factors

PAY FACTOR		Minimum Required Percent of Work Within Specification Limits for a Given Pay Factor $P_U + P_L - 100$													
Category															
I	II	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to ∞
0.85	0.90	46	51	54	56	58	60	61	62	64	66	67	69	71	72	75
0.84	0.89	45	49	53	55	57	58	60	61	63	65	66	68	70	71	73
0.83	0.88	44	48	51	54	56	57	58	60	62	64	65	67	69	70	72
0.82	0.87	43	47	50	53	54	56	57	59	61	62	64	66	67	69	71
0.81	0.86	41	46	49	51	53	55	56	58	59	61	63	64	66	68	70
0.80	0.85	40	44	48	50	52	54	55	56	58	60	62	63	65	67	69
0.79	0.84	39	43	46	49	51	52	54	55	57	59	61	62	64	66	68
0.78	0.83	38	42	45	48	50	51	52	54	56	58	59	61	63	65	67
0.77	0.82	36	41	44	46	48	50	51	53	55	57	58	60	62	64	66
0.76	0.81	35	39	43	45	47	49	50	52	54	56	57	59	61	63	65
0.75	0.80	33	38	42	44	46	48	49	51	53	54	56	58	60	62	64
REJECT	0.79	32	37	40	43	45	47	48	49	52	53	55	57	59	60	63
	0.78	30	36	39	42	44	45	47	48	50	52	54	56	57	59	62
	0.77	28	34	38	41	43	44	46	47	49	51	53	55	56	58	61
	0.76	27	33	37	39	42	43	45	46	48	50	52	53	55	57	60
	0.75	25	32	36	38	40	42	43	45	47	49	51	52	54	56	59
	Values less than those shown above															

Note: If the value of $P_U + P_L - 100$ does not correspond to a $P_U + P_L - 100$ value in this table, use the next smaller $P_U + P_L - 100$ value.

(d) Pay factor determination (value of the work). The pay factor for a lot will be determined as follows:

(1) The pay factor for each quality characteristic will be determined from Table 106-2 using the total number of test values and the total estimated percentage within the specification limits from Subsection 106.05(c)(7).

(2) When all quality characteristics for a lot are Category I, the lot pay factor is based on the lowest single pay factor for any Category I quality characteristic. The maximum obtainable pay factor is 1.05.

(3) When quality characteristics for a lot are both Category I and II, the lot pay factor is based on the following:

(a) When all Category II quality characteristics are 1.00, the lot pay factor is based on the lowest single pay factor for all Category I characteristics. The maximum obtainable pay factor is 1.05.

(b) When any Category II quality characteristic is less than 1.00, the lot pay factor is based on the lowest single pay factor for any Category I or II quality characteristic.

(4) When all quality characteristics for a lot are Category II, the lot pay factor is based on the lowest single pay factor for any Category II quality characteristic. The maximum obtainable pay factor is 1.00.

(5) Adjusted payment for material in a lot will be made at a price determined by multiplying the contract unit price by the lot pay factor as determined above, or as described in the Payment Subsection of the Section ordering the work.

106.06 Partial and Final Acceptance. Maintain the work during construction and until the project is accepted. Repair damage before final acceptance of the entire project at no additional cost to the Government. See FAR Clause 52.236-11 Use and Possession Prior to Completion.

(a) Partial acceptance. When a segment of the project is completed, a final inspection of that segment may be requested by the Contractor. If the segment is complete and in compliance with the contract, it may be accepted. If accepted, the CO may relieve the Contractor of further responsibility for maintenance of the completed segment.

When public traffic is accommodated through construction and starts using sections of roadway as they are completed, continue maintenance of such sections until final acceptance.

(b) Final acceptance. Notify the CO when the entire project is complete to schedule an inspection. If work is determined to be complete, the inspection will constitute the final inspection. The Contractor will be notified in writing of final acceptance as of the date of the final inspection. Final acceptance relieves the Contractor of further responsibility for the maintenance of the project.

If the inspection discloses unsatisfactory work, the CO will provide to the Contractor a list of the work that is incomplete or requires correction. Immediately complete or correct the work. Submit notification when the work has been completed.

Section 107. — LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01 Laws to be Observed. Follow the requirements of FAR Clause 52.236-7 Permits and Responsibilities.

Comply with applicable laws, ordinances, safety codes, regulations, orders, and decrees. Protect and indemnify the Government and its representatives against claim or liability arising from or based on the alleged violation of the same.

Comply with permits and agreements obtained by the Government for performing the work that is included in the contract. Notify CO of proposed changes, including required revisions to Government-obtained permits that are required by the Contractor's methods of operation. Obtain additional permits or agreements that are required by the Contractor's methods of operation. Submit copies of approved permits and finalized agreements upon receipt.

107.02 Protection and Restoration of Property and Landscape. Follow the requirements of FAR Clause 52.236-9 Protection of Existing Vegetation, Structures, Equipment, Utilities, and Improvements.

Do not disturb the area beyond the construction limits.

(a) Property. Preserve public and private property. Protect monuments established for perpetuating horizontal, vertical, cadastral, or boundary control. If necessary to destroy a monument, reestablish the monument according to applicable state statute or by the direction of the agency or individual who established the monument.

(b) Vegetation. Replace trees, shrubs, or vegetated areas damaged by construction operations as directed and at no additional cost to the Government. Remove damaged limbs of existing trees by an approved arborist.

(c) Archeological. Do not excavate, remove, damage, alter, or deface archeological or paleontological remains or specimens. Control the actions of employees and subcontractors on the project to ensure that protected sites are not disturbed or damaged. Should these items be encountered, suspend operations at the discovery site, notify the CO immediately and continue operations in other areas. The CO will inform the Contractor when operations may resume at the discovery site.

(d) Utilities. Before starting work in an area, contact the local utility locating service to mark the utilities. Protect utilities from construction operations. Cooperate with utility owners to expedite the relocation or adjustment of their utilities to minimize interruption of service and duplication of work.

If utility services are interrupted because of damage by the construction, immediately notify the utility owner, the CO, and other proper authorities. Cooperate with them until service is restored. Do not work around fire hydrants until provisions for continued service are made and approved by the local fire authority.

Notify the CO if utility work is required. Compensation for the work will be provided under applicable clauses of the contract. Satisfactorily repair damage due to the fault or negligence of the Contractor at no additional cost to the Government.

Repair of damage to underground utilities not shown in the plans or identified before construction, and not caused by the fault or negligence of the Contractor will be paid for by the Government.

107.03 Bulletin Board. Provide a weatherproof bulletin board of suitable size and construction for continuous display of posters and other information required by the contract. Erect and maintain the bulletin board at a conspicuously accessible location on the project and remove and dispose of it after project final acceptance.

Display the following documents on the bulletin board:

(a) Equal Employment Opportunity Commission (EEOC), *Know Your Rights: Workplace Discrimination is Illegal* poster according to FAR Clause 52.222-26 Equal Opportunity;

(b) Form FHWA 1022, *Notice* that the project is subject to Title 18, U.S.C., Section 1020 poster;

(c) Department of Labor, Wage and Hour Division (WHD), WHD 1321, *Employee Rights Under The Davis-Bacon Act* poster (regarding proper pay);

(d) Department of Labor, OSHA, *Job Safety and Health It's The Law* poster, according to CFR Title 29, Part 1903;

(e) "General Wage Decision" contained in the contract;

(f) Company equal employment opportunity policy, according to FAR Clause 52.222-27 Affirmative Action Compliance Requirements for Construction;

(g) OSHA, Emergency telephone numbers (in areas where 911 is not available), according to CFR Title 29, Part 1926.50(f);

(h) Department of Labor, WHD Publication, *Employee Rights and Responsibilities Under the Family and Medical Leave Act* poster according to CFR Title 29, Part 825.300(a);

(i) WHD 1462, Employee Polygraph Protection Act poster; and

(j) National Labor Relations Act (NLRA), *Employee Rights Under The National Labor Relations Act* poster according to Executive Order 13496.

107.04 Railroad Protection. The Government will obtain the necessary permits and agreements from the railroad for specified work for relocating railroads or for work at or adjacent to railroad crossings. If necessary, obtain additional permits and agreements for other work that, due to the method of operation, may also impact the railroad. Submit copies of permits and agreements.

Do not interfere with railroad operations. If the construction damages railroad property, reimburse the railroad for damages, or at the railroad's option, repair the damage at no additional cost to the Government.

Do not cross railroad tracks, with vehicles or equipment, except at existing and open public grade crossings or railroad approved temporary grade crossings. If there is a need for a temporary grade crossing, make the necessary arrangements with the railroad for its construction, protection, and removal. Reimburse the railroad for temporary grade crossing work or at the railroad's option, perform the work.

107.05 Responsibility for Damage Claims. Indemnify and hold harmless the Government, its employees, and its consultants from suits, actions, or claims brought for injuries or damage received or sustained by a person, persons, or property resulting from the construction operations or arising out of the negligent performance of the contract.

Procure and maintain until final acceptance of the contract, liability insurance of the types and limits specified below. Obtain insurance from companies authorized to do business in the appropriate state. Ensure the insurance covers operations under the contract whether performed by the Contractor or by subcontractors.

Before work starts, submit "*certificates of insurance*" certifying that the policies will not be changed or canceled until written notice has been given to the Government. Insurance coverage in the minimum amounts set forth below does not relieve the Contractor of liability in excess of the coverage.

Carry insurance conforming to the following minimums:

(a) Worker's compensation insurance. Minimum required by law.

(b) Comprehensive or commercial general liability insurance.

(1) Personal injury and property damage coverage;

(2) Contractual liability coverage;

(3) Completed operations liability coverage;

(4) $1,000,000 combined single limit for each occurrence; and

(5) $2,000,000 general aggregate limit.

(c) Automobile liability insurance. $1,000,000 combined single limit for each occurrence.

107.06 Contractor's Responsibility for Work. Assume responsibility for all work until final acceptance, except as provided in Subsection 106.06. This includes periods of suspended work. Protect the work against injury, loss, or damage from all causes whether arising from the execution or non-execution of the work. Maintain public traffic according to Section 156.

Rebuild, repair, restore, and make good losses, injuries, or damages to any portion of the work. This includes losses, injuries, or damages caused by vandalism, theft, accommodation of public traffic, and weather that occurs during the contract.

The Government will only be responsible for costs attributable to repairing or replacing damaged work caused by declared enemies and terrorists of the Government and cataclysmic natural phenomenon. The Government will not be responsible for delay costs, impact costs, or extended overhead costs.

107.07 Furnishing Right-of-Way. The Government will obtain right-of-way.

107.08 Sanitation, Health, and Safety. Follow the requirements of FAR Clause 52.236-13 Accident Prevention.

Observe rules and regulations of Federal, state, and local health officials. Do not allow workers to work in surroundings or under conditions that are unsanitary, hazardous, or dangerous.

Admit OSHA inspectors or other legally responsible officials involved in safety and health administration to the project work site upon presentation of proper credentials.

Report accidents on forms furnished by the Government or with prior approval, on forms used to report accidents to other agencies or insurance carriers. Maintain an OSHA Form 300, *Log of Work-Related Injuries and Illnesses* and make it available for inspection.

Install a reverse signal alarm audible above the surrounding noise level on motorized vehicles having an obstructed view and on earth-moving and compaction equipment.

107.09 Legal Relationship of the Parties. In the performance of the contract, the Contractor is an independent contractor. The Contractor's independent contractor status does not limit the Government's general rights under the contract. No Government employee or a business organization owned or substantially owned or controlled by one or more Government employees may be a contractor.

107.10 Environmental Protection. Comply with the following:

(a) Federal Water Pollution Control Act (Clean Water Act) 33 USC § 1251 et seq.

(1) Do not operate equipment or discharge material within the boundaries of wetlands and the waters of the United States as defined by the Federal and state regulatory agencies. Permits are issued by the U.S. Army Corps of Engineers according to 33 USC § 1344 and delegated by the agency having jurisdiction. If an unauthorized discharge occurs:

(a) Prevent further contamination;

(b) Notify appropriate authorities and the CO; and

(c) Mitigate damages.

(2) Construct and maintain barriers in work areas and in material sources to prevent sediment, petroleum products, chemicals, and other liquids and solids from entering wetlands or waters of the United States. Remove and properly dispose of barrier collected material.

(3) Do not revise terms or conditions of permits without the approval of the issuing agency.

(b) Oil and hazardous substances. Submit a hazardous spill plan as required by Federal, state, or local regulations at least 2 days before starting work. Where a hazardous spill plan is not required submit a "*Spill Prevention, Control, and Countermeasure (SPCC) Plan*".

Describe preventative measures including the location of refueling and storage facilities and the handling of hazardous material. Describe actions to be taken in case of a spill. Identify personnel, equipment, and resources available to address spill prevention and response.

Do not use equipment with leaking fluids. Repair equipment fluid leaks immediately. Keep absorbent material manufactured for containment and cleanup of hazardous material on the job site.

Notify the CO of hazardous spills.

(c) Dirt, plant, and foreign material. Remove dirt, plant, and foreign material from vehicles and equipment before mobilizing to work site. Prevent introduction of noxious weeds and non-native plant species into the work site. Follow applicable Federal land management agency and state rules and regulations. Maintain cleaning and inspection records.

(d) Clearances for Contractor-selected, noncommercial areas. Contractor-selected, noncommercial areas include material sources, disposal sites, waste areas, water sources, haul roads, and staging areas located outside project construction limits and permitted commercial areas. Allowed commercial areas include enterprises or developed areas providing same type material or use over the last 2 years with appropriate permits and agreements.

Before using a Contractor-selected, noncommercial areas, submit the following for approval:

(1) Description, schedule, and map of area.

(2) Documentation of compliance with applicable laws, rules, and regulations.

(3) Owner approval for the area use. If use of Federal land is proposed, submit an approval letter or special use permit from the applicable Federal land management agency.

(4) Legal compliance for the area use. Submit documentation showing compliance with applicable tribal, state, and local laws including permits or other approvals issued for the area use.

107.11 Protection of Forests, Parks, and Public Lands. Comply with the rules and regulations of the state fire marshal, conservation commission, Federal land management agency, or other authority having jurisdiction governing the protection of land including or adjacent to the project.

Section 108. — PROSECUTION AND PROGRESS

108.01 Commencement, Prosecution, and Completion of Work. Follow the requirements of FAR Clause 52.211-10 Commencement, Prosecution, and Completion of Work.

A preconstruction conference will be held after the contract is awarded and before starting work. Seven days before the preconstruction conference, submit copies of the preliminary work plan according to Section 155.

108.02 Labor. Follow the requirements of FAR Clause 52.222-6 Construction Wage Rate Requirements.

Adjacent or virtually adjacent work sites are defined to be work sites within ½ mile of the project. Application of Construction Wage Rate Requirements (Davis-Bacon Act) for work sites beyond ½ mile of the project will be determined by the CO.

108.03 Subcontracting. Subcontracting does not relieve the Contractor of liability and responsibility under the contract and does not create any contractual relation between subcontractors and the Government. The Contractor is liable and responsible for actions or lack of action of subcontractors.

Within 14 days of subcontract award, submit an SF 1413, *Statement and Acknowledgment* with Part I completed. Complete other forms that may be provided by the Government to show the work subcontracted and the total dollar amount of the subcontract. For subcontracts involving on-site labor, require the subcontractor to complete Part II of the SF 1413 and complete other forms that may be provided by the Government. Submit a separate statement documenting the cumulative number of on-site subcontracts to date as a percentage of the original contract amount. Submit this information on subcontracts at lower tiers.

In FAR Clause 52.219-8, Utilization of Small Business Concerns and FAR Clause 52.232-27 Prompt Payment for Construction Contracts, the term "*subcontracts*" includes on-site and off-site work and supply contracts.

108.04 Determination and Extension of Contract Time. Follow the requirements of FAR Clause 52.211-10 Commencement, Prosecution, and Completion of Work.

(a) Definitions.

(1) Time impact analysis. The procedure by which the Contractor demonstrates the effect of specific time impacts on the overall construction schedule. Time impacts may result in an increase or decrease in contract time.

(2) Float. The amount of time between when an activity "*can start*" (the early start) and when an activity "*must start*" (the late start).

(b) Time impact analysis. Comply with the applicable contract clauses when requesting a time extension. Notify the CO in writing within 7 days after identifying a time impact.

Submit a time impact analysis and revised construction schedule within 14 days after the end of the time impact event for which notice has been given. Include the following:

(1) A title page or header block with:

(a) Contract number;

(b) Project number and name;

(c) Contractor name;

(d) Current fixed completion date;

(e) Date of submittal; and

(f) Consecutive number for each analysis.

(2) State the impact that requires a time impact analysis:

(a) CO proposed or directed contract modification;

(b) Contractor proposed contract modification;

(c) Weather delay; or

(d) Other Government caused delay.

(3) A copy of the most current approved construction schedule existing before the impact.

(4) A detailed narrative describing each impact event. Describe impacts to each affected activity in the construction schedule. Include the following:

(a) Contract clauses under which the request is being made;

(b) Cause of the impact;

(c) Start date of the impact;

(d) Duration of the impact; and

(e) Methods to be employed to re-sequence or reschedule the work to mitigate the impact. Discuss the feasibility of re-sequencing future work to mitigate delay. Re-sequencing or rescheduling of work will be at no additional cost to the Government. Include corresponding rationale and assumptions of measures which increase the cost of mitigating the impact.

(5) A revised construction schedule to show the impact of the activities identified, including re-sequencing which would mitigate the delay.

(c) Time extensions. Only delays or modifications that affect critical activities or cause noncritical activities to become critical will be considered for time extensions.

If a CPM schedule is used, no time extension will be made for delays or modifications that use available float as shown in the most current approved construction schedule existing before the impact.

No time extension will be made for a claim that states insufficient time was provided.

For delays due to weather, demonstrate that the weather was unusually severe based on the most recent 10 years of historical data according to FAR Clause 52.249-10 Default (Fixed-Price Construction).

(d) Execution of the time impact analysis. Incorporate accepted logic changes or time extensions into the construction schedule update by the next monthly submittal.

108.05 Failure to Complete Work on Time. Follow the requirements of FAR Clause 52.211-12 Liquidated Damages — Construction.

Liquidated damages in the amount shown in Table 108-1 will be assessed for each calendar day beyond the time specified in the contract until substantial completion of the work.

If a winter shutdown occurs during this period, liquidated damages in an amount equal to 10 percent of the amount shown in Table 108-1 will be assessed for each day until the winter shutdown ends at which time full liquidated damages will be assessed.

Table 108-1
Charge for Liquidated Damages
for Each Day Work Is Not Substantially Completed

Original Contract Price	Daily Charge(1)
Less than $1,000,000	$2,100
$1,000,000.00 to $4,000,000.00	$3,900
$4,000,000.01 to 10,000,000.00	$5,100
$10,000,000.01 to $20,000,000.00	$7,600
Greater than $20,000,000.00	$8,800

(1) Liquidated damages include Government costs and traffic control.

108.06 Stop Work Order. Follow the requirements of FAR Clause 52.236-13 Accident Prevention and FAR Clause 52.242-14 Suspension of Work. The CO may order the performance of the work to be stopped, either in whole or in part, for such periods deemed necessary including, but not limited to, the following:

(a) Weather or soil conditions considered unsuitable for prosecution of the work; or

(b) Failure of the Contractor to:

(1) Correct conditions unsafe for the workers or the general public;

(2) Carry out written orders given by the CO; or

(3) Perform provisions of the contract.

Section 109. — MEASUREMENT AND PAYMENT

109.01 Measurement of Work. Take and record measurements and perform calculations to determine pay quantities for invoicing for work performed. Take or convert measurements of work according to U.S. Customary measures.

Unless otherwise specified, measure when the work is in-place and complete according to the contract. Measure the actual work performed, except do not measure work outside the design limits or other adjusted or specified limits (staked limits). Measure structures to the lines according to the plans or to approved lines adjusted to fit field conditions.

Take measurements as described in Subsection 109.02 unless otherwise modified by the Measurement Subsection of the Section controlling the work being performed.

Measurement of quantities for payment for the individual pay items will be based on the contract price for each pay item according to Table 109-1.

Table 109-1
Decimal Accuracy of Quantities for Payment

Contract Unit Price	Decimal Accuracy of Quantities for Payment
Less than $1.00	0 decimal
$1.00 to $100.00	1 decimal
Greater than $100.00	2 decimals

Decimal precision for measurement is one decimal beyond accuracy of quantities for payment.

Remeasure quantities if it has been determined that a portion of the work is acceptable, but has not been completed to the lines, grades, and dimensions shown in the plans or established by the CO.

Prepare, sign, and submit measurement notes and supporting field note documentation using an approved format. Unacceptable measurement notes will be rejected and returned. Correct rejected measurement notes and resubmit.

Submit measurement notes within 24 hours of completing work that is in-place and complete according to the contract. For on-going work, submit measurement notes weekly or as approved. When work is not complete, identify the measurement as being an interim measurement. Submit the final measurement when the work is completed. Measurement notes form the basis of the Government's receiving reports described in Subsection 109.08(c).

Include the following information in the measurement notes:

(a) Project number and name;

(b) Line item number, pay item number, and description;

(c) Date the work was performed;

(d) Location of the work;

(e) Measured quantity;

(f) Calculations made to arrive at the quantity;

(g) Supporting sketches and details as needed to clearly define the work performed and the quantity measured;

(h) Names of persons measuring the work;

(i) Identification as to whether the measurement is interim or final; and

(j) Signed certification statement by the persons taking the measurements and performing the calculations, that the measurements and calculations are correct.

109.02 Measurement Terms and Definitions. Unless otherwise specified, the following terms are defined as follows:

(a) Acre. 43,560 square feet. Make longitudinal and transverse measurements for area computations horizontally. Do not make deductions from the area computation for individual fixtures having an area of 500 square feet or less.

(b) Contingent sum. Perform only the work authorized by written order. The estimated cost of the contingent sum work is approximate and is considered the maximum cost for the required work. The quantity to be paid will be equivalent to the costs incurred. Submit paid invoice receipts as documentation.

(c) Contract quantity. The quantity to be paid is the quantity listed in the bid schedule. The contract quantity will be adjusted for authorized changes that affect the quantity or for errors made in computing this quantity. If there is evidence that a quantity specified as a contract quantity is incorrect, submit calculations, drawings, or other evidence indicating why the quantity is in error and request in writing that the quantity be adjusted.

(d) Cubic foot and cubic yard. Measure by one of the following methods:

(1) In place. Measure solid volumes by one of the following:

(a) Average end area method. Take cross-sections of the original ground. Use design or staked templates to determine end areas. Do not measure work outside of the lines or slopes established by the CO.

If a portion of the work is acceptable but is not completed to the established lines and slopes, retake cross-sections or comparable measurements of that portion of the work. Use the remeasurements to calculate new end areas.

Compute the quantity using the average end areas multiplied by the horizontal distance along a centerline or reference line between the end areas. Deduct quantities outside the designed or staked limits.

(b) Finite element analysis method. Use digital terrain modeling to determine the difference between existing and constructed terrain surfaces.

(2) In the hauling vehicle. Measure according to Subsections 109.03 and 109.04.

Measure the cubic yard volume in the hauling vehicle using three-dimensional measurements at the point of delivery. Use vehicles bearing a legible identification mark with the body shaped so the actual contents may be readily and accurately determined. Before use, mutually agree in writing on the volume of material to be hauled by each vehicle. Vehicles carrying less than the agreed volume may be rejected or accepted at the reduced volume.

Level selected loads. If leveling reveals the vehicle was hauling less than the approved volume, reduce the quantity of all material received since the last leveled load by the same ratio as the current leveled load volume is to the agreed volume. Payment will not be made for more than the agreed volume.

Material measured in the hauling vehicle may be weighed and converted to cubic yards for payment purposes if the conversion factors are mutually agreed to in writing.

(3) In the structure. Measure according to the lines of the structure as shown in the plans, except as altered by the CO to fit field conditions. Make no deduction for the volume occupied by reinforcing steel, anchors, weep holes, piling, or pipes less than 8 inches in diameter.

(4) By metering. Use an approved metering system.

(e) Day. A 24-hour period starting and ending at midnight. Round portions of a day up to the full day.

(f) Each. One entire unit. Measure the actual number of units completed and accepted.

(g) Gallon. The quantity may be measured by the following methods:

(1) Measured volume container. Use an approved container with a verified volume.

(2) Metered volume. Use an approved metering system.

(3) Commercially-packaged volumes. Use the volume as identified on the commercially-packaged product.

(4) Measured by mass. Use an approved weighing device.

When asphalt material is measured by the gallon, measure the volume at 60 °F or correct the volume to 60 °F using recognized standard correction factors.

(h) Hour. 60 minutes. Measure the actual number of hours ordered by the CO and performed by the Contractor. Round portions of an hour up to the next half hour. Measure time in excess of 40 hours per week at the same rate as the first 40 hours.

(i) Linear foot. As applicable, measure the work along its length from end-to-end, parallel to the base or foundation, along the top, along the front face, or along the invert. Do not measure overlaps.

(j) Lump sum. Do not measure directly. The bid amount is complete payment for all work described in the contract and necessary to complete the work for that pay item. The quantity is designated as "*All*". Estimated quantities of lump sum work shown are approximate.

(k) M-gallon. 1000 gallons. Measure according to Subsection 109.02(g).

(l) Mil. Thousandth of an inch. Use to measure thickness.

(m) Mile. 5280 linear feet. Measure horizontally along the centerline of each roadway, approach road, or ramp.

(n) Month. A month as defined by the Gregorian calendar. Measure portions of a month by prorating based on the total days worked.

(o) Pound. Measure according to Subsection 109.03 and 109.04. If sacked or packaged material is provided, the net weight as packed by the manufacturer may be used.

(p) Square foot and square yard. 1 square yard equals 9 square feet. Measurements for area computations will be made horizontally or vertically to the surface being measured. No deductions from the area computation will be made for individual fixtures having area of 9 square feet or less. Do not measure overlaps.

(q) Thousand board feet measure. 1000 board feet. Measurement equal to 1000 feet of wood that is 12 inches wide and 1 inch thick.

(r) Ton. 2000 pounds. Measure according to Subsections 109.03 and 109.04.

No adjustment in a contract price will be made for variations in quantity due to differences in the specific gravity or moisture content.

Use net-certified scale masses or masses based on certified volumes in the case of rail shipments as a basis of measurement subject to correction if asphalt material is lost from the car or the distributor, wasted, or otherwise not incorporated in the work. If asphalt material is shipped by truck or transport, net-certified masses, subject to correction for loss or foaming, may be used for computing quantities.

When emulsified asphalt is converted from volume to mass, use a factor of 240 gallons per ton regardless of temperature.

If the asphalt binder for asphalt concrete pavement is stored in tanks devoted exclusively to the project, base quantities on invoices. If asphalt binder for asphalt concrete pavement is not stored in tanks devoted exclusively to the project or if the validity of the quantity requested for payment is in question, base quantities on the asphalt content determined by testing.

(s) Week. A 7-day period starting and ending at the same designated time. Measure portions of a week by prorating based on the total days worked.

109.03 Weighing Procedures and Devices. Batch masses may be acceptable for determination of pay quantities if an approved automatic weighing, cycling, and monitoring system is included as part of the batching equipment.

If a weighing device is determined to indicate less than true mass, no additional payment will be made for material previously weighed and recorded. If a weighing device is determined to indicate more than true mass, material received after the last previously correct weighing accuracy test will be reduced by the percentage of error in excess of 0.5 percent.

When material is proportioned or measured and paid for by mass, provide one of the following:

(a) Commercial weighing system. Use permanently-installed and certified commercial scales.

(b) Invoices. If bulk material is shipped by truck or rail and is not passed through a mixing plant, submit a supplier’s invoice with net mass or volume converted to mass. Perform check weighing as requested.

(c) Project weighing system. Provide, erect, and maintain approved automatic digital scales. Provide scales that record mass at least to the nearest 100 pounds. Maintain the scale accuracy to within 0.5 percent of the correct mass throughout the calibration range of the scale.

Do not use spring balances. Do not use scales mounted on non-stationary equipment.

Install and maintain platform scales with the platform level with rigid bulkheads at each end. Make the platform of sufficient length to allow simultaneous weighing of all axle loads of the hauling vehicle. Coupled vehicles may be weighed separately or together according to Subsection 2.20, paragraph UR.3.3, Single-Draft Vehicle Weighing of the NIST *Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*.

Install and maintain belt-conveyor scales according to Subsection 2.21, Belt-Conveyor Scale Systems of the NIST *Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices.*

Before production on the project, after relocation, and at least once per year; have the weighing portion of the system checked and certified by the State bureau of weights and measures or a private scale service certified by the bureau of weights and measures. Seal the system to prevent tampering or other adjustment after certification.

Attach an automatic printer to the scale that is programmed or otherwise equipped to prevent manual override of mass information. For weighed pay quantities, program the printer to provide the following information for each weighing:

(1) Project number and name;

(2) Line item number, pay item number, and description;

(3) Date;

(4) Time;

(5) Ticket number;

(6) Haul unit number;

(7) Net mass in load at least to the nearest 100 pounds;

(8) Subtotal net mass for each haul unit since the start of the shift; and

(9) Accumulated total net mass for all haul units since the start of the shift.

If a printer malfunctions or breaks down, the Contractor may manually weigh and record masses for up to 24 hours provided the method of weighing meets other contract requirements.

Provide competent scale operators to operate the system.

When platform scales are used, weigh empty haul units at least twice per day.

Use an approved format for the mass records. Submit the original records and a written certification as to the accuracy of the masses at the end of each shift.

109.04 Receiving Procedures. When the method of measurement requires weighing or volume measurement in the hauling vehicle, provide a person to direct the spreading and distribution of material and to record the location and placement of the material on the project. During the placement, maintain a record of each delivery and document it in an approved manner. Include the following as applicable:

(a) Project number and name;

(b) Line item number, pay item number, and description;

(c) Location where placed;

(d) Date;

(e) Load number;

(f) Truck identification;

(g) Time of arrival;

(h) Mass or volume; and

(i) Spread person’s signature.

Submit the original records and a written certification of the delivery of the material at the end of each shift.

109.05 Scope of Payment. Payment for contract work is provided, either directly or indirectly, under the pay items listed in the bid schedule.

(a) Direct payment. Payment is provided directly under a pay item listed in the bid schedule when one of the following applies:

(1) The work is measured in the Measurement Subsection of the Section ordering the work and the bid schedule contains a pay item for the work from the Section ordering the work.

(2) The Section ordering the work references another Section for the work and the bid schedule contains a pay item for the work from the referenced Section.

(b) Indirect payment. Work for which direct payment is not provided is a subsidiary obligation of the Contractor. Payment for such work is indirectly included under other pay items listed in the bid schedule. This includes instances when the Section ordering the work references another Section for performing the work and the work is not referenced in the Measurement Subsection of the Section ordering the work.

Compensation provided by the pay items included in the bid schedule is full payment for performing contract work in a complete and acceptable manner. Risk, loss, damage, or expense arising out of the nature or prosecution of the work is included in the compensation provided by the pay items.

Work measured and paid for under one pay item will not be paid for under other pay items.

The quantities listed in the bid schedule are approximate unless designated as a contract quantity. Limit pay quantities to the quantities staked, ordered, or otherwise authorized before performing the work. Payment will be made for the actual quantities of work performed and accepted or material provided according to the contract. No payment will be made for work performed in excess of that staked, ordered, or otherwise authorized.

109.06 Pricing of Adjustments. Determine costs according to FAR Part 31 Contract Cost Principles and Procedures. Follow the requirements of FAR clauses providing for an equitable price adjustment.

If agreement on price and time cannot be reached, the CO may make a unilateral determination.

If the work will delay contract completion, request a contract time extension according to Subsection 108.04.

(a) Contract modification standard rates. Provide the following information to the CO with contract modification proposals.

(1) Overhead. Provide copies of the current job site and home office overhead rates for the Contractor and subcontractors that have been certified or audited by the Contractor's controller or accountant. Provide supporting data, which justifies the rates. List each cost category that is included in overhead and identify the cost pools to which overhead is applied.

(2) Equipment. Provide a complete descriptive listing of equipment to be used by the Contractor and subcontractors, including the make, model, and year of manufacturer of each piece of equipment and attachments to the base equipment. Provide the following cost information:

(a) Rented equipment. Provide current invoices to support rented or leased equipment costs.

(b) Owned equipment. Determine allowable ownership and operating costs for Contractor- and subcontractor-owned equipment using actual equipment cost data determined from the operating cost records and following the U.S. Army Corps of Engineers *Construction Equipment Ownership and Operating Expense Schedule* (CEOOES) method. If actual equipment cost data is not available, provide the CO with a statement signed by an individual that can bind the Contractor that such cost data is not available.

Provide a complete set of supporting documentation containing ownership records that are available, including purchase records, depreciation records, maintenance records, or other records that relate to the ownership and operating costs for each piece of equipment.

If actual costs cannot be determined, or are not provided at the preconstruction conference, use the rates shown in the CEOOES for the region where costs are incurred. Adjust the rates for used equipment and for other variable parameters used in the schedules. Provide the CO with supporting documentation.

Compute standby costs from approved ownership records or, if actual costs cannot be determined, according to CEOOES. Do not exceed 8 hours in a 24-hour period or 40 hours in a week. Do not include standby for periods when the equipment would have otherwise been in an idle status or for equipment that was not in operational condition.

(b) Proposal for forward priced work. Submit a written proposal, including price breakdown, for each line item of the work. Identify the major elements of the work, the quantity of the element, and its contribution to the proposed price. Submit additional information as requested to allow the CO to determine the reasonableness of the proposed price. Provide the following information:

(1) Direct costs.

(a) Material. Include estimated costs of material delivered to the work.

(b) Labor. Include a list of anticipated crew members and estimated work hours. Show basic hourly wage rates, fringe benefits, applicable payroll costs (such as FICA, FUTA, worker's compensation, insurance, and tax levies), paid subsistence, and travel costs for each labor classification and foreperson employed in the work.

(c) Equipment. Include documentation or invoices to support equipment costs according to Subsection 109.06(a)(2).

(d) Other direct costs. Include documentation to support other estimated direct costs (such as bonds, mobilization, demobilization, permits, and royalties).

(e) Production rates. Include estimated production rates for major elements of the work.

(f) Subcontract costs. Include supporting data as required.

(2) Overhead. Include overhead costs according to Subsection 109.06(a)(1). Limit Contractor overhead applied to subcontractor payments to 5 percent unless a higher percentage is justified.

(3) Profit. Include a reasonable profit, except when precluded by the FAR.

(c) Post-work pricing. When a contract modification is not forward priced, it requires a change order and a supplemental agreement reflecting the resulting equitable adjustment. When negotiating the price of a contract modification after all or most of the work has been performed, submit the following:

(1) Direct costs.

(a) Material. Include invoices showing the cost of material delivered to the work.

(b) Labor. Include a list of crew members and actual hours worked. Show actual wage rates, fringe benefits, applicable payroll costs (such as FICA, FUTA, worker's compensation, insurance, and tax levies), paid subsistence, and travel costs for each labor classification and foreperson employed in the adjusted work.

(c) Equipment. Include documentation or invoices to support equipment costs according to Subsection 109.06(a)(2).

(d) Other direct costs. Include documentation to support other estimated direct costs (such as bonds, mobilization, demobilization, permits, and royalties).

(e) Production rates. Include actual hours of performance daily for each labor classification and for each piece of equipment. Include production rate information reflecting the actual work occurring on an approved Contractor daily record document.

(f) Subcontract costs. Include supporting data as required.

(2) Overhead. Include overhead costs according to Subsection 109.06(a)(1). Limit Contractor overhead applied to subcontractor payments to 5 percent unless a higher percentage is justified.

(3) Profit. Include a reasonable profit, except when precluded by the FAR. Limit profit to 10 percent of the total cost. Due to the limited risk in post-work pricing, a lower profit percentage may be determined by a profit analysis according to FAR 15.404-4 Profit.

(d) Cost or pricing data. When the contract modification exceeds the amount indicated in FAR Clause 52.214-27 Price Reduction for Defective Cost or Pricing Data - Modifications - Sealed Bidding, FAR Clause 52.215-10 Price Reduction for Defective Certified Cost or Pricing Data, or FAR Clause 52.215-11 Price Reduction for Defective Cost or Pricing Data - Modifications, and the CO has determined that an exception does not apply, submit cost or pricing data according to Subsection 109.06(b) or (c) as applicable and as defined in FAR Subpart 2.1 Definitions, for the Contractor and each major subcontractor. See FAR Subpart 15.4 Contract Pricing and FAR Table 15-2 Instructions for Submitting Cost/Price Proposals When Certified Cost or Pricing Data Are Required for guidance.

Certify cost or pricing data according to FAR Subpart 15.4 Contract Pricing, upon completion of negotiations.

109.07 Eliminated Work. Follow the requirements of FAR Clause 52.243-4 Changes.

Work may be eliminated from the contract without invalidating the contract. The Contractor is entitled to compensation for direct costs incurred before the date of elimination of work plus profit and overhead on the direct incurred costs. Anticipated profit and overhead expense on the eliminated work will not be compensated.

109.08 Progress Payments. Follow the requirements of FAR Clause 52.232-5 Payments under Fixed-Price Construction Contracts and FAR Clause 52.232-27 Prompt Payment for Construction Contracts.

(a) General. Only invoice payments will be made under this contract. Invoice payments include progress payments made monthly as work is accomplished and the final payment made upon final acceptance. Only one progress payment will be made each month. No progress payment will be made in a month in which the work accomplished results in a net payment of less than $1,000. The CO may withhold full or partial progress payment according to Subsection 109.08(h).

(b) Invoice requirements. Submit the invoice to the Government's designated billing office with the following items:

(1) The information required by FAR Clause 52.232-27(a)(2) Contractor's invoice.

(2) A tabulation of total quantities and contract prices of work accomplished or completed on each pay item. Do not include quantities unless measurement notes for those quantities were submitted by the closing date. Do not include quantities of work involving material for which test reports required under Sections 153 and 154, or certifications required by Subsection 106.03 are, or will be, past due as of the closing date.

(3) The certification required by FAR Clause 52.232-5(c) and if applicable, the notice required by FAR Clause 52.232-5(d).

(4) If applicable, a copy of the notices that are required by FAR Clause 52.232-27(e)(5) and (g).

(5) The amount included for work performed by each subcontractor under the contract.

(6) The total amount of each subcontract under the contract.

(7) The amounts previously paid to each subcontractor under the contract.

(c) Government's receiving report. The Government's receiving report will be developed using the measurement notes received by the CO and determined acceptable.

(d) Closing date and invoice submittal date. The closing date for progress payments will be designated by the CO. Include work performed after the closing date in the following month's invoice.

Submit invoices to the designated billing office by the 7th day following the closing date. Invoices received by the designated billing office after the 16th day following the closing date will not be accepted for payment processing that month. Include late, unprocessed invoice submittals in the following month's invoice.

(e) Processing progress payment requests. No payment will be made for work unless measurement notes for the work are submitted by the closing date.

(1) Proper invoices. If the invoice meets the requirements of Subsection 109.08(b), and the quantities and unit prices shown on the Contractor's invoice agree with the corresponding quantities and unit prices shown on the Government's receiving report, the invoice will be paid.

(2) Defective invoices. If the invoice does not meet the requirements of Subsection 109.08(b), or if any of the quantities or unit prices shown on the Contractor's invoice exceed the corresponding quantities and unit prices shown on the Government's receiving report, the invoice will be deemed defective and the Contractor notified according to FAR Clause 52.232-27(a)(2). Defective invoices will not be corrected by the Government and will be returned to the Contractor within 7 days after the Government's designated billing office receives the invoice. Correct and resubmit returned invoices. If the defects are minor, the Contractor may elect, in writing, to accept the quantities and contract prices shown on the Government's receiving report for payment.

(f) Partial payments. Progress payments may include partial payment for material to be incorporated in the work according to FAR Clause 52.232-5(b)(2), provided the material is delivered on or in the vicinity of the project, or stored in an approved storage location.

Provide test results and material certifications for material when partial payment is requested.

Do not request partial payment for materials that do not meet the contract specifications according to Subsections 106.03 and 106.04 or when the pay factor is less than 0.9 as calculated under Subsection 106.05. Partial payments will not be made for living or perishable material.

Submit measurement notes according to Subsection 109.01. Provide a price breakdown of the bid item components and submit invoices or other documents supporting the partial payment. Individual and cumulative partial payments for preparatory work and material will not exceed the lesser of:

(1) 80 percent of the contract bid price for the item; or

(2) 100 percent of amount supported by copies of invoices submitted.

The quantity paid will not exceed the corresponding quantity estimated in the contract. Partial payment for preparatory work and materials does not constitute acceptance of work. The CO may adjust partial payments for protection of the Government.

(g) Lump sum. If the basis for lump sum progress payments is not specified in the Section controlling the work, submit a price breakdown for use in making progress payments. Payments will be made based on the information in the price breakdown, and the work completed.

(h) Retainage. Follow the requirements of FAR Clause 52.232-5 Payments under Fixed-Price Construction Contracts. The CO may withhold, retain, or adjust the invoice after validation of the invoice as follows:

(1) The CO may withhold full or partial progress payment until a construction schedule or schedule update is submitted according to Section 155, and according to FAR Clause 52.236-15 Schedules for Construction Contracts.

(2) The CO may withhold full or partial progress payment until certified payrolls are submitted according to FAR Clause 52.222-8 Payrolls and Basic Records.

(3) The CO may withhold a maximum of 10 percent of the amount the progress payment until satisfactory progress has been made according to FAR Clause 52.232-5 Payments under Fixed-Price Construction Contracts. Satisfactory progress includes performance of all work under the contract including submittals, schedules, certifications, reports, test results, and drawings.

(4) The CO may withhold Liquidated Damages for failure to complete work according to Subsection 108.05 and FAR Clause 52.211-12 Liquidated Damages – Construction.

(5) After substantial completion of the contract, the CO may retain an amount adequate for protection of the Government according to FAR Clause 52.232-5 Payments under Fixed-Price Construction Contracts.

109.09 Final Payment. Follow the requirements of FAR Clause 52.232-5 Payments under Fixed-Price Construction Contracts and FAR Clause 52.232-27 Prompt Payment for Construction Contracts.

Upon final acceptance and verification of final pay records, the Government will send an SF 1034, *Public Voucher for Purchases and Services other than Personal* (final voucher) and a release of claims document. Execute both the voucher and the release of claims and return the documents to the Government for payment. The date of approval by the Government of the final voucher for payment constitutes the date of final settlement of the contract.

If unresolved claims exist or claims are proposed, reserve the right to the claims by listing a description of each claim and the amount being claimed on the release of claims document.

Failure to execute and return the voucher and release of claims document within 90 days after receipt will constitute execution of the documents and the release of claims against the Government arising by virtue of the contract. In this event, the day after 90 days from receipt constitutes the date of final settlement of the contract.

DIVISION 150
PROJECT REQUIREMENTS

Section 151. — MOBILIZATION

Description

151.01 This work consists of moving personnel, equipment, material, and incidentals to the project and performing work necessary before starting work at the project site. This work also includes obtaining permits, insurance, and bonds.

Measurement

151.02 Measure the Section 151 pay items listed in the bid schedule according to Subsection 109.02.

Payment

151.03 The accepted quantities will be paid at the contract price per unit of measurement for the Section 151 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for mobilization by the lump sum will be paid as follows:

(a) Bond premiums will be reimbursed from the mobilization pay item according to FAR Clause 52.232-5 Payments under Fixed-Price Construction Contracts, after receipt of the evidence of payment.

(b) 50 percent of the pay item amount, less the amount paid under Subsection 151.03(a), will be paid after 5 percent of the original contract amount is earned from pay items (not including mobilization). The amount paid will not exceed 5 percent of the original contract amount.

(c) 100 percent of the pay item amount, less the amount paid under Subsections 151.03(a) and 151.03(b), will be paid after 10 percent of the original contract amount is earned from pay items (not including mobilization). The amount paid will not exceed 10 percent of the original contract amount.

(d) Any portion of the pay item amount more than 10 percent of the original contract amount will be paid after final acceptance.

Section 152. — CONSTRUCTION SURVEY AND STAKING

Description

152.01 This work consists of surveying, staking, calculating, and recording data for the control of work. See FAR Clause 52.236-17 Layout of Work.

Construction Requirements

152.02 Qualifications. Provide technically qualified survey crews experienced in highway construction survey and staking. Provide personnel who can perform in a timely and accurate manner. At least 14 days before starting survey and staking work, submit a résumé for each individual.

Include the following if AMG methods are used:

(a) The name, authority, relevant experience, and qualifications of the person with overall responsibility for the AMG system; and

(b) The names, authority, and relevant experience of personnel directly responsible for operating the AMG equipment.

152.03 Submittals. At the preconstruction conference, submit a price breakdown by individual tasks if construction survey and staking is paid by the lump sum for use in making progress payments.

Submit the following if AMG methods are used:

(a) Technology statement. A written statement that includes:

(1) The manufacturer, model, and software version of the AMG equipment; and

(2) Certification that the final Government-furnished 3D data is compatible with the AMG equipment.

(b) QCP. Describe procedures for checking, mechanical calibration, and maintenance of both survey and construction equipment. Include the frequency and types of checks performed.

152.04 General. Provide a crew supervisor on-site when surveying and staking is in progress. Provide survey instruments and supporting equipment that can achieve the specified tolerances. If approved, construction equipment controlled with a GPS or Robotic Total Station (RTS) machine guidance system may be used in the construction of subgrade, subbase, and base aggregate courses, or other construction operations.

Provide acceptable tools and supplies of the type and quality suitable for highway survey work. Provide stakes and hubs of sufficient length to provide a solid set in the ground with sufficient surface area above ground for necessary legible and durable markings.

Include staking activities in the construction schedule according to Section 155. Include the dates and sequence of each staking activity.

The Government may set initial horizontal and vertical control points for the project. If the Government sets initial horizontal and vertical control points, the Government will provide data for use in establishing control for completion of the work. If the Contractor is tasked with setting initial horizontal and vertical control for the project, provide the contractor-established control network to the Government for verification.

The Government will furnish data relating to horizontal and vertical alignment, theoretical slope stake catch points, and other miscellaneous design data. Reformatting and additional calculations may be required for the convenient use of the Government-furnished data. Provide immediate notification to the CO of apparent errors in the initial staking or in the Government-furnished data.

Record survey and measurement field data in an approved format. Submit as-staked data and corrections made to the Government-furnished survey data. Submit survey and measurement data at least weekly while surveys are being conducted. Field data and supporting documentation become the property of the Government upon completion of the work.

Discuss and coordinate the following with the CO before surveying or staking:

(a) Surveying and staking methods;

(b) Stake marking;

(c) Grade control for courses of material;

(d) Referencing;

(e) Structure control;

(f) Field staking data;

(g) Localization of the GPS systems to the Government-established control points; and

(h) Other procedures and controls necessary for the work.

Do not start work until staking or 3D verification data for the affected work has been approved.

Preserve initial reference and control points. Notify the CO of missing control points or stakes at least 10 days before starting construction. Reestablish initial control points and obtain approval before starting construction.

Acceptance of the construction staking does not relieve the Contractor of responsibility for correcting errors discovered during the work and for bearing additional costs associated with the error.

Maintain legibility of stake markings for the duration of the project or until notified in writing the stakes are no longer needed. Replace stakes as necessary to ensure markings are maintained.

Remove and dispose of flagging, paint, lath, stakes, and other staking material after the project is complete.

Compute and provide calculations supporting pay quantities. Measure quantities within the tolerances established by the CO according to Section 109.

152.05 Survey and Staking Requirements. Perform survey, staking, recording of data, and calculations as necessary to construct the project. Survey and set stakes to the tolerances shown in Table 152-1. Reset stakes and hubs as required and maintain in an acceptable condition for the duration of the project or until notified they can be removed. Notify the CO if errors are discovered.

(a) Control points. Relocate initial horizontal and vertical control points in conflict with construction to areas that will not be disturbed by construction operations. Provide the coordinates, elevations, and supporting documentation for the relocated points before the initial points are disturbed. Set durable monuments for survey control that uniquely identify the points according to Subsection 107.02 and Section 621. Notify the CO at least 10 days before disturbing original monumentation to verify the newly set control.

Provide the GPS localization results or total station check shot data at least 10 days before starting construction layout work. The CO may order the GPS localization calibration and associated 3D model to be broken into two or more zones to maintain the localized relationship between control points and original ground.

(b) Centerline establishment. Establish or reestablish centerline at roadway design cross-section locations and as necessary to construct the work. Reestablish the centerline if construction survey and staking work does not meet the tolerances.

(c) Original ground topographic verification. Use an approved method to verify existing ground survey. In areas where theoretical and actual ground elevations do not meet a tolerance of ±0.5 feet, notify the CO as resurvey may be required. Re-measure 3D data to verify existing ground topography to mapping. Submit 3D data in electronic format.

Re-measure 3D data 10 feet beyond catch points to verify existing ground topography.

(d) Slope and references stakes. Perform the following:

(1) AMG method. After clearing operations are completed, set centerline reference stakes and hubs on both sides of centerline at 100-foot intervals at the clearing limit locations. Where clearing limits are greater than 10 feet vertically, 25 feet horizontally, or both from subgrade hinge point; provide an additional reference stake and hub as approved. Label each centerline reference stake with station, hub elevation, and offset from centerline.

Construct a 1000-foot-long test section using AMG at an approved location before starting grading operations. Select a test location with superelevation and curve widening transitions if applicable. Notify the CO 10 days before starting the test section. Demonstrate capability, knowledge, equipment, and experience to achieve work within tolerances. Allow 14 days to evaluate the test section. Do not start full grading operations until the test section is approved.

Visibly delineate or mark the centerline reference stakes and hubs at cross-section locations for use in verifying grade and elevation. Use conventional survey methods at random locations specified by the CO, no more than 500-foot intervals. Submit 3D coordinates of centerline reference stakes and hubs QC checks. If QC checks do not meet the tolerances in Subsection 204.13(c), rework the section until the specified tolerances are achieved and provide additional cross-sections as directed.

(2) Conventional survey methods. Verify and set slope stakes on both sides of centerline at the theoretical catch point. If the theoretical catch point is not within a tolerance of ±0.5 feet, perform original ground topographic verification according to Subsection 152.05(c). Set the slope stake at the actual intersection of the design roadway slope with the natural ground-line. Set reference stakes outside the clearing limits. Include reference points and slope stake information on the reference stakes. At minimum, label each slope stake with grade information to subgrade shoulder, station, hub elevation, and offset from centerline. Include other relevant information on the stakes if requested.

Establish slope stakes in the field as the actual point of intersection of the design roadway slope with the natural ground-line if theoretical catch point information is not available.

(e) Clearing and grubbing limits. Before ground disturbance occurs, set clearing and grubbing limits on both sides of centerline at least every 100 feet. Label each clearing and grubbing limit reference stake with station and offset from centerline.

(f) Grade finishing stakes.

(1) AMG method. Construct a 1000-foot-long test section using AMG at an approved location before starting grading operations. Select a test location with superelevation and curve widening transitions if applicable. Notify the CO 10 days before starting the test section. Demonstrate the capability, knowledge, equipment, and experience to achieve work within tolerances. Allow 14 days to evaluate the test section. Do not start full grading operations until the test section is approved.

Visibly delineate or mark the centerline and shoulder catch point at cross-section locations for use in verifying grade and elevation. Verify the grade elevation and horizontal alignment of roadway grade-finishing operations. Use conventional survey methods at random locations specified by the CO, no more than 500-foot intervals. Submit 3D coordinates of grade finishing QC checks.

(2) Conventional survey methods. Set grade finishing stakes for grade elevations and horizontal alignment, on centerline and on each shoulder at design roadway cross-section locations. Set stakes at the top of subgrade and the top of aggregate course. Reset grade finishing stakes as many times as necessary to construct the subgrade and each aggregate course.

During turnout or pullout construction, set stakes on the centerline, on each normal shoulder, and on the shoulder of the turnout. In parking areas, set stakes at the center and along the edges of the parking area. Set stakes in ditches to be paved.

If the centerline curve radius is less than or equal to 250 feet, use a maximum longitudinal spacing between stakes of 25 feet. If the centerline curve radius is greater than 250 feet, use a maximum longitudinal spacing between stakes of 50 feet. Use a maximum transverse spacing between stakes of 20 feet. Use brushes or guard stakes at each stake.

(g) Culverts. Verify and set culvert locations at the inlet, outlet, and inlet basin points as shown in the plans. Perform the following:

(1) Survey and record the ground profile along the culvert centerline and additional channel profile for an appropriate offset to capture required information in Subsection 152.05(g)(4).

(2) Determine the slope catch points at the inlet and outlet.

(3) Set reference points and record information necessary to determine culvert length and end treatments.

(4) Plot to scale the profile along the culvert centerline. Show the natural ground, flow line, roadway section, culvert, end treatments, and other appurtenances. Show elevations, grade, culvert length, and degree of elbow.

(a) For single skewed culverts, submit a plotted field-design cross-section normal to roadway centerline and at each end section. Plot the offset and elevation of natural ground at the end section and at proposed template break points between centerline and the end section. Ensure the template design embankment slope is not exceeded.

(b) For multiple skewed culverts, submit a plotted field-design cross-section normal to roadway centerline and at the end sections (left and right) nearest to the shoulder. Plot the offset and elevation of natural ground at the end section and at proposed template break points between centerline and the end section. Ensure the template design embankment slope is not exceeded.

(c) Submit the plotted field-design cross-section for approval of final culvert length and alignment. Plot at a clear and readable scale.

(d) Set inlet, outlet, and reference stakes after the field design has been approved. Stake inlet and outlet ditches to ensure the culvert and end treatments (such as drop inlets) are functional.

(e) Adjust slope, reference, and clearing stakes as necessary to provide for culvert inlet treatments in cut slopes. Readjust slope, reference, and clearing stakes as necessary if culvert inlets are moved from their plan locations. Review slope adjustments with the CO and obtain approval.

(h) Bridges. Set adequate permanent horizontal and vertical control and reference points for bridge substructure and superstructure components to last through project construction. Establish and reference the bridge chord, bridge tangent, or control lines as shown in the bridge plans. Also establish and reference the centerline of each pier, bent, and abutment.

(i) Retaining walls, rockeries, special rock embankments, rock buttresses, gabion walls, and reinforced soil slopes. Survey and record profile measurements along the face of the proposed wall, rockery, embankment, buttress, or reinforced soil slope at 5 feet and 10 feet in front of the wall or slope face. Take cross-sections every 25 feet along the length of the wall or reinforced soil slope and at major breaks in terrain within the limits designated by the CO. Measure and record points every 25 feet and at major breaks in terrain for each cross-section. Set reference and control points to perform the work.

(j) Borrow and waste sites. Perform field work necessary for initial layout, baseline, and measurement of the borrow or waste site. Establish site limits and clearing limits. Measure both original and final ground conditions and submit survey data as directed.

(k) Permanent monuments and markers. Perform survey and staking work necessary to establish permanent monuments and markers as described in Section 621 or reestablish monuments as described in Subsection 107.02.

(l) Miscellaneous survey and staking. Survey and stake other work as directed to the proper location and required tolerances. Propose staking increments and tolerances for approval if not shown in Table 152-1.

Table 152-1
Construction Survey and Staking Tolerances[1]

Staking Phase	Horizontal, feet (±)	Vertical, feet (±)
Control points set from existing control points	0.03	$0.01 \times \sqrt{N}$ [2]
Mapping, topography, & cross-section points	0.16	0.16
Centerline points[3] & references	0.06	0.06
Slope stake and slope stake references[4]	0.16	0.16
Culverts, ditches, & minor drainage structures stakes	0.16	0.06
Retaining walls stakes	0.06	0.03
Curb & gutter stakes	0.06	0.03
Bridge substructures stakes	0.03[5]	0.03
Bridge superstructures stakes	0.03[5]	0.03
Clearing & grubbing limit stakes	1.00	–
Roadway subgrade finish stakes[6]	0.16	0.03
Roadway finish grade stakes[6]	0.16	0.03

(1) At statistical 95 percent confidence level. Tolerances are relative to existing Government control points.
(2) N is the number of instrument setups.
(3) Centerline points: point of curve (PC), point of tangent (PT), point on tangent, point on curve (POC).
(4) Take the cross-sections normal to the centerline ±1 degree.
(5) Bridge control is established as a local network and the tolerances are relative to that network.
(6) Includes paved ditches.

152.06 Acceptance. Construction survey and staking will be evaluated under Subsections 106.02 and 106.04.

Survey notes will be evaluated under Subsection 106.02.

Permanent monuments and markers will be evaluated under Section 621.

Measurement

152.07 Measure the Section 152 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring grade finishing by the mile, measure one time for the subgrade and one time for each aggregate course.

When measuring survey and staking by the hour, do not measure time spent in making preparations, traveling to and from the project site, performing calculations, plotting cross-sections and other data, and processing computer data.

Do not measure re-establishing missing control points or stakes after construction operations have begun.

Payment

152.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 152 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for lump sum pay items will be prorated based on total work completed under this Section.

Section 153. — CONTRACTOR QUALITY CONTROL

Description

153.01 This work consists of planning and implementing a construction quality process to ensure work conforms to the contract. This work also includes inspection and documentation, and process control sampling and testing. See FAR Clause 52.246-12 Inspection of Construction.

Construction Requirements

153.02 Qualifications. At least 14 days before starting work, submit documentation of the following for approval:

(a) QCM. Provide a QCM with documented authority to stop non-compliant work or work that results in non-compliance with contract requirements.

Provide a QCM with at least 3 years' experience in areas of material testing, inspection, management, supervision, and QC on highway construction projects of similar type and scope;

(b) Alternate QCM. Provide an alternate QCM, meeting QCM qualifications;

(c) Inspectors. Provide inspectors with at least 2 years' experience inspecting work of similar type and scope; and

(d) Testers. Provide testers with at least 1 year's experience in the type of sampling and testing required, and with one of the following for the type of sampling and testing performed:

(1) National Institute for Certification in Engineering Technologies (NICET) Level II certification in construction materials testing for similar material types or equivalent state or industry certification;

(2) Certification by a state or regional certification program, such as Western Alliance for Quality Transportation Construction or Northeast Transportation Technician Certification Program; or

(3) At least 1 year of employment by an AASHTO accredited laboratory performing equivalent sampling and testing with competence according to AASHTO R 18.

153.03 Quality Control Plan. Develop and submit a QCP for approval at least 14 days before starting a Section of work. Include the work of subcontractors, material suppliers, and technical services suppliers. Include the work required under Section 154. Do not perform work unless the QCP for that Section is approved. Approval does not imply that the QCP will result in contract compliance.

For each Section of work, include the following:

(a) QC personnel. Provide the name, authority, responsibilities, and qualifications of the QCM and other personnel directly involved in inspection and testing.

(b) QC procedures. Describe the inspection, testing, and other activities to be performed for each phase of work in Subsection 153.06. Include methods, schedules, equipment, and laboratory facilities.

Include the following for materials to be tested:

(1) Pay item;

(2) Brief operational work plan including, but not limited to, the locations, crews, equipment, and proposed methods to complete the work. Describe the plan for staging, disposal, and storage areas.

Include the following in the plan for each Section of work:

(a) The process to ensure the completed work conforms to contract requirements.

(b) The inspection and testing frequency to ensure the process remains valid or work is being performed according to the established process.

(3) Sampling, testing, and acceptance requirements including the location of sampling, and the frequency of testing. At a minimum, perform testing according to the requirements in each applicable Section;

(4) Personnel responsible for performing the inspection, sampling, and testing;

(5) Laboratory testing facilities to be used for process control and project acceptance testing; and

(6) Proposed reporting formats.

(c) Records. Describe the reporting format for inspection, testing, certification, and daily reports.

Revise the QCP if contract quality requirements are not achieved, or changes occur in the contract, work processes, or personnel.

153.04 Quality Control Manager. Provide a QCM who is on site while contract work is being performed. Provide a QCM with no responsibilities for managing or superintending the project or performing operations other than managing QC.

Do not use an alternate QCM for more than 3 consecutive days unless approved.

153.05 Certifications and Submittals. The QCM is required to review certifications and submittals to ensure compliance with the contract requirements. Provide a copy of the reviewed submittals and certifications signed by the QCM. Submit material certifications and submittals at least 7 days before the applicable work starts, unless otherwise specified.

153.06 Prosecution of Work. Complete the following:

(a) Preparatory and start-up phase.

(1) Before starting each Section of work, hold a preparatory phase meeting. Include the project superintendent, work foreperson, CO, QCM, inspectors, testers, and appropriate subcontractors. Discuss the following:

(a) Contract requirements for the work including, but not limited to, acceptance procedures, schedule, and control strip;

(b) Process and equipment for constructing the work; and

(c) Plan for inspection, process control, testing, measuring, and reporting the work.

(2) Review and coordinate certifications, submittals, plans, drawings, and permits.

(3) Verify the capabilities of equipment, material, and personnel. Provide training as necessary.

(4) Establish a detailed testing schedule based on the production schedule.

(5) Report the required preparatory testing, calibration, and inspection results.

(6) Review accuracy of the surveying and staking.

(7) Explain procedures to be followed if defective work is identified.

(8) Describe the plan for staging, disposal, and storage areas.

(9) Provide a brief operational work plan including, but not limited to, the locations, crews, equipment, and proposed methods to complete the work.

(b) Production phase.

(1) Inspect, test, and report according to the QCP and evaluate the acceptability of the work produced. Meet with the CO weekly, or as requested, to discuss the status and effectiveness of the QC process.

(2) Identify and correct deficiencies. Identify root causes and make changes to work processes to prevent repeated deficiencies.

(3) Request Government inspection. Allow 24 hours for inspection of the completed work after the Government has been notified.

153.07 Sampling and Testing. At least 45 days before project use, ensure laboratory test equipment has been checked, calibrated, standardized, and verified according to AASHTO and ASTM standards by an individual qualified to perform the work. Keep laboratory facilities clean and maintain equipment in proper working condition. Certify that equipment conforms to testing requirements and submit evidence of current calibrations.

Inspect and calibrate mobile laboratory equipment after the laboratory is moved to the project, before using equipment, and every time it is moved thereafter.

Allow the CO unrestricted access to the laboratory for inspection and review. Provide additional inspections and tests to demonstrate sampling and testing proficiency if requested. Submit proficiency sample test results within 48 hours of sample receipt.

Perform QC sampling and testing according to the QCP and the Sampling, Testing, and Acceptance Requirements tables included at the end of each applicable Section. If no sampling frequencies are specified, submit the proposed sampling and testing frequencies.

Allow the CO the opportunity to witness all sampling and testing. If requested, sample and split QC samples according to AASHTO or other acceptable procedures. Deliver and label split QC samples according to Subsection 154.03.

Sample and test material that appears defective or inconsistent with similar material being produced, unless such material is voluntarily removed and replaced or otherwise corrected according to Subsection 106.01.

153.08 Records and Control Charts. Maintain records and control charts by pay item.

(a) QC and construction operations reports. Submit written QC and construction operations reports daily according to the QCP. Document meetings, work locations, labor and equipment used. Include actual hours worked, testing and measurement activities, inspection results, deficiencies observed, corrective actions taken, and process changes. Use Form FHWA 1413, *Inspector's Daily Record of Construction Operations* or approved alternate forms. Include the following certification signed by the QCM on all reports:

> "I certify that the information contained in this record is accurate and that work documented herein complies with the contract. Exceptions to this certification are documented as a part of this record."

(b) Test Results. Label test results according to Subsection 154.03. Attach worksheets used to determine test values to the test result forms when submitted.

(c) Control charts. Maintain linear control charts that identify the test number, test parameter, upper and lower specification limit applicable to each test parameter, and test results for applicable material. Use the control charts to document variability of the process, to identify production and equipment problems, and to identify actions to improve processes or quality.

Update and post control charts daily in a location accessible to the CO. Stop production and correct the process when problems are evident.

153.09 Acceptance. The Contractor's QC process will be evaluated under Subsections 106.02 and 106.04 based on its demonstrated effectiveness to ensure work conforms to the contract. Performance of the work may be stopped according to Subsection 108.06, either in whole or in part, for failure to comply with the requirements of this Section.

Measurement

153.10 Measure the Section 153 pay items listed in the bid schedule according to Subsection 109.02.

Payment

153.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 153 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 154. — CONTRACTOR SAMPLING AND TESTING

Description

154.01 This work consists of obtaining samples, testing, and reporting the required test results. It excludes Contractor process and QC sampling and testing required under Section 153.

Construction Requirements

154.02 General. Sample and test material according to the Sampling, Testing, and Acceptance Requirements tables included at the end of each Section. Provide testers conforming to Subsection 153.02(d). Perform additional sampling and testing as directed if material does not meet requirements.

Provide the CO the opportunity to witness sampling, splitting, and testing of material.

Where process control sampling and testing frequencies are identical to the sampling and testing frequencies for acceptance, the process control samples may be used for acceptance for the applicable work.

154.03 Sampling. Sample and split samples according to AASHTO or other acceptable procedures. For statistical acceptance sampling, the exact location of sampling will be determined by the CO based on random numbers. Perform splits when required and deliver the Government's portion of the sample or split sample in an acceptable container suitable for shipment. Label samples with the following:

(a) Project number and name;

(b) Pay item number and description;

(c) Source of material;

(d) Sample number;

(e) Date sampled;

(f) Time sampled;

(g) Location sample taken;

(h) Name of person sampling;

(i) Name of person witnessing sampling; and

(j) Type of test required on sample.

154.04 Testing. Conform to Subsection 153.07 for sampling and testing. Demonstration of testing competence may be required.

154.05 Records. If tests are on material being incorporated in the work, report test results within 24 hours unless otherwise specified in the Sampling, Testing, and Acceptance Requirements tables. Report test results on forms containing sample information required by Subsection 154.03. Label interim measurements used to determine the results. Attach worksheets used to determine test values to the test result forms. Payment for work may be delayed or the work stopped until test results are submitted.

154.06 Acceptance. Contractor sampling and testing will be evaluated under Subsections 106.02 and 106.04 based on Government verification testing.

Measurement

154.07 Measure the Section 154 pay items listed in the bid schedule according to Subsection 109.02.

Payment

154.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 154 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for Contractor testing by the lump sum will be paid as follows:

(a) 25 percent of the pay item amount, no more than 0.5 percent of the original contract amount, will be paid after the testing facilities are in place, qualified sampling and testing personnel are identified, and the work being tested has started.

(b) The remaining portion of the pay item amount will be prorated based on total work completed under this Section.

Payment may be retained if Government testing does not validate the Contractor testing or if it is determined that documentation of sampling and testing does not meet requirements.

Section 155. — SCHEDULES FOR CONSTRUCTION CONTRACTS

Description

155.01 This work consists of scheduling, monitoring, and reporting the progress of construction activities.

155.02 Definitions.

(a) Baseline construction schedule. The first approved construction schedule submitted after the preliminary work plan, showing the order to perform the work, and the dates for starting and completing the work. Once approved the baseline construction schedule cannot be changed.

(b) Construction schedule. Designated as either a Bar Chart Method (BCM) or a Critical Path Method (CPM) schedule.

(1) BCM schedule. A BCM schedule includes a progress bar chart, written narrative, and a submittal list.

A progress bar chart is a time-scaled graphic representation of a project displaying the overall sequencing of work. Each activity includes an activity number, description, start and finish date, and duration. BCM schedules list predecessor activities that must be finished before each activity can be started.

(2) CPM schedule. A CPM schedule includes a time-scaled logic diagram, tabular schedule, written narrative, and a submittal list.

The time-scaled logic diagram is a computer-generated diagram showing the sequence in which the Contractor, in coordination with subcontractors, plans to perform the work; the interdependence of all activities and milestones; the work completed through the data date; and the remaining work necessary to complete the project.

(c) Construction schedule update. An update to the previously approved construction schedule that shows the completed work and the remaining work necessary to complete the project and includes progressing of the schedule, changes to the schedule logic, changes to the schedule activities, changes to the activity durations, or any other modification to the schedule of planned work. A construction schedule update may show construction being completed at a date other than the contract completion date.

(d) Critical path. The longest sequence of activities in the CPM schedule that determines the project’s duration. If the duration of any activity on the critical path is changed, the time required to complete the project will change unless a separate CPM schedule adjustment is made.

(e) Preliminary work plan. A narrative and schedule diagram of contract activities for the first 60 days after the NTP.

Construction Requirements

155.03 General. Follow the requirements of FAR Clause 52.236-15 Schedules for Construction Contracts.

Designate an individual who will be the authorized representative responsible for the schedule. Submit the name of the authorized representative with the preliminary work plan.

Failure to include elements of work in the schedule that are required for performance of the contract, even if approved by the Government, will not excuse the Contractor from completing the work required by the contract completion date.

Approval of the construction schedule does not relieve the Contractor of the responsibility to schedule the work to meet the contract requirements.

Do not suppress or sequester float. Do not alter planned durations and sequencing to give the appearance that activities do not have float. Float time within the construction schedule is not for use or benefit of either the Government or the Contractor but is a jointly owned project resource available to both parties as needed to meet the contract completion date. Either party has the full use of float until it is depleted.

In case of discrepancy, the approved electronic format governs over native file format of the construction schedule.

155.04 Preliminary Work Plan. Do not start work, except mobilization, temporary traffic control, and Section 637 work, without an approved preliminary work plan. No progress payments will be made until a preliminary work plan has been approved. Include the following:

(a) A title page stating contract number, project number, project name, Contractor name, contract completion date, date of submittal, submittal number, and "Preliminary Work Plan";

(b) A schedule diagram showing work activities;

(c) Description of proposed work within each activity including the type and quantity of equipment, labor, and material to be used;

(d) Description of site mobilization;

(e) Description of planned production rates for each applicable pay item by pay item quantities;

(f) Description of the number of workdays per week, holidays, number of shifts per workday, and number of hours per shift. Include all calendars used in the schedule module;

(g) Estimate of idle and partially idle periods within each activity, showing start and finish dates;

(h) Description of expected and critical delivery dates for equipment and material that can affect completion of the project. Describe the fabrication and delivery of key and long-lead time procurement activities;

(i) Name of vendor, supplier, or subcontractor to perform an activity. State assumptions made in scheduling their work;

(j) A list of shop drawings, sample submittals, and review times; and

(k) A list of drawings, permits, and other submittals by pay item number required for the entire contract period.

Submit a preliminary work plan at least 7 days before the preconstruction conference. Within 14 days of submission, the preliminary work plan will be approved or rejected. If rejected, submit a revised plan within 3 days.

155.05 Baseline Construction Schedule. Submit a construction schedule within 45 days of the NTP. Include a title page or header block for each component with the contract number, project number, project name, Contractor name, contract completion date, date of submittal, and submittal number. Show all activities including those in the preliminary work plan.

Prepare and submit a CPM construction schedule unless otherwise specified.

(a) CPM schedule. Depict the order and interdependence of all activities and the sequence of the work that will be accomplished by the Contractor and subcontractors.

Do not provide logic relationships between unrelated activities. Do not constrict start or finish dates without rationale.

Obtain approval before using lags or leads in the construction schedule. Remove lags or leads and replace with an activity identifying the lag or lead upon request.

(1) Time-scaled logic diagram.

(a) Show activity descriptions. Relate activities or groups of activities to pay items. Include activities for submittals, submittal reviews, fabrication, and deliveries. Do not include continuous activities (such as traffic control and QC).

(b) Show activity name or description with the activity bar on the diagram.

(c) Group activities by area (such as separate distinct bridges or roadways), and by type of work (such as submittals, utilities, roadway, or bridge).

(d) Show original and remaining durations for construction activities. Break construction activities into subtasks with activity durations no longer than 20 workdays.

(e) Show original and remaining durations of non-construction activities (such as mobilization and submittals). Include pay item number, and the fabrication and delivery of key materials. Non-construction activities may have durations exceeding 20 workdays consistent with the contract. Indicate intended submittal dates and delivery dates for fabrication and delivery activities. Allow for review of each submittal.

(f) Start the construction schedule with the date of the NTP and conclude with a milestone that shows the contract completion date.

(g) Show early start and finish dates.

(h) Show late start and finish dates.

(i) Show total float and free float.

(j) Show relationship lines. Include at least one predecessor and one successor activity for each activity, except for the NTP and contract completion date.

(k) Use a time scale to graphically show the work scheduled for performance.

(l) Show the sequence and interdependence of all activities.

(m) Identify the critical path.

(2) Tabular schedule. Submit a tabular schedule sorted by early start and total float. Include the following information in the tabular schedule:

(a) Activity number;

(b) Activity description;

(c) Subcontractor and supplier activity codes;

(d) Activity percent complete;

(e) Original and remaining duration;

(f) Early and late schedule dates;

(g) Total float;

(h) A predecessor/successor report; and

(i) Other tabular schedule report formats for analyzing CPM schedule revisions or time impacts, if requested.

(3) Written narrative. Describe the rationale and assumptions used in the development of the construction schedule. Use the time-scaled logic diagram as the basis of schedule-related comments and reference specific activities by number and description. Ensure there are no conflicts between the diagram and the narrative. Include the following:

(a) Description of the planned critical path and the general sequence of work.

(b) Information and references to adequately define the scope of work by pay item included in each major activity type (such as roadway excavation and aggregate base course). Include station numbers and location.

(c) Description of the resource loading planned for use in the performance of the work for each major activity. Include manpower allocation by types of labor and crew size, types and number of equipment and special equipment, material, and subcontractors.

(d) Description of the basis (including the resource loading above) for the calculation of the duration for major activities, to be stated as quantity production rates.

(e) Description of workdays per week, number of shifts per workday, and number of hours per shift.

(f) A description of the assumptions used in converting workdays to calendar dates. Include anticipated holidays, non-workdays, winter shutdowns, and other constraints within the

contract. Describe calendars used in the schedule module and list the calendar used for each activity in the schedule module.

(g) Name of the subcontractor or supplier performing an activity and identify their activity codes used on the schedule diagram. State assumptions made in the scheduling of the subcontractor's or supplier's work.

(h) Description of site mobilization and critical delivery dates for equipment and material that can affect completion of the project.

(i) A description of organizational limitations (such as resource constraints or subcontractor commitments) which limit scheduling flexibility.

(j) Estimate of idle and partially idle periods within each activity, showing start and finish dates.

(k) A list and description of constraints used in the CPM scheduling software.

(4) Submittal list. Provide a submittal list according to Subsection 155.05(b)(3).

(b) BCM schedule. Include the following:

(1) Progress bar chart.

(a) Use a time scale to graphically show the percentage of work scheduled for completion during the contract time;

(b) Define and relate activities to the pay items;

(c) Show activities in the order the work will be performed, including submittals, submittal reviews, fabrication, and delivery;

(d) Highlight activities that are controlling factors in the completion of the work;

(e) Show the time needed to perform each activity and its relationship in time to other activities;

(f) Show the total time to complete work; and

(g) Provide enough space for each activity to allow two additional plots parallel to the original time span plot. Use one space for revision of the planned time span, and one for showing actual time span achieved.

(2) Written narrative.

(a) Estimate start and finish dates of each activity;

(b) Describe work to be done within each activity including the type and quantity of equipment, labor, and material to be used;

(c) Describe the location on the project where each activity occurs;

(d) Describe planned production rates for each applicable pay item by pay item quantities;

(e) Describe the number of workdays per week, holidays, number of shifts per workday, and number of hours per shift. Include all calendars used in the schedule;

(f) Estimate of idle and partially idle periods within each activity, showing start and finish dates;

(g) Describe expected and critical delivery dates for equipment or material that can affect completion of the project. Describe the fabrication and delivery of key and long-lead time procurement activities;

(h) Identify the vendor, supplier, or subcontractor to perform the activity. State assumptions made in the scheduling their work; and

(i) Describe critical completion dates for maintaining the construction schedule.

(3) Submittal list. Submit a list of drawings and other submittals by pay item number required for the entire contract period. Include the following information for each drawing or submittal:

(a) Pay item number and description;

(b) Planned date of initial submittal; and

(c) Planned date of CO's initial response.

Submit the construction schedule according to Subsection 104.04.

Within 14 days of submission, the construction schedule will be approved or rejected. If rejected, submit a corrected schedule within 7 days. If rejected again, schedule a meeting within 3 days to discuss corrections and submit another construction schedule.

If a construction schedule is not received within 45 days after the NTP is issued, the CO will withhold the progress payment according to Subsection 109.08(h) until the construction schedule is received.

The approved construction schedule with supporting documents becomes the baseline construction schedule.

155.06 Construction Schedule Update. Submit a construction schedule update by the 15th day of each month, or on the date established by the CO.

Submit the construction schedule update according to Subsection 104.04.

Do not make changes to the schedule logic, activities, or critical path without prior approval.

Within 7 days of submission, the construction schedule update will be approved or rejected. If rejected, submit a corrected construction schedule within 7 days. If rejected again, schedule a meeting within 3 days to discuss corrections and submit another construction schedule.

If an acceptable construction schedule update is not received by the 15th day of the month, or on the date established by the CO, the CO will withhold 10 percent of each progress payment according to

Subsection 109.08(h)(3), until a construction schedule update is approved. Failure to receive approval of a prior construction schedule update does not relieve the Contractor of the responsibility to meet the requirement to provide construction schedule updates each month.

Submitting a proposed construction schedule update is not considered a notification of delay or of other basis for change. Continue to submit monthly construction schedule updates until a construction schedule update is approved.

Approval of a construction schedule update showing completion past the fixed completion date will not alter the fixed completion date or affect the Government's rights under the contract.

(a) Update summary. Provide a summary of the changes and progressing made to the construction schedule since the last approved construction schedule update.

(b) Written narrative. Submit an update of the written narrative identifying adjustments made to each operation since the last update. Include the following:

(1) Equipment added or removed from the project;

(2) Changes to labor (such as added crews or subcontractors);

(3) Work shift adjustments (such as extended hours or added shifts);

(4) Changes to anticipated periods of suspension or holiday;

(5) Changes in material delivery;

(6) Early completion of individual work items;

(7) Efficiency of operations;

(8) Changes to the critical path and logic revisions;

(9) Delays and disruptions that are ongoing as of the date of the proposed construction schedule update. If delays or disruptions have occurred, propose efforts to return the project to a schedule consistent with the contract requirements including the commitment of additional resources or other appropriate action; and

(10) Notification that completion date or other contract requirements will not be met, if applicable.

(c) Submittal list. Provide an update to the submittal list. Include the following:

(1) Actual dates for submittals;

(2) Proposed dates for anticipated submittals;

(3) CO's responses (approved, rejected, or approved as noted); and

(4) Comments.

(d) CPM schedule updates.

(1) Tabular schedule. Update the tabular schedule. Include the following:

(a) Actual start and finish dates for completed activities;

(b) Remaining duration required to complete each activity started, or scheduled to start, but not completed;

(c) Float remaining for each activity;

(d) Percentages for completed and partially completed activities;

(e) Additional tabular schedules using different sort parameters if requested; and

(f) Revised construction activities affected by impacts addressed with a time impact analysis. Include a revised completion date for the total work.

(2) Updated time-scaled logic diagram. Update the diagram and show the approved baseline construction schedule on the construction schedule update for comparison. Show the data date for the update.

(e) BCM schedule updates.

(1) Progress bar chart. Update the progress bar chart. Include the following:

(a) Actual start and planned finish dates of activities underway;

(b) Remaining duration of uncompleted activities;

(c) Actual finish dates of completed activities;

(d) Revised construction activities affected by impacts addressed with a time impact analysis. Include a revised completion date for the total work; and

(e) The initial time span plot adjacent to the updated time span plot for each work activity.

155.07 Progress Meetings. Schedule and facilitate a weekly progress meeting. Invite the CO, superintendent, QCM, and other personnel directly supervising or managing the project.

Provide a two-week look-ahead schedule one day before the meeting. Review actual progress as compared to the planned progress and review planned activities for the upcoming 2 weeks. Discuss the status of submittals, QC documentation, contract modifications, and requests for information.

155.08 Acceptance. Construction schedules and supporting documents will be evaluated under Subsection 106.02.

Measurement

155.09 Measure the Section 155 pay items listed in the bid schedule according to Subsection 109.02.

Payment

155.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 155 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for construction schedule by the lump sum will be paid as follows:

(a) 25 percent of the pay item amount, no more than 0.5 percent of the original contract amount, will be paid after the baseline construction schedule is approved.

(b) The remaining portion of the pay item amount will be prorated based on the total work completed in the contract.

Section 156. — PUBLIC TRAFFIC

Description

156.01 This work consists of controlling and protecting public traffic adjacent to and within the project. See FAR Clause 52.236-13 Accident Prevention.

Construction Requirements

156.02 Qualifications. Provide a traffic control supervisor (TCS) certified by a state department of transportation, ATSSA, or other acceptable certification programs. At least 30 days before starting work, submit documentation of appropriate certifications for approval.

156.03 Accommodating Traffic During Work. Accommodate traffic according to the MUTCD, Section 635, this Section, and as shown in the plans. At least 30 days before intended use, submit a temporary traffic control plan according to Subsection 104.06.

Ensure the safety and convenience of the public and protect the residents and property adjacent to the project. Accommodate public traffic on roads adjacent to and within the project until the project is accepted according to Subsection 106.06(b).

Immediately open the road to emergency vehicles.

156.04 Maintaining Roadways During Work. Maintain roadways as follows:

(a) Construct and remove temporary traffic diversions and bridges as required by the temporary traffic control plan.

(b) Maintain intersections and provide access to trails, roads, streets, businesses, parking areas, residences, garages, farms, and other features at all times.

(c) Snow removal to facilitate the work is the Contractor’s responsibility. Snow removal to provide public access is the responsibility of the maintaining agency and may be performed at the maintaining agency’s discretion. Allow the maintaining agency access to perform snow removal.

(d) Provide dust control according to Section 158 or 312. Apply water or dust palliative as ordered to maintain visibility and eliminate hazardous conditions.

(e) Remove accumulations of soil and other material from the traveled way.

(f) Do not allow water to pond on the traveled way.

(g) Maintain the roadway, detours, and temporary traffic diversions in a safe and acceptable condition.

If corrective action is requested and the corrective action is not taken immediately, the condition may be corrected by the CO and the cost of the corrective action deducted from monies due the Contractor.

156.05 Maintaining Roadways During Non-Work Periods. Maintain roadways and traffic control for public traffic during periods when work is not in progress. Snow removal to provide public access is the responsibility of the maintaining agency.

156.06 Limitations on Construction Operations. When the roadway is open to public traffic, perform the following:

(a) Limit construction-caused delays to public traffic to no more than 30 minutes per passage through the project.

(b) Operate equipment in the direction of traffic, where practical.

(c) For shoulder drop-offs of 3 inches or less, provide "*Low Shoulder*" warning signs. For shoulder drop-offs more than 3 inches, provide a 1V:3H fillet with "*Shoulder Drop-Off*" warning signs. Complete the construction of shoulders adjacent to traffic lanes to the same elevation within 14 days.

(d) Provide minimum lane widths of 10 feet. Use barricades, drums, or other approved devices to delineate traffic lanes through areas where the edge of pavement or intended path has been obliterated by construction operations. Notify and coordinate with the oversize load permitting authority for lane width limitations before reducing lane width or closing roadway shoulders.

(e) Locate staging areas outside the clear zone or behind approved traffic barriers. Obtain approval of the location and access to staging areas. Store unused traffic control devices at staging areas.

(f) Park equipment outside of the clear zone or behind approved traffic barriers.

(g) Provide parking areas for employee’s personal vehicles in approved areas.

(h) Provide uninterrupted two-way communications between flaggers and between flaggers and pilot cars unless flaggers can see each other and communicate. Citizen band radios are unacceptable. Make communication devices available to the CO as necessary or if requested.

(i) Maintain existing guardrails, barriers, and bridge railings until removal is necessary for construction. Use a temporary barrier or appropriate channelizing devices while the guardrails and bridge rails are absent. Install permanent barriers, guardrails, and bridge rails as soon as possible.

156.07 Nighttime Operations. Perform construction operations during the hours of daylight. Daylight hours are defined as one-half hour after sunrise to one-half hour before sunset.

Where nighttime operations are allowed, submit a night lighting plan for approval. Include the number of lights, types, and locations. Submit the proposed plan at least 14 days before use. Do not use vehicle or incandescent lights for work zone lighting.

Provide and install the approved system to illuminate the entire work area. Position the lights so they do not shine directly at motorists traveling from any direction. If the operation is moving, move the lighting with the operation. Describe how lighting system moves will be accomplished and designate a person responsible. Provide lighting at each flagger location. Equip vehicles with an exterior flashing yellow dome light. If arrow boards are used, reduce brightness by an acceptable level during nighttime.

156.08 Traffic Control Supervisor. Provide a TCS according to Subsection 156.02 during construction operations and as necessary to inspect the devices as defined below. Provide the TCS’s name and 24-hour telephone numbers at the preconstruction conference.

Do not designate the superintendent as the TCS.

During the contract, including periods of suspensions and work stoppages, perform the following:

(a) Implement the temporary traffic control plan and monitor the effectiveness of the plan.

(b) Coordinate traffic control operations. Include those of subcontractors and suppliers.

(c) Ensure the condition, position, and applicability of traffic control devices in use.

(d) Immediately correct traffic control deficiencies.

(e) Coordinate and ensure that traffic control devices are provided, installed, maintained, removed, stored, replaced, relocated, and cleaned according to Section 635. Ensure unused traffic control devices are properly handled and stored.

(f) Conduct weekly traffic safety meetings for construction workers and invite the CO to these weekly meetings.

(g) Submit a weekly certification that inspections and reviews were conducted and that the traffic control devices meet contract requirements. Include the number and types of devices in use. Report with the weekly certification, changes or corrective actions taken to ensure the safe passage of public traffic through the project.

(h) Inspect traffic control devices, including those in staging, storage, material source, and disposal areas, as follows:

(1) Daily, during daylight hours and during hours of darkness;

(2) Weekly during:

(a) Daylight hours and hours of darkness when work is suspended for periods of more than one week; and

(b) Periods of winter suspension.

(3) Additional inspections, day or night, as directed; and

(4) Submit reports of inspections within 24 hours.

(i) Before winter suspension, conduct an inspection of the project with the CO to ensure proper provisions are made for winter travel during the period of suspension.

(j) Provide temporary flagging assistance.

156.09 Acceptance. Controlling and protecting public traffic work will be evaluated under Subsection 106.02.

Dust control will be evaluated under Sections 158 and 312.

Temporary traffic control devices and services will be evaluated under Section 635.

Measurement and Payment

156.10 Do not measure controlling and protecting public traffic for payment. See Subsection 109.05.

Section 157. — SOIL EROSION AND SEDIMENT CONTROL

Description

157.01 This work consists of providing, constructing, maintaining, and removing soil erosion and sediment control measures to eliminate or minimize pollutants in stormwater discharges from the project.

Material

157.02 Conform to the following Subsections:

Fiber rolls	713.12
Filter rock	705.08
Floating turbidity curtains	713.21
General purpose tackifier	713.11(a)
Geotextile	714.01
Gravel bags	713.13
Mulch	713.05
Nonloadbearing concrete masonry units	725.07(c)
Plastic lining	713.22
Prefabricated filter insert	713.20
Rock for riprap	705.02
Rock mulch	705.07
Rolled erosion control products	713.17
Sandbags	713.14
Sediment filter bags	713.19
Seed	713.04
Silt fence	713.16
Soil and soil-aggregate materials	704.01
Temporary culvert pipe	713.15
Temporary plastic fence	710.08
Turf reinforcement mats	713.18
Water for vegetation	725.01(b)

Construction Requirements

157.03 Qualifications. Provide personnel with experience providing erosion and sediment control and pollution prevention. At least 14 days before starting earth disturbing work, submit a résumé for each individual describing at least 5 years' experience providing erosion and sediment control and pollution prevention on highway or road construction projects for approval. Include certifications in those states where applicable.

157.04 General. Provide and construct permanent and temporary soil erosion and sediment control measures according to the plans, contract permits, Section 107, and this Section. Contract permits amend the requirements of this Section. Do not modify the type, size, or location of measures or practices without approval.

Manage SWPPP documentation and reporting requirements according to contract permits. An alternate erosion and sediment control plan or SWPPP, with necessary permits, may be submitted for approval according to Subsection 104.06. Submit alternate erosion and sediment control proposals at least 30 days before their intended use.

If soil erosion and sediment control measures are not functioning as intended, take corrective action to eliminate or minimize pollutants in stormwater discharges from the project.

157.05 Controls and Limitations on Work. Mark clearing limits and construct sediment perimeter control measures before ground disturbing activities.

Limit the combined grubbing and grading operations areas to 5 acres of exposed soil at one time.

Construct and implement soil erosion and sediment control measures as follows:

(a) Construct temporary measures in incremental stages as construction proceeds.

(b) Following each day's grading operations, shape earthwork to minimize and control soil erosion and sediment transport from stormwater runoff.

(c) Divert runoff around exposed soils.

(d) Stabilize areas of exposed soil where construction activities have permanently ceased or will be temporarily inactive for the next 14 days. Complete the installation of stabilization measures as soon as practical, but no later than 14 days since last disturbance.

(e) Construct outlet protection as soon as culverts or other structures are complete.

(f) Construct and maintain soil erosion and sediment controls on and around soil stockpiles.

(g) Maintain stabilized construction exits to minimize tracking of soil onto existing roads.

157.06 Filter Barriers. Construct silt fence, berms, and fiber rolls to reduce the velocity of runoff to allow sediment to settle.

157.07 Sediment Retention Structures. Construct sediment retention structures of the following types:

(a) Temporary sediment traps. Construct temporary sediment traps to detain runoff from disturbed areas and settle out sediment. Provide outlet protection.

(b) Sediment basins. Construct sediment basins to store runoff and settle out sediment for large drainage areas. Excavate and construct sediment basins according to Section 204. Construct riser pipes according to Section 602. Provide outlet protection.

157.08 Outlet Protection. Construct riprap aprons or basins to reduce water velocity and prevent scour at the outlet of permanent and temporary erosion and sediment control measures. Construct riprap according to Section 251.

157.09 Water Crossings. Construct temporary culvert pipe or bridge at temporary crossings where construction vehicles cross a live waterway according to Section 107.

157.10 Temporary Stormwater Diversions. Construct temporary channels, temporary culverts, earth berms, or sandbags to divert stormwater around disturbed areas and slopes. Stabilize channels according to Subsection 157.11. Provide outlet protection.

157.11 Channel and Slope Protection and Stabilization. Use the following:

(a) Plastic lining. Use plastic lining to protect underlying soil from erosion. Place the plastic lining loosely on a smooth soil surface free of projections or depressions that may cause the liner to puncture or tear. Anchor the lining in place using riprap, gravel bags, or sandbags. If plastic liner is being used for a temporary stormwater diversion channel, place seams perpendicular to the direction of stormwater flow and overlap at least 18 inches.

(b) Riprap. Construct riprap according to Section 251.

(c) Check dams. Construct riprap, filter rock, gravel bags, sandbags, and fiber rolls for check dams to reduce the velocity of runoff in ditches and swales.

(d) Rolled erosion control products. Use rolled erosion control products before or after temporary or permanent seeding. Install according to Section 629.

(e) Temporary slope drains. Use drain pipe, riprap, or plastic lined channel for temporary slope drains. Channel water into the slope drain with an earth berm, gravel bag, or sandbag headwall constructed at the top of a cut or fill. Anchor slope drains to the slope. Provide outlet protection.

(f) Floating turbidity curtains. Install floating turbidity curtains within a body of water to minimize the migration of silt laden stormwater out of the construction area.

157.12 Temporary Soil Stabilization. Control soil erosion on unprotected slopes. Do not import wood chips without approval. Use the following:

(a) Temporary cover. Use mulch, plastic lining, RECP, or tackifier. Apply according to the manufacturer's recommendations or as approved.

(b) Temporary turf establishment. Apply seed and mulch for soil erosion protection at the rates shown in Table 157-1. Protect and care for seeded areas, including watering, until permanent turf establishment is in place.

Table 157-1
Application Rates for Temporary Turf Establishment

Material	Application Rate, pounds/acre
Seed	45
Wood fiber or grass straw cellulose fiber mulch	2000(1)

(1) Apply mulch using hydraulic method according to Subsection 625.08(b). For other mulch products and application methods, use the manufacturer's rate as approved.

157.13 Permanent Soil Stabilization. Control soil erosion on completed permanent slopes. Use the following:

(a) Turf establishment. Apply turf establishment according to Section 625.

(b) Plants, trees, shrubs, vines, groundcovers, and other plants. Plant trees, shrubs, vines, groundcovers, and other plants according to Section 626.

(c) Sod. Place sod of perennial turf-forming grasses according to Section 627.

(d) Rock mulch. Place rock on finished surfaces.

157.14 Inspection and Reporting. Inspect erosion and sediment control measures according to contract permits. If no contract permits apply, inspect at least once every 7 days and within 24 hours of the occurrence of a storm event of 0.25 inch.

Within 24 hours after each inspection, submit an inspection report. Include the following:

(a) Date and time of the inspection;

(b) Names and titles of persons making the inspection;

(c) Summary of the inspection;

(d) Weather since the last inspection or since the start of work, if the first inspection. For each storm event, include the starting date and time, duration, precipitation quantity in inches, and whether discharge occurred;

(e) Weather and description of discharges occurring during the inspection;

(f) Locations of discharges or other pollutants from the site;

(g) Locations of erosion and sediment control measures that need maintenance;

(h) Locations of erosion and sediment control measures that failed to operate as designated or proved inadequate for a particular location;

(i) Locations where additional erosion and sediment control measures are needed; and

(j) Other necessary corrective actions including action taken, locations, dates, and times.

157.15 Maintenance and Cleanup. Maintain temporary and permanent erosion and sediment control measures in working condition until final acceptance or the measures are no longer needed.

Remove sediment trapped in perimeter protection control measures before deposits reach 50 percent of the above ground height. Remove sediment from sediment retention structures when their capacity is reduced to 50 percent of design capacity. Use removed sediment in the work if approved or dispose of it according to Subsection 204.14.

Replace erosion and sediment control measures that cannot be maintained and those that are damaged by construction operations.

When vegetation coverage meets permit requirements, conforms to Subsection 625.09, and drainage ditches and channels are lined and stabilized, remove and dispose of temporary erosion and sediment control measures according to Subsections 203.05 and 203.07.

Restore the ground to its natural or intended condition and provide permanent erosion control measures.

157.16 Acceptance. Material for erosion and sediment control measures will be evaluated under Subsections 106.02 and 106.03.

Construction, maintenance, and removal of erosion and sediment control measures will be evaluated under Subsections 106.02 and 106.04.

Measurement

157.17 Measure the Section 157 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring soil stabilization by the acre, measure on the ground surface.

Do not measure replacement items.

Payment

157.18 The accepted quantities will be paid at the contract price per unit of measurement for the Section 157 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for erosion control measures will be paid as follows:

(a) 25 percent of the pay item amount will be paid after installation.

(b) An additional 50 percent of the pay item amount will be prorated based on total work completed under this Section.

(c) The remaining portion of the pay item amount will be paid after the temporary erosion control measure is removed from the project or at final acceptance.

Section 158. — WATERING FOR DUST CONTROL

Description

158.01 This work consists of providing and applying water for the control of dust caused by the work and public travel.

Material

158.02 Conform to the following Subsection:

Water for construction	725.01(c)

Construction Requirements

158.03 General. Provide an adequate water supply and apply water uniformly across the traveled way as necessary to control dust. Uniformly apply water using pressure-type distributors, pipelines equipped with spray systems, or hoses with nozzles. Apply water at the locations, rates, and frequencies as necessary to control the dust, or as ordered.

(a) Project dust control for public benefit. Control dust within the construction limits as necessary including nights, weekends, and periods of non-work when the project is open to public traffic. When the project is not open to public traffic, control dust in areas of the project that have adjacent residences or businesses. Control dust on approved, active detours established for the project.

(b) Other dust control. Control dust on active haul roads, in pits and staging areas, and on the project during periods not covered in Subsection 158.03(a).

158.04 Acceptance. Water will be evaluated under Subsection 106.02.

Providing and applying water will be evaluated under Subsections 106.02 and 106.04.

Measurement

158.05 Measure the Section 158 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring water for dust control by volume or mass, measure in the hauling vehicle or by metering.

Do not measure water for dust control applied according to Subsection 158.03(b).

Payment

158.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 158 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 200
EARTHWORK

Section 201. — CLEARING AND GRUBBING

Description

201.01 This work consists of clearing and grubbing within the clearing limits designated in the plans.

Material

201.02 Conform to the following Subsections:

Soil and soil-aggregate materials	704.01
Tree wound dressing	713.08(g)

Construction Requirements

201.03 General. Construct erosion and sediment control measures according to Section 157. Do not start clearing until the limits have been approved. Perform work within approved limits. Where possible, preserve vegetation adjacent to bodies of water.

Do not damage vegetation designated to remain. If damage occurs, repair or replace the vegetation in an acceptable manner. Treat wounds or scarred surfaces of trees or shrubs with tree wound dressing.

201.04 Clearing. Within the clearing limits, clear trees, brush, downed timber, and other vegetation as follows:

(a) Cut trees so they fall within the clearing limits.

(b) In areas of cut slope rounding, cut stumps flush with or below the final ground-line.

(c) In areas outside the excavation, embankment, and slope rounding limits, cut stumps to within 6 inches of the existing ground.

(d) Trim tree branches that extend over the road surface and shoulders to a clear height of 20 feet. If required, remove other branches to present a balanced appearance. Trim according to accepted tree surgery practices. Treat cuts with tree wound dressing.

201.05 Grubbing. Grub deep enough to remove stumps, roots, buried logs, moss, turf, grass, and other vegetation as follows:

(a) Grub areas to be excavated, except for cut slope rounding areas.

(b) Grub embankment areas. Undisturbed stumps less than 24 inches in diameter may be left in place if they protrude less than 4 inches above the original ground and will be covered with more than 48 inches of embankment. Remove all other stumps.

(c) Grub pits, channel changes, and ditches only to the depth necessary for the excavation.

(d) Backfill stump and grubbing holes with common backfill to the level of the surrounding ground according to Subsection 209.09. Compact backfill according to Subsection 209.10.

201.06 Disposal. Merchantable timber is the Contractor's property. Dispose of clearing and grubbing debris according to Subsection 203.07.

201.07 Acceptance. Material for tree wound dressing will be evaluated under Subsections 106.02 and 106.03.

Clearing and grubbing will be evaluated under Subsection 106.02.

Backfilling and compacting of stump and grubbing holes will be evaluated under Section 209.

Measurement

201.08 Measure the Section 201 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not make deductions from the area computation unless excluded areas are shown in the plans.

Do not measure clearing and grubbing of borrow or material sources.

Payment

201.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 201 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 202. — ADDITIONAL CLEARING AND GRUBBING

Description

202.01 This work consists of clearing and grubbing outside the clearing limits specified in Section 201.

202.02 Definitions.

(a) Selective clearing. Clearing where some trees and vegetation are designated to remain.

(b) Selective clearing and grubbing. Clearing and grubbing where some trees and vegetation are designated to remain.

(c) Special clearing and grubbing. Clearing and grubbing where all trees and vegetation are removed.

(d) Removal of individual trees or stumps. Removing individual trees or stumps outside the clearing limits designated in Section 201 or outside areas designated in Subsections 202.02(a) through (c).

Construction Requirements

202.03 General. Clear and grub according to Section 201. Clear, grub, and dispose of trees, snags, brush, downed timber, stumps, roots, buried logs, moss, turf, grass, and other vegetation designated to be removed.

Do not push, pull, or fall trees into trees designated to remain. Remove designated debris by methods that prevent damage to vegetation not designated to be removed.

Cut trees to within 4 inches of the existing ground. Remove and dispose of designated trees or stumps according to Subsections 203.05 and 203.07.

Dispose of clearing and grubbing debris according to Subsection 203.07.

202.04 Acceptance. Additional clearing and grubbing will be evaluated under Subsection 106.02.

Clearing and grubbing will be evaluated under Section 201.

Measurement

202.05 Measure the Section 202 pay items listed in the bid schedule according to Subsection 109.02.

Payment

202.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 202 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 203. — REMOVAL OF STRUCTURES AND OBSTRUCTIONS

Description

203.01 This work consists of removing, disposing, and salvaging of structures, obstructions, and materials not designated to remain. The work also includes backfilling the trenches, holes, and pits resulting from structure removal.

Material

203.02 Conform to the following Subsection:

Soil and soil-aggregate materials	704.01

Construction Requirements

203.03 Submittals. At least 30 days before starting the specified work, submit the following according to Subsection 104.06:

(a) Bridge removal plan. Submit a plan that includes the following:

(1) Methods and equipment to be used;

(2) Measures to be used for protecting the environment, public, adjacent property, and workers; and

(3) Methods to keep debris out of wetlands and waters.

(b) Hazardous material disposal plan. Submit a detailed disposal plan according to Subsection 203.08 that includes how material will be handled, loaded, and transported to the disposal facility. Submit a copy of disposal permits. Include the name and address of the facility where the material will be taken. Describe steps that will be taken to ensure that contaminated materials will be contained throughout the process. Measures may include additional steps or precautions when lifting and handling the material.

203.04 Salvaging Material. Salvage designated material with reasonable care. Salvage in readily transportable sections or pieces. Replace or repair members, pins, nuts, plates, and related hardware damaged, lost, or destroyed during the salvage operation. Notify the CO in writing if parts are damaged, missing, or destroyed before starting the salvage operation.

Label all members of salvaged structures with match marks. Securely attach parts to adjacent members or pack them in approved and marked containers with the contents clearly listed.

Submit one set of drawings according to Subsection 104.06 identifying the members and their respective match marks.

Stockpile salvaged material at a designated area.

203.05 Removing Material.

(a) Full removal. Remove the structure or obstruction from the project unless otherwise specified. Raze and remove buildings, foundations, pavements, culverts, sidewalks, curbs, fences, structures, and other obstructions interfering with the work and not designated to remain.

(b) Partial removal. Saw cut sidewalks, curbs, pavements, and structures if partial removal is required.

Remove structures and obstructions in the roadbed to 36 inches below subgrade elevation. Remove structures and obstructions outside the roadbed to 24 inches below finished ground or to the natural stream bottom.

Construct structurally adequate debris shields to contain debris within the construction limits. Do not allow debris to enter wetlands and waters, travel lanes open to public traffic, or areas designated not to be disturbed. Handle material with lead contamination according to Section 563.

Except in excavation areas, backfill and compact resulting trenches, holes, and pits left by structure removal with common backfill to the lines and grades of the finished ground. Backfill according to Section 209.

203.06 Abandoning Structures. Abandon structures or obstructions from the project as shown in the plans or as directed. Ensure that abandoned structures do not entrap water.

If abandoning manholes, inlets, catch basins, and spring boxes, seal pipes entering the structure with a tight-fitting plug of concrete at least 6 inches thick or water-tight masonry at least 8 inches thick.

If abandoning culvert pipes in place, remove the upstream and downstream portion of the culvert to within 48 inches of the subgrade or embankment slope. Ensure the abandoned pipe is at least 48 inches from a new culvert or structure. Seal the abandoned culvert ends with a tight-fitting plug of concrete according to Section 601, at least 6 inches thick.

203.07 Disposing of Material. Dispose of unsuitable and excess material. Recycle or dispose of material legally off the project according to Sections 105 and 107. Submit a statement documenting the nature and quantity of material processed or sold for recycling. Otherwise, submit a signed copy of the disposal agreement before disposal starts.

Dispose of hazardous material according to Subsection 203.08.

203.08 Disposing of Hazardous Material. Dispose of material according to Federal, state, and local rules and regulations.

Include the SDS with the material to the disposal facility. Ensure that loads transported from the site are adequately contained and covered. Submit a copy of the receiving report from the disposal facility acknowledging that the material being delivered contains hazardous material.

(a) Lead paint removal. Dispose of lead contaminated steel either by transporting to an approved scrap facility for recycling or remove and dispose of lead contamination in an appropriate waste facility.

If the Contractor chooses to salvage the steel members, the paint may be removed subject to the following requirements:

(1) Remove lead contaminated paint in an appropriate containment facility.

(2) Conform to Section 563.

(3) Manifest and dispose of lead contaminated waste according to the requirements of 40 CFR 260 through 268 – Resource Conservation and Recovery Act (RCRA).

(b) Asbestos containing material. Dispose of asbestos containing material (ACM) according to Federal, state, and local rules and regulations. Ensure the safety of workers, visitors to the site, and the public according to applicable laws, rules, and regulations.

(1) Asbestos abatement plan. Submit a detailed asbestos abatement plan that includes how ACM will be handled, loaded, and transported for disposal. Include the following in the plan:

(a) Name of the National Emission Standards for Hazardous Air Pollutants (NESHAP) certified supervisor and training program for workers handling ACM.

(b) Name and address of the facility where the ACM will be taken.

(c) Proposed steps taken to remove ACM according to applicable rules and regulations.

(d) Description of how the work will comply with OSHA protective clothing and personal protective equipment requirements, and employee monitoring requirements.

(2) Certification and worker training. Provide at least one NESHAP certified person on site during asbestos removal. Ensure that workers are trained according to 29 CFR 1926.1101.

(3) ACM removal and disposal. Before removal of ACM, submit required notifications to the appropriate regulatory agency and submit copies of approvals. Complete and sign transport and disposal forms. Maintain ACM in an undamaged and non-friable condition by keeping the material wet during demolition or by using methods approved by the regulatory agency. Keep material sealed during transport to the disposal facility. Dispose of containerized asbestos waste according to 40 CFR, Part 61.156.

203.09 Acceptance. Removal of structures and obstructions will be evaluated under Subsection 106.02.

Backfilling and compacting trenches, holes, and pits resulting from structure removal will be evaluated under Section 209.

Lead contaminated material removal will be evaluated under Section 563.

Minor concrete will be evaluated under Section 601.

Measurement

203.10 Measure the Section 203 pay items listed in the bid schedule according to Subsection 109.02.

Payment

203.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 203 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 204. — EXCAVATION AND EMBANKMENT

Description

204.01 This work consists of excavating material and constructing embankments. This work also includes providing, hauling, stockpiling, placing, disposing, sloping, shaping, compacting, and finishing earthen and rocky material.

204.02 Definitions.

(a) Excavation. Excavation consists of the following:

(1) Roadway excavation. Material excavated from within the right-of-way or easement areas, except subexcavation covered in Subsection 204.02(a)(2) and structure excavation covered in Sections 208 and 209. Roadway excavation includes all material encountered regardless of its nature or characteristics.

(2) Subexcavation. Material excavated from below subgrade elevation in cut sections or from below the original ground-line in embankment sections. Subexcavation excludes the work required by Subsection 204.05 or 204.06.

(3) Borrow excavation. Material used for embankment construction that is obtained from outside the roadway prism. Borrow excavation includes unclassified borrow and select borrow.

(b) Embankment construction. Embankment construction consists of placing and compacting roadway or borrow excavation. This work includes:

(1) Preparing foundations for embankments;

(2) Constructing roadway embankments;

(3) Benching for side-hill embankments;

(4) Constructing dikes, ramps, mounds, and berms; and

(5) Backfilling subexcavated areas, holes, pits, and other depressions.

(c) Conserved topsoil. Excavated material conserved from the roadway excavation and embankment foundation areas that is suitable for growth of grass, cover crops, or native vegetation.

(d) Waste. Excess or unsuitable roadway excavation and subexcavation that cannot be used.

Material

204.03 Conform to the following Section and Subsections:

Crushed aggregate	703.06
Geosynthetic material	714
Select borrow	704.02

Soil and soil-aggregate materials	704.01
Water for construction	725.01(c)

Construction Requirements

204.04 Preparation for Roadway Excavation and Embankment Construction. Clear the area of vegetation and obstructions according to Section 201 and 203.

Road pioneering may proceed concurrently with excavation and embankment. Maintain drainage during pioneering operations.

204.05 Conserved Topsoil. Conserve topsoil from roadway excavation and embankment foundation areas. Stockpile conserved topsoil in low windrows less than 4 feet in height and located immediately beyond the rounding limits of cut and embankment slopes or in other approved locations. Separate topsoil from other excavated material. Do not drive or park on conserved topsoil.

Place conserved topsoil on completed slopes according to Section 624 within 1 year of stockpiling.

204.06 Roadway Excavation. Excavate as follows:

(a) Rock cuts. Verify the top portion of the rock cuts during pioneer access or initial excavation. Construct the final soil cut before starting drilling for rock blasting or other rock excavation methods unless approved.

Blast rock according to Section 205. Excavate rock cuts to 6 inches below subgrade within the roadbed limits. Backfill to subgrade with select borrow. Compact the material according to Subsection 204.11.

(b) Earth cuts Scarify earth cuts to 6 inches below subgrade within the roadbed limits. Compact the scarified material according to Subsection 204.11.

Conserve 6-inch minus material from the roadway excavation to use for finishing the roadbed. Dispose of unsuitable or excess excavation material according to Subsection 204.14. Replace shortage of suitable material caused by premature disposal of roadway excavation.

At the end of each day's operations, shape to drain and compact the work area to a uniform cross-section.

204.07 Subexcavation. Excavate material to the required limits. Dispose of unsuitable material according to Subsection 204.14. Take measurements before backfilling. Backfill with select borrow in horizontal lifts no more than 12 inches in compacted thickness and compact according to Subsection 204.11. Place earthwork geosynthetics according to Section 207 as shown in the plans. Place crushed aggregate according to Section 302 as shown in the plans. Prevent unsuitable material from mixing with backfill.

204.08 Borrow Excavation. Use suitable roadway excavation in embankment construction. Do not use borrow excavation if it results in excess roadway excavation. Deduct excess borrow excavation from the total borrow excavation quantity.

Obtain borrow source approval according to Subsection 105.02. Develop and restore borrow sources according to Subsections 105.03 and 105.06. Do not excavate beyond the established limits. If applicable, shape the borrow source to allow accurate measurements when excavation is complete.

204.09 Preparing Foundation for Embankment Construction. Prepare foundation for embankment construction as follows:

(a) Embankment over natural ground. Remove topsoil and break up the ground surface to a minimum depth of 6 inches by plowing or scarifying. Compact the ground surface according to Subsection 204.11.

(b) Embankment over an existing asphalt, concrete, or gravel road surface. Scarify gravel roads to a minimum depth of 6 inches. Scarify or pulverize asphalt and concrete roads to 6 inches below the pavement. Reduce particles to a maximum size of 6 inches and produce a uniform material. Compact the surface according to Subsection 204.11.

(c) Embankment across ground that cannot support equipment. Dump successive loads of embankment material in a uniformly distributed lift to construct the lower portion of the embankment. Limit the lift thickness to the minimum depth necessary to support the equipment.

(d) Embankment on an existing slope steeper than 1V:3H. Cut horizontal steps in the existing slope to a sufficient width to accommodate placement and compaction operations and equipment. Step the slope as the embankment is placed and compacted in lifts. Start each step at the intersection of the original ground and the vertical cut of the previous step.

204.10 Embankment Construction. Incorporate only suitable roadway excavation material into the embankment. When the supply of suitable roadway excavation is exhausted, provide unclassified borrow to complete the embankment. Construct embankments as follows:

(a) General. At the end of each day's operations, shape to drain away from the embankment and compact the embankment surface to a uniform cross-section. Eliminate ruts and low spots that could hold water.

During all stages of construction, route and distribute hauling and leveling equipment over the width and length of each lift of material.

Compact embankment side slopes with a tamping foot roller, by walking with a dozer, or by over-building the fill and then removing excess material to the final slope line. For slopes 1V:1¾H or steeper, compact the slopes as embankment construction progresses.

(b) Embankment within the roadway prism. Place embankment material in horizontal lifts no more than 12 inches in compacted thickness. Construct the top 12 inches of the embankment using 6-inch minus material. Incorporate oversize boulders or rock fragments into the lower lifts by reducing them in size or placing them individually as required below. Compact each lift according to Subsection 204.11 before placing the next lift.

Material composed predominately of boulders or rock fragments too large for 12-inch lifts may be placed in lifts up to 24 inches thick. Incorporate oversize boulders or rock fragments into the 24-inch lift by reducing them in size or placing individual rock fragments and boulders greater than 24 inches in diameter as follows:

(1) Reduce rock to less than 48 inches in the largest dimension.

(2) Distribute rock within the embankment to prevent voids.

(3) Place lifts of embankment material around each rock to a depth not greater than allowed by Subsection 204.10(b). Fill voids between rocks.

(4) Compact each lift according to Subsection 204.11(a) before placing the next lift.

(c) Embankment outside of roadway prism. If placing embankment outside the staked roadway prism, place material in horizontal lifts less than 24 inches in compacted thickness. Compact each lift according to Subsection 204.11.

204.11 Compaction. For compaction, use AASHTO T 27 to determine the quantity of material retained on a No. 4 sieve. Compact each lift of material to a firm and stable condition and until there is no visible evidence of further consolidation or deflection. Compact as follows:

(a) More than 80 percent retained on a No. 4 sieve. Compact as follows:

(1) Adjust the moisture content to a level suitable for compaction.

(2) Fill the voids around rock with earth or other fine material as practical.

(3) Use compression-type rollers at speeds less than 6 feet per second and vibratory rollers at speeds less than 3 feet per second.

(4) Compact each lift of material full width with one of the following:

(a) 4 roller passes of a vibratory roller with a minimum centrifugal force of 40,000 pounds impact per vibration and a minimum frequency of 1000 vibrations per minute;

(b) 8 roller passes of a 20-ton compression-type roller; or

(c) 8 roller passes of a vibratory roller with a minimum centrifugal force of 30,000 pounds impact per vibration and a minimum frequency of 1000 vibrations per minute.

(5) Increase the compactive effort for lifts deeper than 12 inches as follows:

(a) For each additional 6 inches or fraction thereof, increase the number of roller passes in Subsection 204.11(a)(4)(a), by 4 passes; or

(b) For each additional 6 inches or fraction thereof, increase the number of roller passes in Subsection 204.11(a)(4)*(b)* and *(c)*, by 8 passes.

(b) 50 to 80 percent retained on a No. 4 sieve. Classify the material according to AASHTO M 145. Adjust the moisture content of material classified A-1 through A-5 to a moisture content suitable for compaction. Adjust the moisture content of material classified A-6 and A-7 to within 2 percent of the optimum moisture content. Use AASHTO T 99 to determine the optimum moisture content of the portion of the material passing a No. 4 sieve. Multiply this number by the percentage of material passing a No. 4 sieve and add 2 percent to determine the optimum moisture content of the material.

Use nonvibratory rollers at speeds less than 6 feet per second and vibratory rollers at speeds less than 3 feet per second. Compact each lift of material full width according to Subsection 204.11(a).

(c) Less than 50 percent retained on a No. 4 sieve. Classify the material according to AASHTO M 145. For material classified A-1 or A-2-4, determine the maximum density according to AASHTO T 180, Method D. For other material classifications, determine the optimum moisture content and maximum density according to AASHTO T 99, Method C. For material with more than 30 percent retained on the ¾-inch sieve, compact according to Subsection 204.11(a).

Adjust the moisture content of material classified A-1 through A-5 to a moisture content suitable for compaction. Adjust the moisture content of material classified A-6 and A-7 to within 2 percent of the optimum moisture content.

Use compression-type or vibratory rollers. Compact each lift of material full width to at least 95 percent of the maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

204.12 Ditches. Slope, grade, and shape ditches. Remove projecting roots, stumps, rock, and similar matter. Maintain ditches in an open condition and without debris.

Form furrow ditches by plowing or using other approved methods to produce a continuous furrow. Place excavated material on the downhill side so the bottom of the ditch is approximately 18 inches below the crest of the loose material. Clean the ditch using a hand shovel or other suitable method. Shape to provide drainage without overflow.

204.13 Sloping, Shaping, and Finishing. Complete slopes, ditches, culverts, riprap, and other underground minor structures before placing aggregate courses. Slope, shape, and finish as follows:

(a) Sloping. Leave earth slopes with uniform roughened surfaces, except as described in Subsection 204.13(b), with no noticeable break as viewed from the road. Except in solid rock, round tops and bottoms of slopes including the slopes of drainage ditches. Round material overlaying solid rock to the extent practical.

Remove loose or unstable rocks and dress all rock slopes as the excavation process progresses and slopes are still accessible to the equipment.

Do not round slopes in wetlands or other sensitive areas.

Do not place topsoil or mulch on slopes until approved. If a shallow landslide occurs on a cut or embankment slope, remove or replace the material and repair or restore damage to the work. Bench or key the slope to stabilize the slide. Reshape the cut or embankment slope to an acceptable condition.

(b) Shaping. Shape the subgrade to a smooth surface and to the cross-section required. Shape slopes to gradually transition into slope adjustments without noticeable breaks. At the ends of cuts and at intersections of cuts and embankments, adjust slopes in the horizontal and vertical planes to blend into each other or into the natural ground.

(c) Finishing. Remove material larger than 6 inches from the top 6 inches of the roadbed. Remove unsuitable material from the roadbed and replace it with suitable material.

Finish roadbeds and ditch cross-sections to within ±0.10 foot of the design or staked line and grade. Maintain proper ditch drainage.

204.14 Disposal of Unsuitable or Excess Material. Dispose of unsuitable or excess material according to Subsection 203.07.

If there is a pay item for waste, shape and compact the waste material in its final location. Do not mix clearing or other material not subject to payment with the waste material.

204.15 Acceptance. See Table 204-1 for sampling, testing, and acceptance requirements.

Material for embankment will be evaluated under Subsections 106.02 and 106.04.

Excavation and embankment construction will be evaluated under Subsections 106.02 and 106.04.

Subexcavation will be evaluated under Subsections 106.02 and 106.04.

Clearing will be evaluated under Section 201.

Crushed aggregate will be evaluated under Section 302.

Earthwork geosynthetics will be evaluated under Section 207.

Placing conserved topsoil will be evaluated under Section 624.

Removal of obstructions will be evaluated under Section 203.

Rock blasting will be evaluated under Section 205.

Measurement

204.16 Measure the Section 204 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

(a) Roadway excavation. Measure roadway excavation in its original position as follows:

(1) Include the following volumes in roadway excavation:

(a) Roadway prism excavation. Use the design volume. The design volume is defined as the bid schedule quantity less any allowance, as shown in the summary of quantities sheet in the plans. This volume is subject to adjustments resulting from changes to slope stakes according to Subsection 152.05(d);

(b) Rock material excavated and removed from below subgrade in cut sections;

(c) Unsuitable material below subgrade and unsuitable material beneath embankment areas, when a pay item for subexcavation is not listed in the bid schedule;

(d) Ditches, except furrow ditches measured under a separate pay item;

(e) Conserved topsoil stripped from cuts;

(f) Borrow material used in the work when a pay item for borrow is not listed in the bid schedule;

(g) Loose scattered rocks removed and placed as required within the roadway;

(h) Conserved material taken from pre-existing stockpiles and used in Section 204 work, except topsoil measured under Section 624; and

(i) Shallow landslide material not attributable to the Contractor's method of operation.

(2) Do not include the following in roadway excavation:

(a) Overburden and other spoil material from borrow sources;

(b) Overbreakage from the backslope in rock excavation;

(c) Water or other liquid material;

(d) Material used for purposes other than required;

(e) Roadbed material scarified in place and not removed;

(f) Material excavated while rounding cut slopes;

(g) Preparing foundations for embankment construction;

(h) Conserved topsoil stripped from fill;

(i) Material excavated while benching for embankments;

(j) Shallow landslide material attributable to the Contractor's method of operation;

(k) Conserved material taken from stockpiles constructed at the option of the Contractor;

(l) Material excavated outside the established slope limits;

(m) Pioneering for temporary roads outside of the proposed roadway prism; and

(n) Material removed during sloping, shaping, and finishing of rock slope excavations.

(3) If both roadway excavation and embankment construction pay items are listed in the bid schedule, measure roadway excavation only for the following:

(a) Unsuitable material below subgrade in cuts and unsuitable material beneath embankment areas if a pay item for subexcavation is not listed in the bid schedule;

(b) Shallow landslide material not attributable to the Contractor's method of operations; and

(c) Drainage ditches, channel changes, and diversion ditches.

(b) Unclassified borrow and select borrow. When measuring by the cubic yard, measure in its final position.

Measure borrow only after suitable roadway excavation is depleted.

(c) Embankment construction. Measure embankment construction in its final position. Do not make deductions from the embankment construction quantity for the volume of minor structures.

(1) Include the following volumes in embankment construction:

(a) Roadway prism embankments;

(b) Material used to backfill holes, pits, and other depressions;

(c) Material used to restore obliterated roadbeds to original contours; and

(d) Material used for dikes, ramps, mounds, and berms.

(2) Do not include the following in embankment construction:

(a) Preparing foundations for embankment construction;

(b) Adjustments for subsidence or settlement of the embankment or of the foundation on which the embankment is placed;

(c) Material used to round fill slopes; and

(d) Material used to backfill subexcavated areas.

(d) Rounding cut slopes. Measure rounding cut slopes horizontally along the centerline of the roadway.

(e) Waste. Measure waste by the cubic yard in its final position. Take initial cross-sections of the ground surface after stripping overburden. Upon completion of the waste placement, retake cross-sections before replacing overburden.

(f) Subexcavation. Measure subexcavation by the cubic yard in its original position.

Payment

204.17 The accepted quantities will be paid at the contract price per unit of measurement for the Section 204 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 204-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Unclassified borrow (704.01)	Measured & tested for conformance (106.04 & 105)	Classification(1)	–	AASHTO M 145	1 per soil type & source of material	Source of material	Yes	Before using in work	–
Select borrow (704.02)	Measured & tested for conformance (106.04 & 105)	Classification(1)	–	AASHTO M 145	1 per soil type & source of material	Source of material	Yes	Before using in work	–
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"	–
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–
Production									
Unclassified borrow (704.01)	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D(2) or T 99, Method C(2)	1 per soil type but not less than 1 per each 13,000 yd^3	Processed material	Yes	Before using in work	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 but not less than 1 per lift	In-place	No	Before placement of next lift	–

Table 204-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Select borrow (704.02)	Measured & tested for conformance (106.04)	Classification	–	AASHTO M 145	1 per soil type but not less than 1 per each day of production	Processed material	Yes	Before using in work	–
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"	–
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–
		Moisture-density	–	AASHTO T 180, Method D(2) or T 99, Method C(2)	1 per soil type but not less than 1 per each 13,000 yd^3	"	"	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 but not less than 1 per lift	In-place	No	Before placement of next lift	–

Table 204-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Earth embankment (204.11)	Measured & tested for conformance (106.04)	Classification	–	AASHTO M 145	1 per soil type	Source of material	Yes	Before using in work	–
		Moisture-density	–	AASHTO T 180, Method D(2) or T 99, Method C(2)	1 per soil type but not less than 1 per each 13,000 yd^3	"	"	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 but not less than 1 per lift	In-place	No	Before placement of next lift	–
Top of subgrade (204.11)	"	Density	–	AASHTO T 310 or other approved procedures	1 per 2500 yd^2 but not less than 1 per lift	In-place	No	Before placement of next lift	–
Finished Product									
Roadbed (204.13)	Measured & tested for conformance (106.04)	Final line & grade	–	Field measured	As directed	As directed	No	Before placement of next lift	–

(1) Not required if using Government-furnished source.
(2) At least 5 points per proctor.

Section 205. — ROCK BLASTING

Description

205.01 This work consists of rock fragmentation blasting using production and controlled blasting techniques to construct engineered rock cuts.

205.02 Definitions.

(a) Production blasting. Blasting using widely spaced blast holes that typically contain larger explosive charges to expedite movement and fragmentation for rock removal.

(b) Controlled blasting. Blasting that includes presplit blasting and cushion blasting hole techniques. Controlled blasting uses closely-spaced and carefully aligned blast holes that typically contain lighter charges than production holes to produce stable, aesthetically pleasing rock faces with minimal blast damage. Controlled blast holes are the first row of blast holes, normally located within 24 inches of the top of the staked slope.

(1) Presplit blasting. Presplit blasting detonates closely spaced backslope holes before drilling for production blasting or before detonating the production blasting holes to produce a highly controlled, smooth cut face.

(2) Cushion blasting. Cushion blasting is similar to presplitting, except that the detonation of the cushion holes along the backslope is detonated immediately after the detonation of the production and buffer holes, generally resulting in a more natural cut face appearance.

(c) Lift. For rock blasting, a lift is the vertical height of rock fragmented from a single blast.

(d) Mudcapping. The blasting of boulders by placing a quantity of explosives against a rock, boulder, or other object without confining the explosives in a drill hole.

(e) Blockholing. The breaking of boulders by firing a charge of explosives that has been loaded in a drill hole.

Construction Requirements

205.03 Regulations. Comply with Federal, state, and local rules and regulations for the purchase, transportation, storage, and use of explosive material. Federal regulations include the following:

(a) Safety and health. OSHA, CFR Title 29, Part 1926, Subpart U.

(b) Storage, security, and accountability. Bureau of Alcohol, Tobacco, and Firearms (ATF), CFR Title 27, Part 555, *Commerce in Explosives*.

(c) Shipment. DOT, CFR Title 49, Parts 171-179, 390-397.

(d) National Park Service. For projects in National Park Service lands, comply with National Park Service Director’s Order No. 65, *Explosives Use and Blasting Safety*.

205.04 Qualifications. At least 14 days before starting drilling and blasting work, submit the following for approval:

(a) Blaster-in-charge. Provide an individual to directly supervise the drilling and blasting crew during drilling, loading, and detonation of charges. Include the following:

(1) A résumé describing at least 5 years' experience as a blaster-in-charge on 3 projects with similar work, and provide a brief description of each project including the owner's name and contact information; and

(2) Copy of a valid blaster license accepted by the state where the project is located for the type of blasting required.

(b) Blasting crew personnel. Documentation that each blasting crew member has completed at least 24 hours of blasting safety training within the past 5 years or has at least 2 years' blasting experience along with proof of a Federal Employee Possessor Permit;

(c) Drillers. A résumé for each drill operator describing at least 1 year's experience as a driller; and

(d) Vibration specialist. A résumé describing at least 5 years' experience as a vibration specialist on projects with similar work.

205.05 Blasting Plans. Submit proof of applicable permits, licenses, and a general blasting plan signed by the blaster-in-charge at least 14 days before drilling and blasting operations. Blasting plans are not required for boulder reduction blasts (mudcapping or blockholing).

(a) General blasting plan. Submit a general blasting plan for review and approval. The CO will review and approve the General Blasting Plan within 7 days or return it for corrections. Include the following:

(1) Procedures and safety precautions for transporting, handling, storing, loading, and detonating explosives, conducting pre- and post-blast surveys, monitoring blasts, managing misfires, and removing and disposing of excess explosives.

(2) Explosives transportation and storage plan, including:

(a) Name, address, and telephone number of explosives suppliers;

(b) Description and license number of explosives transport vehicles, routes to be traveled, proposed hours of travel, and driver qualifications;

(c) Magazine and day-box locations;

(d) Explosives and accessories inventory system; and

(e) Contact information for the person responsible for security of project blasting material and supplies.

(3) Area security plan including explosives and general site security, methods of site communication, pre- and post-blast signage and audible signaling systems, road closure requirements, and pre-blast notification for affected agencies or entities.

(4) Manufacturer's technical and safety data sheets for proposed explosives, primers, initiators, and related blasting devices and accessories.

(5) Excavation plans and equipment lists for pre-blast dressing and access roads, and benches for drilling and blasting operations.

(6) Typical scaled plan and section views for both production and controlled blasting. Include the following:

(a) Stationing intended for each typical blast plan;

(b) Maximum blast length and free face;

(c) Hole spacing, hole inclination, hole depth, hole diameter, and burden;

(d) Stemming depth, decking method and materials (if required), and subdrill depth;

(e) Powder factor, charge weight per delay; and

(f) Initiation method, sequence, and delay times.

(7) Methods for limiting dust and noise.

(8) Fire watch plan including number of post-blast observers and duration of the fire watch.

(9) Contingency plan for blast flyrock containment, including a drawing and description of the proposed containment system designs.

Do not deliver explosives to the project until the general blasting plan is accepted. Submit revisions and updates within 48 hours of changes in the above information. Do not blast until revisions and updates to the general blasting plan are approved.

(b) Site-specific blasting plans and general plan revisions and updates. Submit site-specific blasting plans after approval of the general blasting plan or at times there is a change in drilling and blasting methods provided in the general blasting plan. Allow 3 days for approval. Do not start drilling until the plan is approved. Include the following:

(1) Proposed excavation sequence;

(2) Station limits and plan view of the proposed blast, showing how the proposed blast fits into the lift excavation sequence;

(3) Elevations of the tops and bottoms of each lift;

(4) Scaled drawings for each blast showing access, containment, plan and section views of drill patterns, clearing limits, free face, burden, blast hole locations, blast hole spacing, subdrill depths, lift height, blast hole diameters, and blast hole angles;

(5) Loading diagram for each blast showing powder factor, charge weight per delay, type and quantity of explosives, primers, initiators, locations of decking, and range of stemming depths for substantial variations within the drill pattern;

(6) Initiation method and sequence of blast holes for each blast. Include delay times, delay system, and downhole firing times;

(7) Flyrock, air-blast overpressure (noise), and ground vibration control measures;

(8) Estimated volume of in-place rock to be blasted. Include the total length of production and controlled blast hole;

(9) Location and orientation of significant joints, fractures, faulting, bedding planes or other rock mass structural features that affect the site-specific blasting plan;

(10) Post-blast rockfall containment designs and procedures; and

(11) If structures are within an area of ground vibration or air-blast overpressure concern, prepare an attenuation study with information for the affected structures. Develop a plot of peak particle velocity versus peak frequency according to the United States Department of the Interior, Bureau of Mines *Report of Investigation 8507* (RI 8507). From this plot, determine the values of peak particle velocity and peak frequency that will not damage each structure in the site-specific blast plan.

205.06 Pre-Blast Condition Survey and Vibration Monitoring and Control. The Contractor is responsible for damage resulting from blast related ground vibrations and air-blast overpressures. Determine the need for vibration monitoring depending on soil and rock conditions, blasting parameters as outlined in the blasting plan, and proximity of buildings, structures, utilities, and sensitive natural features that may be subject to damage from ground vibrations or air-blasts. If vibration monitoring is required, comply with the following requirements:

(a) If not specified in the contract, establish referenceable blasting criteria for buildings, structures, utilities, and natural features that conform to Federal, state, and local rules and regulations. Present blasting criteria in terms of distance of the facility or feature from blasting, maximum allowable peak particle velocity limits versus structure type, maximum allowable peak particle velocity and peak frequency as determined by RI 8507, and air overpressure structure damage limits.

(b) Conduct a pre-blast condition survey of nearby buildings, structures, utilities, and natural features potentially damaged by blasting-related ground vibrations or air-blast. Document the natural frequency of each affected structure or feature. Use a survey method acceptable to the Contractor’s insurance company. Submit a copy of pre-blast condition survey records with the site-specific blasting plans for CO review.

(c) If ground vibration or air-blast damage is possible, monitor each blast with digital recording seismographs and approved air-blast monitoring equipment calibrated within the last year. Locate monitoring equipment according to the directions of the vibration specialist. Place at least three recording stations between the blast area and closest susceptible structures, utilities, and immediately adjacent to natural features. Place one of the three recording stations on the critical structures. For ground vibration monitoring, use self-triggering seismographs that can measure peak air blast overpressure and record particle velocity, displacement, and acceleration for three mutually perpendicular components of vibration in the range generally found for controlled blasting. Provide instruments with internal calibration and triaxial orthogonal transducers with flat frequency response from 2 to 250 hertz with a sampling rate of at least 1000 data points per second with sufficient memory to store the full blasting sequence and their locations. Provide seismographs that can produce a permanent digital time history file for each ground motion episode.

(d) Control ground vibrations and air-blast overpressures with adjustments to delay sequences and maximum allowable charge weights per delay. Verify allowable charge weights per delay by conducting representative trial blasts and measuring ground vibrations and air-blast overpressure levels. Prepare an attenuation study that will enable prediction of the peak particle velocity in any component (longitudinal, transverse, or vertical) on the surface of all structures. Conduct test blasts with blast plan modifications that limit ground vibrations and air-blast overpressures to levels that will not cause damage to nearby buildings, structures, utilities, and or natural features as determined by the vibration specialist. Submit a copy of the attenuation study results and predicted maximum allowable peak particle velocity and peak frequency for each structure based on a plot of peak particle velocity versus peak frequency according to RI 8507.

(e) Record each blast using digital video equipment from two locations that clearly show the entire proposed blast site, preferably from locations on both sides or by unmanned aircraft system above the blast. Provide digital videos with sound, with a minimum 1080p resolution, and in a common file format for viewing.

(f) Ensure blasting operations incorporate collected data and findings from vibration monitoring by having the vibration specialist interpret seismograph and air-blast records.

(g) Submit a copy of the interpreted seismograph and air-blast records with a certifying signature by the vibration specialist. If actual peak particle velocity versus peak frequency measurements exceeds those predicted for a structure, adjust the site-specific blast plans for the actual structural response to the blasting.

205.07 Test Blasting. Before starting full-scale drilling and blasting, demonstrate adequacy of the site-specific blasting plan by drilling, blasting, and excavating a test blast up to 100 linear feet, as measured along the roadway centerline, with proposed containment measures in-place. Conduct the test blast at an approved location within the planned excavation area.

Space blast holes for presplit and cushion blasting no more than 30 inches apart for the initial test blast. Adjust the spacing based on the results of the test blasts for each excavation in differing geology as approved. Use the approved spacing in the full-scale blasting or subsequent test blasts if necessary.

A test blast is unacceptable if it results in excessive flyrock, potentially damaging ground vibrations or air-blasts, unplanned overbreak and backbreak, excessive damage to the final rock cut face, or results in unwanted overhangs. If a test blast is unacceptable, revise the site-specific blasting plan and conduct additional test blasts until the combination of blast hole pattern spacing, timing, controlled blast hole alignment, and charges produce acceptable results.

205.08 Blasting. Use explosives and initiating devices less than 1 year old. Locate explosives magazines at approved sites.

Inspect the pre-blast area and submit the proposed extent of pre-blast clearing and dressing for approval.

Blasting with angle-drilled or fan-drilled holes is only allowed during initial pioneering operations to establish access to the top of cut. Controlled blasting requirements are applicable to pioneering work.

Before drilling, remove overburden, soil, and loose or decomposed rock along the top of the excavation for a distance of at least 30 feet beyond the end of the production hole drilling limits, or to the end of the cut.

Record and maintain a log of each blast hole drilled identifying the depth, color, and character of the cuttings, penetration rate, hole collar location and hole orientation, loss of drilling air, groundwater, and other pertinent information. Before initiating the blast, prepare a blast plan map and submit it showing designated hole numbers along with individual hole logs completed, dated, and signed by the driller.

Ensure blast holes are free of obstructions for the entire depth before placing charges. Take necessary precautions when placing charges so caving of material from the walls of the holes and the hole collar will not occur.

Mitigate uncontrolled gas pressure loss during blasting and excessive blast noise by stemming the upper portion of blast holes with appropriate dry granular material passing the ½-inch sieve. Do not stem holes with drill cuttings or trash.

Blast according to the approved site-specific blasting plan. Use blasting mats, rockfall containment systems, and other protective devices to prevent damage to surrounding features.

(a) Production blasting. When conducting cushion blasting or presplitting, drill a lighter-loaded buffer row of production holes on a parallel plane adjacent to the controlled blast line to minimize blast damage to the final slope.

Drill production blast holes a maximum of 4 inches in diameter to a depth such that unbroken rock does not extend above the finish surface. Drill production blast holes to the design depth. If more than 5 percent of the production blast holes in a lift do not conform to the design depth requirements, redrill the shallow holes to the proper depth. Except when subdrilling, do not drill production blast holes below the base plane of the controlled blast holes.

Drill production blast holes within two drill hole diameters of the planned collar location. If more than 5 percent of the drill hole collars in a lift are out of tolerance, fill each hole outside of the location tolerance with crushed stone and redrill.

Detonate production holes in a controlled delay sequence.

(b) Controlled blasting. Use controlled blasting to form the final cut face on rock cuts where the staked slope ratio is 1⅓V:1H or steeper and the slope height is more than 10 feet above the ditch grade.

Use drilling equipment that accurately controls the angle of the drill as it enters the rock. Select a lift height and conduct drilling operations so the blast hole spacing and downhole alignment does not vary more than 8 inches from the proposed spacing and alignment. If more than 5 percent of the holes exceed the variance, reduce the lift height and modify drilling operations until the holes are within tolerance.

Drill holes a maximum of 3 inches in diameter and within 3 inches of the staked collar location. Fill and redrill blast holes outside of the location tolerance if more than 5 percent of the hole collars in a lift are outside of the location tolerance. Fill the blast holes with crushed stone before redrilling. Drill the controlled blast hole line at least 30 feet beyond loaded production holes or to the end of the cut.

Do not exceed 30 feet for bench height or drill hole length. Limit subdrilling of holes to one-half of the hole spacing or 24 inches, whichever is deeper.

Offset lifts up to 24 inches horizontally to allow for drill equipment clearance. Remove benches resulting from the drilling offset.

Compensate for drift that may occur in the upper lifts. Adjust the drill inclination angle or the initial drill collar location to obtain the required typical section. Limit drilling to one-half of the hole spacing or 24 inches, whichever is deeper.

Do not use bulk ammonium nitrate and fuel oil for controlled blasting. Only use standard explosives manufactured specifically for controlled blasting in controlled blast holes, unless approved.

For explosives in controlled blast holes use a maximum diameter no greater than one-half of the diameter of the presplit hole.

(c) Revising blasting plans. Stop drilling and blasting operations, and submit a revised site-specific blasting plan according to Subsection 205.05(b), if the following occur:

(1) Slopes are unstable;

(2) Slopes exceed overbreak tolerances within the limits of the excavation or as determined by the CO for the site geology;

(3) Unwanted overhangs, ridges, or ledges are created;

(4) Excessive blast damage occurs within the limits of the excavation or as determined by the CO;

(5) Poor fragmentation results in oversize material requiring secondary blasting and rehandling;

(6) Safety of the public is jeopardized;

(7) Property or natural features are endangered;

(8) Excessive or uncontrolled flyrock is generated;

(9) Excessive ground vibration or air-blast overpressure occurs where damage to buildings, structures, utilities, or natural features is possible; or

(10) Desired slope or rock face conditions are not produced.

Dress the cut face by removing or stabilizing cut face rock that is loose, hanging, or potentially dangerous after each blast. Dress the cut face by approved methods. Leave minor irregularities or surface variations in place if they do not create a hazard. Excavate and remove material outside the neat line slopes which is unstable and a potential hazard. Drill the next lift only after the slope stabilization and blast cleanup work is complete.

205.09 Reporting.

(a) Post-blast. Prepare a post-blast report. Submit the report within 3 days following a blast and before drilling for the next blast. Include the following:

(1) Results of the blast. Include overbreak, blast damage, noise levels, flyrock, drill trace retention, fragmentation, material containment, material rehandling requirements, and misfires;

(2) Proposed changes for future site-specific blasting plans that will produce acceptable results if blasting objectives were not met;

(3) Proposed repairs or stabilization plans for unstable or blast damaged backslopes;

(4) A detailed blasting plan modified to show significant changes in pattern, loading, or timing;

(5) Drilling logs for each hole completed (dated and signed by the driller) that identify the depth, color, and character of the cuttings. Include the penetration rate, hole collar location, hole orientation, and conditions that adversely affected drilling or explosives loading operations;

(6) Depth measurements of production and controlled blast holes;

(7) A drawing or sketch showing the direction of blast, the face, or faces, hole numbers, and the physical blast layout;

(8) Measurement of overbreak quantities following lift mucking;

(9) Date and time of loading and detonating the blast; and

(10) Name and signature of the blaster-in-charge.

(b) Monitoring. Submit copies of the digital videos after each blast. Do not continue drilling and blasting operations until the video has been received and reviewed by the CO. Allow 24 hours for review.

If vibration or air-blast monitoring is required, submit a vibration and air-blast report within 3 days following a blast and before drilling for further blasting. Do not drill until directed. Include the following:

(1) Type of vibration or air-blast recording station used and instrument identification numbers;

(2) Name of vibration specialist observing the blast and interpreting vibration and air-blast data;

(3) Blast identification number and location of blast;

(4) Distance and direction of ground vibration and air-blast overpressure recording stations from the blast area;

(5) Type of material the ground vibration recording stations were sitting on at the time of the blast;

(6) Maximum applicable charge weight per delay;

(7) Peak displacement, particle velocity, and frequency recorded at each ground vibration sensor location;

(8) Peak overpressure recorded at each air-blast sensor location;

(9) Dated and signed copy of instrument records;

(10) Post-blast condition survey noting changes from the pre-blast survey; and

(11) Comments on success of the blast in terms of adherence to established ground vibration or air-blast criteria and management practices.

If failing to meet ground vibration and air-blast criteria and management objectives, submit proposed changes to future site-specific blasting plans that will produce acceptable results.

(c) Close-out. Before demobilizing from the project site, submit a written statement signed by the blaster-in-charge certifying:

(1) Blast holes loaded with explosive material have been either detonated or unloaded and disposed of properly; and

(2) Blasting is complete and explosive material has been removed from the project site.

205.10 Acceptance. Material for rock blasting will be evaluated under Subsections 106.02 and 106.03.

Rock blasting will be evaluated under Subsections 106.02 and 106.04.

Measurement

205.11 Measure the Section 205 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring controlled blasting by the square foot, measure the face blast as shown in the blasting plan.

When measuring controlled blast holes by the linear foot, measure the actual length of drilling recorded in the post-blast reports. Controlled blast holes include the row of holes lying closest to the trim line.

Do not measure presplit blast holes with more than 8-inch misalignment.

Do not measure production blast holes.

Do not measure dressing of the cut face rock.

Payment

205.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 205 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 206. — RESERVED

Section 207. — EARTHWORK GEOSYNTHETICS

Description

207.01 This work consists of providing and installing geotextile in separation, stabilization, filter, and reinforcement applications, geogrid in stabilization and reinforcement applications, and geomembranes in moisture barrier applications.

Material

207.02 Conform to the following Subsections:

Geomembranes	714.05
Geotextile	714.01
Reinforcement geotextile and geogrid	714.04
Stabilization geogrid	714.03

Construction Requirements

207.03 General. Identify, store, and handle geosynthetics according to ASTM D4873 and the manufacturer's recommendations. Elevate and protect geosynthetic rolls with a waterproof cover if stored outdoors. Maintain product identification labels in a visible location on the inside of the core. Limit geosynthetics exposure to less than 10 days of ultraviolet radiation.

Unless otherwise specified, overlap geosynthetics in the direction, sequence, and distance according to the manufacturer's recommendations.

For seams sewn on site, comply with the manufacturer's recommendations. Obtain approval of the seam before installation. Use thread consisting of high strength polypropylene or polyester. Do not use nylon thread. Use thread that is resistant to ultraviolet radiation and a contrasting color to the geotextile.

If geosynthetic joints are field constructed, submit an installation plan according to Subsection 104.06 at least 14 days before installation that includes proposed equipment, the QCP, and the following:

(a) Assembly description. Include the seam type, seam allowance, stitch type, sewing thread tex ticket numbers and types, stitch density, and stitch gauge;

(b) Proposed panel layout drawing. Show seam and overlap locations; and

(c) Sewn seam samples. Sew seam samples using the same equipment and procedures used to sew production seams. Submit samples that have at least 6 feet of sewn seam and are at least 5 feet wide. If production seams are sewn in both the machine and cross-machine directions, provide sewn seam samples that are oriented in both the machine and cross-machine directions.

Replace or repair geosynthetic that is torn or punctured according to the manufacturer's recommendations.

207.04 Geotextile and Geogrid in Separation and Stabilization Applications.

(a) Surface preparation. Before placing the geotextile remove sharp objects and large rocks. Fill depressions or holes with suitable material to provide a smooth surface. Prepare the surface as follows:

(1) Existing ground. Cut trees and shrubs flush with the ground surface. Clear the area of vegetation and obstructions according to Sections 201 and 203.

(2) Subgrade. Prepare the subgrade according to Subsections 204.13(b) and (c).

(3) Subexcavation. Perform subexcavation according to Subsection 204.07.

(b) Geotextile or geogrid placement. Place geogrid on top of geotextile if both are shown at the same elevation in the plans. Place the geosynthetic smooth, taut, and wrinkle free on the underlying surface. Conform to curves. Overlap in the direction of construction. Overlap at least 24 inches at the ends and sides of adjoining sheets or sew the joints according to the approved installation plan. Do not place longitudinal overlaps below anticipated wheel paths. Hold the geosynthetic in place with pins, staples, or piles of cover material.

(c) Backfilling.

(1) First lift placement and compaction. Place the specified backfill onto the geotextile or geogrid from the edge of the geosynthetic or from previously placed cover material. Do not operate equipment directly on the geosynthetic. Spread the pile of cover material maintaining a minimum 6-inch lift over the geosynthetic. Avoid sudden stops, starts, or turns of the construction equipment. Fill ruts from construction equipment with additional cover material. Do not blade material down to remove ruts. If rutting exceeds 3 inches during placement, decrease the construction equipment size, decrease the equipment weight, or increase the first lift thickness as directed.

Compact according to Subsection 204.11. Do not use sheepsfoot or studded compaction equipment. Compact the cover material with pneumatic-tire or nonvibratory smooth drum rollers.

(2) Subsequent lift placement and compaction. Place subsequent lifts according to Subsection 204.10.

Compact according to Subsection 204.11. Vibratory rollers may be used unless pumping or foundation failures occur. Repair damaged areas and then use only nonvibratory rollers.

207.05 Geotextile Filter Applications.

(a) Surface preparation. Before placing the geotextile remove sharp objects and large rocks. Fill depressions or holes with suitable material to provide a smooth surface. Prepare the surface as follows:

(1) Existing ground. Cut trees and shrubs flush with the ground surface. Clear the area of vegetation and obstructions according to Sections 201 and 203.

(2) Subgrade. Prepare the subgrade according to Subsections 204.13(b) and (c).

(3) Subexcavation. Perform subexcavation according to Subsection 204.07.

(b) Geotextile placement. For slope or wave protection, place the long dimension of the geotextile down the slope. For stream bank protection, place the long dimension of the geotextile parallel to the centerline of the channel.

Overlap or sew seams at the ends and sides of adjoining sheets.

(1) Overlapping. Overlap the uphill or upstream sheet over the downhill or downstream sheet. For above water applications, overlap the geotextile at least 12 inches. For underwater applications, overlap the geotextile at least 36 inches.

(2) Sewing. Sew the geotextile seam according to the approved installation plan.

Offset end joints of adjacent sheets at least 5 feet. Use key trenches or aprons at the crest and toe of slopes to hold the geotextile in place. As an alternative use anchor pins, at least 18 inches long and spaced at 36 inches on centers to hold the geotextile sheets in place.

(c) Backfilling. Place aggregate, slope protection, or riprap on the geotextile starting at the toe of the slope and proceeding upward. Place riprap onto the geotextile from a height of less than 12 inches. Place slope protection rock or aggregate backfill onto the geotextile from a height less than 36 inches. Do not allow stones weighing more than 100 pounds to roll down the slope. In underwater applications, place the geotextile and cover material in the same day.

207.06 Geotextile and Geogrid Reinforcement Applications. For MSE retaining walls and reinforced soil slopes, place reinforcement geosynthetics according to Section 255 or 261, as applicable. For deep patch and other reinforcement geosynthetic applications, perform the work as follows:

(a) Surface preparation. Perform subexcavation according to Section 204. Provide a smooth, flat, and firm foundation for the geosynthetic.

(b) Geosynthetic placement. Place the reinforcement geosynthetic with the higher strength direction oriented perpendicular to the road centerline or slope face, as shown in the plans. Place the geosynthetic smooth, taut, and wrinkle free on the underlying surface. Conform to curves. Overlap 24 inches for biaxial geosynthetics in the direction of construction. For uniaxial geogrids, do not splice in the high strength direction, and abut adjacent sheets of geogrid. Hold the geosynthetic in place with pins, staples, or piles of cover material.

(c) Backfilling. Place the specified material onto the geosynthetic from the edge of the geosynthetic or from previously placed cover material. Do not operate equipment directly on the geosynthetic. Spread the material maintaining a minimum 6-inch lift over the geosynthetic before operating equipment over the geosynthetic. Avoid sudden stops, starts, or turns of the construction equipment. Fill ruts from construction equipment with additional cover material. Do not blade material down to remove ruts. If rutting exceeds 3 inches during placement, decrease the construction equipment size, decrease the equipment weight, or increase the first lift thickness as directed.

Compact according to Subsection 204.11. Do not use sheepsfoot or studded compaction equipment. Compact from the face of slope or wall towards the back of the reinforcement.

207.07 Geomembrane Applications. Conduct a preparatory phase meeting at least 7 days before start of geomembrane installation according to Subsection 153.06(a). Discuss details of the approved submittal according to Subsection 207.03 and observe performance of seam test strips.

(a) Surface preparation. Provide a smooth, flat, firm, unyielding foundation for the geomembrane with no sudden, sharp, or abrupt changes or break in grade. Remove rocks, stones, sticks, sharp objects, and debris protruding more than ½ inch above the prepared surface.

(b) Geomembrane placement. Orient seams parallel to the line of maximum slope. Use sandbags or piles of cover material to hold the geomembrane in place. Do not drive equipment directly on the geomembrane.

(c) Backfilling. Place the specified backfill within the same work shift that the geomembrane is installed or place enough cover material to keep the geomembrane in place to resist thermal shrinking, expansion, and other deformations. Place backfill onto the edge of previously placed cover material and roll it into place. Do not push material along the geomembrane which can result in damage, stretching, or wrinkling.

207.08 Acceptance. Geosynthetics will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of geosynthetics.

Geosynthetic installation will be evaluated under Subsections 106.02 and 106.04.

Sewn joints will be evaluated under Subsection 106.02.

Clearing will be evaluated under Section 201.

Removal of obstructions will be evaluated under Section 203.

Subgrade preparation and subexcavation will be evaluated under Section 204.

Measurement

207.09 Measure the Section 207 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring geosynthetics by the square yard, measure each individual layer on a plane parallel to the slope face. Do not measure return wraps at edges of the reinforced areas.

Payment

207.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 207 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 208. — STRUCTURE EXCAVATION AND BACKFILL FOR SELECTED MAJOR STRUCTURES

Description

208.01 This work consists of excavating material for the construction of selected structures. This work also includes preserving channels, shoring and bracing, constructing cofferdams, sealing foundations, dewatering, preparing foundations, backfilling, and removal of safety features and cofferdams.

Material

208.02 Conform to the following Subsections:

Neat hydraulic cement grout	701.04(a)(2)
Soil and soil-aggregate materials	704.01

Construction Requirements

208.03 General. Slope the sides of excavations, use shoring and bracing, and use other safety features according to OSHA safety standards 29 CFR, Part 1926, Subpart P, Excavations. If sides of excavations are sloped for safety considerations, submit one copy of the design that demonstrates compliance with OSHA standards. If support systems, shield systems, or other protective systems are used, design the shoring according to Section 562. Submit drawings and construction details according to Subsection 104.06.

Clear the area of vegetation and obstructions according to Sections 201 and 203.

Saw cut existing pavements or concrete structures adjacent to the area to be excavated that are designated to remain.

Where necessary, blast rock according to Section 205.

Conserve suitable material for structural backfill from excavated material. Do not deposit excavated material in or near a waterway. From the edge of the excavation, do not stockpile excavated material or allow equipment closer than specified in OSHA safety standards 29 CFR, Part 1926, Subpart P, Excavations. Use suitable material in embankment construction if approved. Dispose of unsuitable or excess material according to Subsection 204.14.

Remove safety features when no longer necessary. Remove shoring and bracing to at least 48 inches below the surface of the finished ground.

208.04 Channel Preservation. Perform work in or next to waters as follows:

(a) Excavate and conserve material inside cofferdams, sheeting, or other separations (such as dikes or sandbags).

(b) Do not disturb the natural bed of the waters adjacent to the work.

(c) Backfill the excavation to original ground-line with conserved material.

208.05 Cofferdams. Use cofferdams when excavating under water or when the excavation is affected by groundwater.

Submit drawings showing proposed methods and construction details of cofferdams according to Subsection 104.06 and Section 562. Design and construct cofferdams that conform to the following:

(a) Extend below the bottom of the footing;

(b) Brace to withstand pressure without buckling and secured in place to prevent tipping or movement;

(c) Construct as watertight as practical;

(d) Provide sufficient clearance for the placement of forms and the inspection of their exteriors;

(e) Provide for dewatering;

(f) Protect fresh concrete from damage; and

(g) Prevent damage to the foundation by erosion.

Remove cofferdam material down to the natural bed of the waterway or to the top of seal, whichever is lower. Remove cofferdam material outside the waterway to at least 48 inches below the surface of the finished ground.

208.06 Foundation Seal. Seal the foundation area from water by placing Class S (Seal) concrete if the area cannot be pumped reasonably free of water.

Provide and place Class S (Seal) concrete according to Section 552. Maintain the water level inside the cofferdam at the same level as the water outside the cofferdam while placing a foundation seal. Vent or port the cofferdam at low water level when a foundation seal is placed in tidal water.

Do not dewater a concrete-sealed cofferdam until the Class S (Seal) concrete strength is sufficient to withstand the hydrostatic pressure.

208.07 Dewatering. Remove and dispose of water according to Federal, state, and local rules and regulations.

208.08 Foundation Preparation and Approval. Provide a firm foundation of uniform density throughout its length and width. Obtain CO approval of the foundation when the excavation is complete.

Prepare foundations as follows:

(a) Footings placed on bedrock. Excavate to the specified elevation. Clean the foundation surface of deleterious material. Clean and grout seams and crevices greater than ½ inch wide. Where needed to backfill over-excavations or over-break areas, place flowable backfill or structural concrete (Class A) to provide a level bearing pad for footing as directed. Do not place soil or aggregate backfill under the footing unless approved for the design bearing resistance.

(b) Footings placed on an excavated surface other than bedrock. Excavate material to foundation grade and compact the foundation before footing is placed.

(c) Footings keyed into undisturbed material. Excavate the foundation to the limits of the footing and compact the foundation. Where material does not stand vertically, fill the space between the limits of the bottom of footing and the undisturbed material with structural concrete (Class A). Fill only to the top of the excavation if the excavation is below the top of the footing. Concrete placed against steel sheet piles in cofferdams is considered as being against undisturbed material.

(d) Unstable material below footing elevation. Excavate unstable material below foundation grade as directed and backfill with foundation fill. Place foundation fill in horizontal lifts that do not exceed 6 inches in compacted thickness. Compact each lift according to Subsection 208.10.

(e) Foundations using piles. If foundation seals are required, drive the piles before placing Class S (Seal) concrete unless otherwise specified. Remove loose and displaced material and reshape the bottom of the excavation to the foundation elevation. Grade and compact the bed to receive the footing.

208.09 Backfill. Place structural backfill in horizontal lifts that do not exceed 6 inches in compacted thickness. Compact each lift according to Subsection 208.10.

Place structural backfill lifts evenly on all sides of the structure as appropriate. Extend each lift to the limits of the excavation or to natural ground.

Do not place structural backfill against concrete until 80 percent of the design strength is attained.

Backfill in or next to a running waterway according to Subsection 208.04.

208.10 Compacting. Determine optimum moisture content and maximum dry density according to AASHTO T 99, Method C. Adjust the moisture content of the backfill to a moisture content suitable for compaction.

Compact material placed in each lift to at least 95 percent of the maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

Do not apply density requirements as measured by AASHTO T 310 to material that cannot be tested or compacted to maximum values determined by AASHTO T 99. For this material, fill the voids around the rocky material in each lift with structural backfill or foundation fill as appropriate. Compact each lift until there is no visible evidence of further consolidation.

208.11 Acceptance. See Table 208-1 for sampling, testing, and acceptance requirements.

Material for grout will be evaluated under Subsections 106.02 and 106.03.

Material for structural backfill and foundation fill will be evaluated under Subsections 106.02 and 106.04.

Grout will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill work will be evaluated under Subsections 106.02 and 106.04.

Clearing will be evaluated under Section 201.

Concrete will be evaluated under Section 552.

Flowable backfill will be evaluated under Section 614.

Removal of obstructions will be evaluated under Section 203.

Rock blasting will be evaluated under Section 205.

Temporary works will be evaluated under Section 562.

Measurement

208.12 Measure the Section 208 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring structural excavation by the cubic yard in its original position, do not include the following volumes:

(a) Material excavated outside the vertical planes located 18 inches outside and parallel to the limits of the footings or foundations;

(b) Material included within the staked limits of the excavation (such as contiguous channel changes and ditches) for which measurement is covered under other Sections;

(c) Water or other liquid material;

(d) Material excavated before measurement of the original ground;

(e) Material re-handled, except when the contract specifically requires excavation after embankment placement; or

(f) Excavation for cofferdam seals.

When measuring foundation fill and structural backfill by the cubic yard in place, measure the volume placed inside the vertical planes located 18 inches outside and parallel to the limits of the footings or foundations.

Payment

208.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 208 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for structure excavation, shoring and bracing, and cofferdams will be full compensation for excavation to a depth of 6 feet below the lowest elevation shown in the plans for each foundation structure. When the excavation exceeds 6 feet, either the Contractor or the CO may request an equitable price adjustment for the depth in excess of 6 feet.

(a) Progress payments for dewatering by the lump sum will be paid as follows:

(1) 25 percent of the pay item amount, no more than 0.5 percent of the original contract amount, will be paid at the start of dewatering operations.

(2) The remaining portion of the pay item amount will be prorated based on the structural excavation work completed.

(b) Progress payments for shoring and bracing by the lump sum will be paid as follows:

(1) 25 percent of the pay item amount will be paid after the design submittal is approved.

(2) An additional 25 percent of the pay item will be paid after 50 percent of the shoring and bracing work is completed.

(3) The remaining portion of the pay item amount will be paid after structural excavation work is completed and shoring and bracing material is removed.

(c) Progress payments for cofferdam by the lump sum will be paid as follows:

(1) 25 percent of the pay item amount will be paid after the design submittal is approved.

(2) An additional 25 percent of the pay item will be paid after 50 percent of the cofferdam work is completed.

(3) The remaining portion of the pay item amount will be paid after structural excavation work is completed and cofferdam material is removed.

Table 208-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Foundation fill[(1)] (704.01)	Measured & tested for conformance (106.04 & 105)	Classification	–	AASHTO M 145	1 per soil type	Source of material	Yes	Before using in work	–
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"	–
Structural backfill[(1)] (704.01)	"	Plasticity index	–	AASHTO R 58, T 89, & T 90	"	"	"	"	–
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"	–
Production									
Foundation fill (704.01)	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C[(2)]	1 per soil type	Source of material	Yes	Before using in work	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 300 yd^3	In place	No	Before placing next lift	–
Structural backfill (704.01)	"	Moisture-density	–	AASHTO T 99, Method C[(2)]	1 per soil type	Source of material	Yes	Before using in work	–
		Density	–	AASHTO T 310 or other approved procedures	2 per lift	In place	No	Before placing next lift	–

(1) Not required when using Government-furnished source.
(2) At least 5 points per proctor.

Section 209. — STRUCTURE EXCAVATION AND BACKFILL

Description

209.01 This work consists of excavating material for the construction of structures, except those specifically designated under Section 208. This work also includes preserving channels, shoring, and bracing, sealing foundations, dewatering, preparing foundations, bedding, and backfilling.

Material

209.02 Conform to the following Subsection:

Soil and soil-aggregate materials	704.01

Construction Requirements

209.03 General. Clear the area of vegetation and obstructions according to Sections 201 and 203.

Excavate trenches or foundation pits according to Subsection 208.03. Excavate to foundation grade without disturbing the trench or foundation surface. Foundation grade is the elevation at the bottom of the bedding for installing the structure.

209.04 Channel Preservation. Preserve channels according to Subsection 208.04.

209.05 Foundation Seal. If foundation seals are necessary, construct a foundation seal according to Subsection 208.06.

209.06 Dewatering. If dewatering is necessary, dewater according to Subsection 208.07.

209.07 Foundation Preparation. Excavate unsuitable material if encountered at foundation grade as directed.

If a footing is required to be keyed into undisturbed material, prepare foundation and construct footing according to Subsection 208.08(c).

Backfill and compact with foundation fill according to Subsection 208.08(d).

209.08 Bedding for Pipe Culverts. Level the foundation. Place uncompacted bedding material over the foundation in a layer of uniform thickness. Lay 4 inches of bedding for pipes with diameters of 12 to 54 inches. Lay 6 inches of bedding for pipe with diameters larger than 54 inches. Recess the bedding to receive the joints for pipes with belled joints. Place the culvert on the uncompacted bedding layer and backfill according to Subsection 209.09(b).

209.09 Backfill. Backfill as follows:

(a) General. Place backfill lifts evenly on all sides of the structure. Extend each lift to the limits of the excavation or natural ground.

Place backfill in compacted lifts no more than 6 inches in thickness. When using flowable backfill, backfill according to Section 614.

Do not place backfill against concrete until 80 percent of the design strength is attained.

Compact each lift according to Subsection 208.10.

(b) Pipe culverts. Backfill according to one of the following:

(1) Pipe culverts. Place and compact common backfill or plastic pipe backfill in evenly balanced lifts on each side of the pipe to a height of 12 inches above the top of the pipe culvert.

Complete backfilling to the top of the trench. Place and compact common backfill or plastic pipe backfill in the trench in lifts no more than 6 inches in thickness according to Subsection 209.10.

(2) Pipe culverts with flowable backfill. Place and anchor pipe to prevent floating and movement. Backfill using flowable backfill according to Section 614.

(c) Box culverts and structures other than pipe culverts. Place and grade common backfill in compacted lifts no more than 6 inches in thickness. Compact each lift according to Subsection 208.10.

(d) Structural plate structures. Place and compact common backfill to a height of 12 inches above the top of the structural plate structure. If applicable, complete backfilling and compacting according to Subsection 204.10.

(e) Repair existing pavement areas. Conform to Subsection 418.04.

209.10 Compacting. Determine optimum moisture content and maximum dry density according to AASHTO T 99, Method C. Adjust the moisture content of the backfill to a moisture content suitable for compaction.

Compact material placed in each lift to at least 95 percent of the maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

Do not apply density requirements as measured by AASHTO T 310 to material that cannot be tested or compacted to maximum values determined by AASHTO T 99. For this material, fill the voids around the rocky material in each lift with structural backfill or foundation fill as appropriate. Compact each lift until there is no visible evidence of further consolidation.

209.11 Acceptance. See Table 209-1 for sampling, testing, and acceptance requirements.

Material for common backfill, bedding material, plastic pipe backfill, and foundation fill will be evaluated under Subsections 106.02 and 106.04, except flowable backfill for bedding or backfill will be evaluated under Section 614.

Shoring and bracing will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill work will be evaluated under Subsections 106.02 and 106.04.

Clearing will be evaluated under Section 201.

Removal of obstructions will be evaluated under Section 203.

Measurement and Payment

209.12 Do not measure structure excavation and backfill for payment. See Subsection 109.05.

Table 209-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Foundation fill, bedding material, common backfill, plastic pipe backfill(1) (704.01)	Measured & tested for conformance (106.04 & 105)	Classification	–	AASHTO M 145	1 per soil type	Source of material	Yes	Before using in work	–
		Gradation	–	AASHTO T 27 & T 11	"	"	"	"	–
Production									
Foundation fill, bedding material, common backfill, plastic pipe backfill (704.01)	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C(2)	1 per soil type	Source of material	Yes	Before using in work	–
		Density	–	AASHTO T 310 or other approved procedures	2 per lift(3)	In-place	No	Before placing next lift	–

(1) Not required if using Government-furnished source.
(2) At least 5 points per proctor.
(3) When installing culvert pipe the backfill placed on both sides of the pipe is considered to be contained in the same lift when the material is placed to the same elevation on both sides of the culvert, the compactive effort applied to one side of the culvert is the same as that applied to the other, and the compactive effort is applied to both sides of the pipe during a single work operation.

Section 210. — RESERVED

Section 211. — ROADWAY OBLITERATION

Description

211.01 This work consists of obliterating or closing roadways and areas outside the roadway prism.

Construction Requirements

211.02 Roadway Obliteration Methods.

(a) Method 1. Obliterate the roadway by restoring to approximate original ground contours. Keep excavated material within the original construction limits. Finish slopes to provide gradual transitions in slope adjustments without noticeable breaks.

(b) Method 2. Close roads by filling ditches and outsloping the roadbed to drain. Remove and slope embankment material at localized drainages to restore the natural drainage patterns. Eliminate ruts and low spots that could hold water.

211.03 Material Handling.

(a) Rigid material. Remove rigid material according to Section 203. Dispose of material according to Federal, state, and local rules and regulations.

(b) Nonrigid material.

(1) Nonasphalt material. Scarify or rip the gravel, crushed stone, or other nonrigid surface, base, and subbase material. Mix the scarified or ripped material with the underlying soil. Bury the mixture under at least 12 inches of onsite soil.

(2) Asphalt contaminated material. Dispose of asphalt contaminated material according to Subsection 203.07.

211.04 Waterbars and Barriers. Construct waterbars as shown in the plans. Construct barriers to prevent vehicle access as shown in the plans.

211.05 Acceptance. Roadway obliteration will be evaluated under Subsection 106.02.

Removal of obstructions will be evaluated under Section 203.

Measurement

211.06 Measure the Section 211 pay items listed in the bid schedule according to Subsection 109.02.

Payment

211.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 211 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 212. — LINEAR AND SITE GRADING

Description

212.01 This work consists of performing linear and site grading at designated locations within specified tolerances.

212.02 Definitions.

(a) Linear grading. Consists of constructing and grading roadways on a designated alignment.

(b) Site grading. Consists of constructing and grading designated areas outside the roadway prism.

Construction Requirements

212.03 Roadway and Site Preparation. Clear the area of vegetation and obstructions according to Sections 201 and 203.

212.04 Excavation and Embankment. Construct the roadbeds and sites according to the applicable requirements of Section 204, except as modified in this Section.

Adjust the moisture content of embankment material to a moisture content suitable for compaction. Place embankment material in 12-inch lifts and compact each lift according to Subsection 204.11(a). If compacting with rollers is not practical, use approved mechanical or vibratory compaction equipment.

Construct approach connections to existing roads, parking areas, and trails as directed.

Do not make alignment or profile grade adjustments that adversely affect drainage.

212.05 Grading Tolerance. Construct roadbeds and sites within the following grading tolerances:

(a) Linear grading.

(1) Alignment (centerline). Alignment may be shifted a maximum of 10 feet left or right of the planned centerline. Curve radii may be reduced by up to 50 percent. Do not construct curves with radii less than 100 feet. Compound curves are allowed.

(2) Profile grade. Profile grade may be shifted a maximum of 5 feet from the plan elevation provided the new grade tangent does not vary more than 2 percent from the plan grade tangent. Connect revised forward and back grade tangents with a uniform vertical curve consistent with the design.

(b) Site grading. The footprint may be shifted a maximum of 10 feet in any direction. The profile of the site may be adjusted a maximum of 2 feet from the plan elevation.

212.06 Acceptance. Linear and site grading work will be evaluated under Subsections 106.02 and 106.04.

Clearing will be evaluated under Section 201.

Removal of obstructions will be evaluated under Section 203.

Measurement

212.07 Measure the Section 212 pay items listed in the bid schedule according to Subsection 109.02.

Payment

212.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 212 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 213. — SUBGRADE STABILIZATION

Description

213.01 This work consists of processing and incorporating stabilizing additives into the upper layer of subgrade.

Material

213.02 Conform to the following Subsections:

Chemical admixtures	711.03
Fly ash	701.03(a)
Hydraulic cement	701.01
Lime for soil stabilization	725.03(b)
Water for construction	725.01(c)

Construction Requirements

213.03 Proportioning. Submit a subgrade stabilization mix design at least 30 days before production. Include compressive strength values for at least three application rates with at least one application rate above and one below the strength shown in Table 213-1.

Table 213-1
Subgrade Stabilization Compressive Strength Requirements

Stabilization Mixture	Test Procedure	Average Unconfined Compressive Strength (3 specimens minimum)
Lime-Soil	ASTM D5102, Procedure B	100 psi minimum(1)
Lime-Fly ash-Soil	ASTM D5102, Procedure B	150 psi minimum(1)
Cement-Soil, Cement-Fly ash-Soil, or Fly ash-Soil	ASTM D1633, Method A	200 psi minimum(2)

(1) At 7-day cure at 105 °F.
(2) At 7-day cure.

Include the following with the mix design as applicable:

(a) Source of each component material;

(b) Results of the applicable tests including optimum moisture content (after treatment), hydration moisture rate, maximum dry density (after treatment), Atterberg limits (before and after treatment), and recommended application rates of stabilizing material; and

(c) If requested:

(1) 200-pound sample of the subgrade soil;

(2) 25-pound sample of the fly ash;

(3) 25-pound sample of the lime;

(4) 25-pound sample of the cement; and

(5) 2-pound sample of each chemical admixture.

Start production after the mix design is approved. Provide a new mix design if there is a material source change.

213.04 Production Start-Up Procedures. Conduct a pre-stabilization preparatory phase meeting at least 7 days before the start of stabilizing operations according to Subsection 153.06(a).

Notify the CO at least 7 days before starting operations.

213.05 General. Store stabilizing additives and chemical admixtures in closed, weatherproof containers.

Recondition the subgrade according to Subsection 303.06. Scarify or pulverize the subgrade to the required depth. Use a rotary mixer with direct water injection capabilities to adequately blend the material and to produce a homogeneous mixture within 2 percent of the optimum moisture content.

At the end of each production day, shape the subgrade surface to provide positive drainage. Provide a construction joint according to Subsection 305.11 for tying into existing stabilized subgrade.

213.06 Application. Do not apply stabilizing additives when weather conditions cause excessive material loss or when the air temperature may fall below 32 °F within 48 hours. Apply stabilizing additives when the prepared subgrade surface temperature is at least 40 °F.

Adjust the subgrade material moisture content to 2 to 3 percent above optimum.

Apply fly ash by the dry method. Apply lime and cement by either the dry or slurry method.

(a) Dry method. Uniformly apply the stabilizers using an approved metered spreader. Apply water using approved methods to obtain the proper moisture content for mixing and compaction. If quicklime and fly ash are pre-blended, limit the maximum particle size of the quicklime to ⅛ inch to avoid segregation.

(b) Slurry method. Mix material with water. Report the percent solids in the slurry to the CO for each production day. Apply the slurry using either trucks with approved distributors or rotary mixers. Equip the distributor truck or rotary mixer tank with an agitator to keep the stabilizers suspended in water. Make successive passes over the material to obtain the proper moisture and additive content.

213.07 Mixing. Keep traffic, except mixing equipment, off the spread material. Use a rotary mixer.

(a) Lime mixtures.

(1) Preliminary mixing. Adjust the moisture content of the mixture to optimum plus necessary hydration moisture. Use the mix design hydration moisture rate. Thoroughly mix the lime, soil, and water to obtain a homogeneous friable mixture. Complete the mixing on the same day lime is applied. Check to ensure lime is fully hydrated and add additional water if necessary.

Mellow the mixture for 1 to 4 days at a moisture content of 2 to 3 percent above optimum as directed.

(2) Final mixing. Remix until 95 percent of the mixture, except hard and durable particles, passes a 1½-inch sieve and at least 50 percent of the soil portion of the mixture passes a No. 4 sieve when tested according to AASHTO T 27 in the non-dried condition.

(b) Lime/fly ash mixtures. Mix according to Subsection 213.07(a)(1). Use either a pre-blended lime/fly ash mixture or mix the lime and fly ash in separate operations.

If the lime and fly ash are mixed separately, mix the lime first and mix the fly ash within 2 days of lime mixing. Adjust the moisture content of the lime/fly ash mixture to 2 to 3 percent above optimum. Mix the material to prevent formation of fly ash balls. Complete the mixing within 2 hours after adding the fly ash.

(c) Cement, fly ash, or cement/fly ash mixtures. Add water to adjust the moisture content of the mixture to 2 to 3 percent above optimum. Mix the material until 95 percent of the mixture, except hard and durable particles, passes a 1½-inch sieve and at least 50 percent of the soil portion of the mixture passes a No. 4 sieve when tested according to AASHTO T 27 in the non-dried condition. Complete the mixing within 2 hours after the cement, fly ash, or both are added.

213.08 Compacting and Finishing. Immediately after final mixing, spread and compact the mixture. Use a vibratory sheepsfoot roller to achieve compaction. Use pneumatic-tire and steel drum rollers for finish rolling.

Compact the mixture to at least 95 percent of maximum dry density from the approved mix design. Complete compaction operations within 2 hours of completion of mixing.

Finish the compacted subgrade to within ±0.10 foot of the staked line, grade, and cross-section. Check the surface with a 10-foot metal straightedge.

Add or remove material to correct surface deviations more than ¾ inch in 10 feet between two contacts of the straightedge with the surface. When adding material, scarify the subgrade to at least 6 inches. Remix according to Subsection 213.07 and recompact the area to restore the required density and strength.

213.09 Curing. Keep the subgrade continuously moist and within 3 percent of optimum moisture content until the next course is placed. Apply water under pressure through a spray bar equipped with nozzles, which produce a fine, uniform spray. Place the next course within 14 days after compacting and finishing. If the subgrade deforms, loses density, or ravels before placement of the next course; correct the damaged subgrade.

Traffic may be allowed on the stabilized subgrade 24 hours after compaction and finishing if approved.

213.10 Acceptance. See Table 213-2 for sampling, testing, and acceptance requirements.

Material for subgrade stabilization stabilizing additives will be evaluated under Subsections 106.02 and 106.03.

Subgrade stabilization work will be evaluated under Subsections 106.02 and 106.04.

Construction joints will be evaluated under Section 305.

Reconditioning of subgrade will be evaluated under Section 303.

Measurement

213.11 Measure the Section 213 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring subgrade stabilization by the square yard, measure the length horizontally along the centerline of the roadway and the width horizontally to include the top of the subgrade stabilization width, including widenings.

Payment

213.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 213 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 213-2
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Subgrade stabilization	Measured & tested for conformance (106.04)	Proportioning	–	Subsection 213.03	1 per submitted mix design	Existing roadbed or subgrade	If requested	30 days before production	–
Production									
Stabilized material	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C(1)	1 per soil type but not less than 1 for each day of production	Processed material behind mixer	If requested	Before using in work	–
		Gradation	–	AASHTO T 27 & T 11	1 per 3500 yd^2 but not less than 1 per layer	"	"	"	–
		Density	–	AASHTO T 310 or other approved procedures	"	In-place	No	Before placing next layer	–
		Compressive strength (7-day cure)	–	ASTM D5102,(2) D1633(3) as applicable	"	Processed material behind mixer	"	"	–

(1) At least 5 points per proctor.

(2) At 7-day cure at 105°F. Compact sampled material immediately according to Procedure B. Do not complete the proportioning and mixing of Sections 10.2 and 10.3. Report average unconfined compressive strength from at least three specimens.

(3) At 7-day cure. Report average unconfined compressive strength from at least three specimens.

DIVISION 250 EARTH RETAINING SYSTEMS AND SLOPES

Section 251. — RIPRAP

Description

251.01 This work consists of providing and placing riprap.

Riprap gradation is designated according to Subsection 251.07.

Material

251.02 Conform to the following Subsections:

Geotextile	714.01
Neat hydraulic cement grout	701.04(a)(2)
Rock for riprap	705.02

Construction Requirements

251.03 General. Excavate and backfill according to Section 209. Dress the slope to produce a smooth surface. Place geotextile according to Section 207, as required.

251.04 Placed Riprap. Place riprap on a prepared surface.

Place riprap to its full thickness in one operation. Do not place riprap material by methods that cause segregation or damage to the prepared surface. Place or rearrange individual rocks by mechanical or hand methods to obtain a dense uniform blanket with a reasonably smooth surface.

251.05 Keyed Riprap. Key riprap on a prepared surface and set into place by impact pressure.

Place rock for keyed riprap according to Subsection 251.04. Set the riprap into place by exerting impact pressure with a hydraulic-powered bucket or an approximate 5000-pound flat-faced mass. Repeat impacts until the rock is firmly seated and forms a reasonably uniform surface without reducing the effective sizes of the rocks. Do not use impact pressure on riprap below the water surface.

251.06 Grouted Riprap. Place or key riprap on a prepared surface with the voids filled with grout.

Place rock for grouted riprap according to Subsection 251.04. Place rock for keyed grouted riprap according to Subsection 251.05. Thoroughly moisten the rocks and wash excess fines from the riprap or to the underside of the riprap. Do not place grout unless the air temperature is at or above 35 °F within the near-surface voids of the riprap. Prevent segregation during grout placement. Start placing grout at the lowest elevation of the riprap. Fill voids without unseating the rocks. Do not exceed 5-foot thickness for each layer of grouted riprap. Allow 3 days curing time before adding the next layer of riprap and grout. Provide weep holes through the grouted riprap as required. Keep the grouted riprap moist for 3 days after the work is completed and protect it from freezing for at least 7 days after grouting.

251.07 Riprap Gradation.

(a) Wolman count. For source approval, test individual riprap size by Wolman Count according to FLH T 521.

(b) Size method. During production, test individual riprap using the size method, by confirming that the largest rock has an intermediate dimension greater than the upper limit of the D85 size range shown in Table 705-1.

251.08 Acceptance. See Table 251-1 for sampling, testing, and acceptance requirements.

Material for grout will be evaluated under Subsections 106.02 and 106.03.

Rock for riprap will be evaluated under Subsections 106.02 and 106.04.

Placing grout will be evaluated under Subsection 106.02.

Riprap construction will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Geotextile will be evaluated under Section 207.

Measurement

251.09 Measure the Section 251 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring riprap by the cubic yard, measure in place.

Payment

251.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 251 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 251-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Rock for riprap (705.02)	Measured & tested for conformance (106.04 & 105)	Apparent specific gravity & absorption	–	AASHTO T 85	1 per material type	Source of material	Yes	Before using in work	–
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	–
		LA abrasion	–	AASHTO T 96	"	"	"	"	–
		Gradation[1]	–	FLH T 521	"	"	No	"	–
Production									
Rock for riprap (705.02)	Process control (153.03)	Gradation	–	FLH T 521	1 per 100 yd^3 per Class	Stockpile or source[2]	No	Before using in work	–
	Measured & tested for conformance (106.02 & 106.04)	Size method[1]	–	Subsection 251.07(b)	1 per 100 yd^3 per Class	On site stockpile or in-place[3]	No	24 hours	–

(1) Notify CO at least 7 days before performing test.
(2) To be measured before delivery to project.
(3) Point of sampling to be approved.

Section 252. — ROCKERY, SPECIAL ROCK EMBANKMENT, AND ROCK BUTTRESS

Description

252.01 This work consists of constructing rockeries, special rock embankments, and rock buttresses.

252.02 Definitions.

(a) Rockeries. Consists of providing and placing interlocking, dry-stacked rocks without reinforcing steel, mortar, or concrete.

(b) Special rock embankments. Consists of providing and placing rock in fill-side sections.

(c) Rock buttresses. Consists of providing and placing rock in cut-side sections.

Material

252.03 Conform to the following Subsections:

Corrugated polyethylene drainage tubing	708.04
Geotextile	714.01
Granular rock backdrain	703.17
Rock for buttresses	705.05
Rock for rockeries	705.06
Rock for special rock embankments	705.04

Construction Requirements

252.04 Qualifications. At least 14 days before starting rockery work, submit a résumé for the on-site supervisor describing experience on at least three projects of similar construction and complexity within the past 5 years. Include project names, a brief description of each project, construction dates and quantities, locations, and contact information for project owners.

252.05 Submittals. At least 14 days before starting rockery, special rock embankment, and rock buttress work, submit the following according to Subsection 104.06:

(a) Start date and schedule;

(b) Description of construction methods and proposed equipment; and

(c) Photos of completed rockeries with narrative descriptions of the rockeries, equipment used, and special or unusual conditions encountered during the construction and how construction methods were adapted.

252.06 General. Survey according to Section 152 and verify the limits of installation. Notify the CO if planned lengths, heights, or both are inadequate to intersect with the adjacent slopes. Submit cross-sections verifying intersections for approval.

Construct as follows:

(a) Excavation. Perform the work according to Sections 204 and 209. Do not excavate more areas than can be replaced with construction in one shift, except as otherwise noted. The CO may allow excavation beyond the limits that can be completed in one shift provided the Contractor demonstrates that the excavation will remain stable until the rock work is completed or provides shoring. Protect backslopes from damage by surface water.

(b) Erection. Place geotextile filter according to Section 207 as shown in the plans. Remove sharp objects from the backslope before installing geotextile filter.

252.07 Rockery. Provide and install underdrain systems according to Section 605 as shown in the plans.

Seat base rocks firmly on stable foundation subgrades or leveling pad as shown in the plans. Do not place rocks with shapes that create voids with a linear dimension greater than 12 inches.

Place rocks to avoid continuous joints in any direction. Locate at least one bearing point a distance no greater than 6 inches from the face of the rockery. Place each rock to ensure it bears on at least two rocks below. Place incrementally smaller rocks as construction proceeds in successive rows. Slope the top surface of each rock towards the back of the rockery at an inclination of at least 5 percent.

Choke voids in each successive row. Choke voids greater than 6 inches with a rock large enough to fill the void.

Backfill with granular rock backdrain concurrent with rock placement until level with the top of rock. Place granular rock backdrain in horizontal lifts no more than 12 inches compacted depth. Compact each lift according to Subsection 204.11. Compact areas not accessible to rollers with other approved methods.

252.08 Special Rock Embankment and Rock Buttress. Place rocks in a stable orientation with minimal voids to produce a random pattern. Construct the exposed face of the rock mass reasonably uniform with projections beyond the line of the slope that are no greater than 12 inches for mechanically-placed rock or 6 inches for hand-placed rock.

Use rock smaller than the minimum rock size to choke the larger rock solidly in position and to fill voids between the large rocks.

252.09 Acceptance. See Table 252-1 for sampling, testing, and acceptance requirements.

Material for rockeries, special rock embankments, and rock buttresses will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of rockeries, special rock embankments, and rock buttresses will be evaluated under Subsections 106.02 and 106.04.

Geotextile filters will be evaluated under Section 207.

Roadway excavation will be evaluated under Section 204.

Structure excavation and backfill will be evaluated under Section 209.

Survey will be evaluated under Section 152.

Underdrain systems will be evaluated under Section 605.

Measurement

252.10 Measure the Section 252 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring rockeries by the square foot, measure the rockery from the bottom of the base rock elevation to the top of the cap rock elevation. Measure the front face on a plane parallel to the rockery face.

When measuring special rock embankments and rock buttresses by the cubic yard, measure in place.

Payment

252.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 252 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 252-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Rock for buttresses (705.05)	Measured & tested for conformance (106.04 & 105)	Rock breadth and thickness	–	Subsection 705.05(a)(1)	1 per rock type	Source of material	No	Before using in work	–
		Apparent specific gravity	–	AASHTO T 85	"	"	Yes	"	Not required if using Government -furnished source
		Absorption	–	"	"	"	"	"	"
		Durability index (coarse)	–	AASHTO T 210	"	"	"	"	"
Rock for rockeries (705.06)	"	Apparent specific gravity	–	"	1 per rock type	Source of material	Yes	Before using in work	Not required if using Government -furnished source
		Absorption	–	"	"	"	"	"	"
		LA abrasion	–	AASHTO T 96	"	"	"	"	"
		Durability index (coarse)	–	AASHTO T 210	"	"	"	"	"
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	"

Table 252-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Rock for special rock embankment (705.04)	Process control (153.03)	Size	–	(1)	1 per 100 yd^3	In-place	No	24 hours	–
Rock for buttresses (705.05)	"	"	–	"	1 per 100 yd^3	"	"	"	–
Rock for rockeries (705.06)	"	"	–	(2)	2 per row of rock per rockery	"	"	"	–

(1) For mechanically-placed embankments, verify rock size by confirming that the largest accessible rock has an intermediate dimension greater than the D50 size shown in Table 705-2. Also confirm that the smallest accessible rock has an intermediate dimension within the lower D50 size range shown in Table 705-2.
For hand placed embankments, verify rock size by confirming that the largest accessible rock has an intermediate dimension greater than the D75 size shown in Table 705-3. Also confirm that the smallest accessible rock has an intermediate dimension within the D25 size range shown in Table 705-3.
(2) Verify rock size by confirming that the largest accessible rock has a width greater than the minimum width shown in the plans.

Section 253. — GABIONS AND REVET MATTRESSES

Description

253.01 This work consists of constructing rock filled gabion structures and revet mattresses.

Material

253.02 Conform to the following Subsections:

Crushed aggregate	703.06
Gabion and revet mattress material	720.02
Gabion and revet mattress rock	705.01
Geotextile	714.01
Soil and soil-aggregate materials	704.01

Construction Requirements

253.03 General. Survey according to Section 152 and verify the limits of installation. Submit installation drawings according to Subsection 104.06. Conform to Section 257 for Contractor-designed gabion walls.

Excavate and backfill according to Section 209. Grade the foundation for a width equal to the base width of the gabions or revet, plus any additional width shown in the plans.

If required, as determined by the Contractor, design and construct temporary shoring according to Section 562.

Excavate wall foundations to within 4 inches horizontally and vertically from the staked location.

If shown in the plans, install underdrain system according to Section 605.

253.04 Basket Assembly. Provide twisted wire or welded wire mesh baskets. Do not damage wire coatings during basket assembly, structure erection, cell filling, or backfilling. Rotate the basket panels into position and join the vertical edges with fasteners according to Subsection 253.05. Temporary fasteners may be used for basket assembly if they are supplemented during structure erection with permanent fasteners according to Subsection 253.05.

Rotate the diaphragms into position and join the vertical edges according to Subsection 253.05.

253.05 Structure Erection. Construct gabion walls to the following tolerances:

(a) Vertical and horizontal. ±1 inch at top of wall for every 10 feet of wall height.

(b) Horizontal straight edge. ±2 inches deviation at a point in the wall from a 10-foot metal straightedge placed horizontally or vertically on the theoretical plane of the design face.

Place the empty gabion baskets on the foundation and interconnect the adjacent baskets along the top and vertical edges using permanent fasteners. Where shown in the plans, place 6 inches of compacted crushed aggregate or other specified leveling course material under the baskets.

Where lacing wire is used, wrap the wire with alternating single and double loops every other mesh opening as shown in the plans or as recommended by the manufacturer and no more than 6 inches apart. Where spiral binders are used, crimp the ends to secure the binders in place. Where alternate fasteners are used, space the fasteners in every mesh opening and no more than 6 inches apart.

Interconnect the base of each basket to the lids of the underlying baskets along the ends and sides of the upper basket.

253.06 Cell Filling. Remove kinks and folds in the wire mesh, and properly align the baskets. Place rock carefully in the basket cells to prevent bulging of the baskets and to minimize voids in the rock fill. Maintain the basket alignment.

Place stiffeners and cross-tie wires as recommended by the manufacturer in each unrestrained exterior basket cell greater than 12 inches in height. This includes interior basket cells left temporarily unrestrained. Place stiffeners and cross-tie wires concurrently with rock placement.

Fill the cells in a row to ensure no cell is filled more than 12 inches above an adjacent cell. Repeat this process until the basket is full and the lid bears on the final rock layer. Secure the lid so that no more than a 1-inch gap remains at any connection.

Secure the lid to the sides, ends, and diaphragms according to Subsection 253.05. Make exposed basket surfaces smooth and neat with no sharp rock edges projecting through the wire mesh.

253.07 Backfilling. Place a geotextile filter over the back face of the gabion structure according to Section 207. Concurrently with the cell filling operation, backfill the area behind the gabion structure with structural backfill according to Subsection 209.09. Compact each lift according to Subsection 209.10, except use an acceptable lightweight mechanical or vibratory compactor within 36 inches of the gabion structure.

If using gabion basket as a free-standing roadside rockfall barrier according to Section 265, do not place a geotextile over the back face or backfill the area behind the gabion structure unless otherwise shown in the plans.

253.08 Revet Mattresses. Place a geotextile filter according to Section 207. Construct revet mattresses according to Subsections 253.04 through 253.06. Anchor the mattresses in place according to the manufacturer's recommendations. Place a geotextile filter against the vertical edges of the mattress and backfill against the geotextile filter using common backfill or the specified backfill. Overfill revet mattresses by 1 to 2 inches.

253.09 Acceptance. Material for gabion structures and revet mattresses will be evaluated under Subsections 106.02 and 106.03.

Construction of gabion structures and revet mattresses will be evaluated under Subsections 106.02 and 106.04.

Geotextile filters will be evaluated under Section 207.

Structure excavation, structural backfill, crushed aggregate, and common backfill will be evaluated under Section 209.

Survey will be evaluated under Section 152.

Temporary works will be evaluated under Section 562.

Underdrains will be evaluated under Section 605.

Measurement

253.10 Measure the Section 253 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring gabions by the cubic yard, measure in the structure.

When measuring revet mattresses by the square yard, measure the exposed face on a plane parallel to the revet mattress face.

Payment

253.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 253 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 254. — SOLDIER PILE RETAINING WALLS

Description

254.01 This work consists of constructing permanent soldier pile retaining walls.

254.02 Definition. For soldier pile retaining walls, a lift is defined as a stable height of unsupported excavation before installation of lagging.

Material

254.03 Conform to the following Section and Subsections:

Geocomposite drain	714.02
Piling	715
Reinforcing steel	709.01
Welded stud shear connectors	717.05

Construction Requirements

254.04 Qualifications. Provide an engineer or geologist, a supervisor, and foreperson with experience installing soldier pile retaining walls. At least 30 days before starting soldier pile retaining wall work, submit the following for approval:

(a) Professional engineer or geologist. A résumé for a professional engineer or professional geologist with at least 2 years' experience logging subsurface profiles of soldier pile retaining wall or drilled shafts, and documenting construction and testing results;

(b) Engineer or geologist. If applicable, a résumé for a geotechnical engineer or engineering geologist working under the direct supervision of the professional engineer or professional geologist described in Subsection 254.04(a); and

(c) Supervisor and foreperson. A résumé for each individual describing their experience on at least five soldier pile retaining wall projects of similar size and complexity within the past 10 years. Include project names, locations, and contact information for project owners.

254.05 Submittals. At least 30 days before starting the soldier pile wall installation work, submit the following according to Subsection 104.06:

(a) Start date;

(b) Description of equipment and methods of excavation, hole stability, cleanout, spoils containment, and pile installation;

(c) Retaining wall construction sequence;

(d) Structural steel types, sizes, and details. Include lifting bracket, support bracing or anchor locations, and centralization methods;

(e) Descriptions of concrete and backfill materials and placement methods;

(f) Drilling method and details for ground anchors according to Subsection 256.04;

(g) Temporary lagging design details, backfill materials, drainage materials, and method of installation;

(h) Reinforcing steel bar order lists and bending diagrams according to Subsections 104.06 and 554.03; and

(i) Production certificates with each shipment of piles and lagging.

254.06 General. Survey according to Section 152 and verify limits of wall installation. Provide an engineer or geologist to log subsurface material condition descriptions from the ground surface to the bottom of the shafts. Conform to Section 257 for Contractor-designed soldier pile walls.

254.07 Soldier Pile Installation. If driven piles are specified, install according to Section 551. Drive or drill pile to the elevation shown in the plans or approved drawings. When drilling, perform the following:

(a) Drill through material to bottom of shaft elevation shown in the plans or approved drawings. If caving conditions are encountered, do not excavate further until implementing the method to prevent ground caving as described in the approved drawings. Do not leave more than 2 inches of loose or disturbed material in the bottom of the hole for soldier piles with permanent ground anchors, or more than 12 inches of loose material for soldier piles without permanent ground anchors.

(b) Install steel soldier pile in the drilled hole. Position and center the steel soldier pile to maintain the specified minimum concrete cover.

(c) Construct structural concrete according to Section 552, and flowable backfill according to Section 614. If multiple types of concrete or backfill are specified, place the specified material in the lower section to specified elevation. Allow the concrete to initially set to sufficient strength before placing the next type of concrete or backfill. Do not drill adjacent holes for 12 hours after backfilling.

(d) Place the specified upper concrete or backfill to the specified upper elevation. Pump out water or place concrete or backfill using a tremie pipe if more than 6 inches of water is present at the time of concrete or backfill placement.

(e) Use the on-site engineer or geologist to log the drilling and ground conditions with depth. Note advancement rates, seepage zones and rates, drilling fluid, casing type and depth, drilling methods and equipment used, installation notes, concrete or backfill placement methods, and remarks.

(f) Place the centerline of the steel soldier piles so that the top is within 1 inch of the plan location and plumb to within 0.5 percent of the length based on the total length of the pile.

254.08 Excavation and Lagging Installation.

(a) Excavation. Excavate for the wall in staged lifts concurrent with lagging installation. Do not allow the exposed unsupported final excavation face cut height to exceed 6 feet or the short-term stand-up height of the ground, whichever is less. Provide a soil face during excavation with a smooth contact surface for the lagging. Backfill caving areas with approved material.

(b) Lagging. Provide timber lagging according to Section 557 and as shown in the plans or approved drawings. Place lagging boards behind the front flange of the soldier pile overlapping the end of the lagging by at least 3 inches on both ends of the lagging boards. Secure the lagging board to prevent slippage as indicated in the plans or approved drawings. Provide a gap between boards as shown in the plans or approved drawings. Install the lagging tight up against the excavated soil. If the excavation caves or is not even enough to install the lagging tight up against the soil, backfill using the method and materials in the approved drawings to accommodate subsurface drainage.

Do not install lagging more than 3 feet below the level of the ground anchors before installation of the anchors.

254.09 Backfill Installation. Backfill behind the lagging according to the approved drawings before continuing excavation. Repeat this process until excavation reaches the elevation as shown in the plans or approved drawings. Do not excavate more than 3 feet below ground anchor elevations and the bottom of lagging elevation.

254.10 Geocomposite Sheet Drain Installation. Install geocomposite sheet drain system according to Section 605.

254.11 Permanent Ground Anchors. Where permanent ground anchors are required, provide permanent ground anchors and bearing assemblies conforming to Section 256 as shown in the plans or approved drawings. Install all anchors at similar levels before excavation to the next level anchors. Do not excavate to next level anchors until all anchors at prior level are locked off. Perform proof test and performance test of anchors according to Section 256.

254.12 Concrete Fascia Wall. If a cast-in-place concrete facing is specified:

(a) Install falsework according to Section 562.

(b) Install headed studs along the soldier pile beam as shown in the plans and according to Subsection 555.13.

(c) Install reinforcing steel according to Section 554.

(d) Install structural concrete according to Section 552.

254.13 Final Backfill. Backfill to final grade behind and in front of the wall with the specified material shown in the plans or approved drawings.

254.14 Acceptance. Material for soldier piles will be evaluated under Subsections 106.02 and 106.03.

Construction of soldier piles will be evaluated under Subsections 106.02 and 106.04.

Concrete will be evaluated under Section 552.

Driven piles will be evaluated under Section 551.

Temporary works will be evaluated under Section 562.

Flowable backfill will be evaluated under Section 614.

Geocomposite sheet drain systems will be evaluated under Section 605.

Permanent ground anchors will be evaluated under Section 256.

Steel structures will be evaluated under Section 555.

Survey will be evaluated under Section 152.

Timber structures will be evaluated under Section 557.

Measurement

254.15 Measure the Section 254 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring soldier piles by the linear foot, measure from the top of steel soldier pile elevation to the pile tip or bottom of shaft elevation, whichever is greater.

Payment

254.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 254 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 255. — MECHANICALLY-STABILIZED EARTH WALLS

Description

255.01 This work consists of constructing MSE walls.

Material

255.02 Conform to the following Subsections:

Geotextile	714.01
Mechanically-stabilized earth wall material	720.01
Reinforcement geotextile and geogrid	714.04
Select granular backfill	704.03
Wall facing fill	705.09

Construction Requirements

255.03 General. Survey according to Section 152 and verify the limits of wall installation. Submit installation drawings according to Subsection 104.06. Conform to Section 257 for Contractor-designed MSE walls. Do not disturb existing ground until limits of the wall installation have been verified and the CO has approved the installation drawings.

Excavate and backfill according to Section 209. Grade the foundation for a width equal to the length of reinforcing elements plus the additional width shown in the plans.

If required, as determined by the Contractor, design and construct temporary shoring according to Section 562.

For concrete panel and SRWU faced walls, provide a precast reinforced or a non-reinforced cast-in-place concrete leveling pad. Cure cast-in-place leveling pads at least 12 hours before placing wall panels. For all other walls, construct a leveling pad from crushed aggregate or the specified material, if shown in the plans.

Construct minor concrete according to Section 601.

Excavate wall foundations to within 4 inches horizontally and vertically from the staked location. Install reinforcement elements to within 2 inches vertically from the staked location. Bench the excavation as necessary to accommodate variable lengths of reinforcement according to the plans and approved drawings.

Install underdrain systems and geocomposite sheet drain systems according to Section 605.

Repair damage to galvanized coatings before installation according to Subsection 563.12(b).

255.04 Wall Erection. Erect the wall according to the plans and approved drawings. Have a field representative from the wall system manufacturer on site during the startup of wall erection. Construct MSE walls to the tolerance shown in Table 255-1.

Connect reinforcement to facing, pull taut, and anchor far end before placing additional backfill. Do not place reinforcing elements below the corresponding connection elevations, unless approved as part of a utility installation detail.

Table 255-1
Construction Tolerance

Facing Type	Vertical, inch(1) (±)	Horizontal, inch(2) (±)	Horizontal Straight Edge Point Check, inch(3) (±)
Precast concrete panel, segmental retaining wall units	0.5	0.5	0.75
Welded wire, gabions	1	1	2

(1) Wall vertical tolerance at top of wall for every 10 feet of wall height. For example, 5 feet wall height multiply 6.5×value.
(2) Wall horizontal tolerance at top of wall for every 10 feet of wall height.
(3) Maximum horizontal deviation at a point in the wall from a 10-foot metal straightedge placed horizontally or vertically on the theoretical plane of the design face.

(a) Precast concrete panel-faced. Construct panels by the following:

(1) Construct according to Section 578. Use concrete class A(AE).

(2) Finish the front face of the panel with a Class 1 finish according to Subsection 552.14. Screed the rear face of the panel to eliminate open pockets of aggregate and surface distortions of more than ¼ inch. Cast the panels on a flat area. Do not attach galvanized connecting devices or fasteners to the face panel reinforcement steel.

(3) Clearly write on an unexposed face of each panel the date of manufacture, the production lot number, and the piece mark.

(4) Handle, store, and ship units according to Subsection 578.08.

(5) Manufacture units within the following tolerances:

(a) Panel dimensions. Position of panel connection devices within 1 inch. All other dimensions within 3⁄16 inch.

(b) Panel squareness. Do not exceed ½ inch as determined by the difference between the two diagonals.

(c) Panel surface finish. Do not exceed ⅛ inch for surface defects on smooth formed surfaces of 5 feet or more in length. Do not exceed 5⁄16 inch for surface defects on textured-finished surfaces of 5 feet or more in length.

(6) Concrete face panels having the following defects will be rejected:

(a) Defects that indicate imperfect molding;

(b) Defects indicating honeycombed or open texture concrete;

(c) Cracked or severely chipped panels; or

(d) Color variation on front face of panel.

Erect panels by lifting devices connected to the upper edge of the panel.

Size the joint openings to prevent damage to facing panels during post-construction structure movement and to prevent loss of wall backfill materials. Construct the joint opening and install joint material according to the approved drawings. Cover joints on the backside of the panels with a 12-inch-wide strip of geotextile filter. Overlap geotextile filter splices at least 4 inches.

Hold the panels in position with temporary wedges or bracing during backfilling operations.

(b) Wire-faced. Place facing and backing mats in successive horizontal rows as backfill placement proceeds. Do not use hardware cloth or geosynthetic material to retain backfill at the face of the wall unless the product is specifically approved for facing applications and part of the approved drawings.

(c) Gabion-faced. Construct gabion structures according to Section 253. Lay reinforcement mesh horizontally on compacted fill and normal to the face of the wall. Connect the gabion facing unit to reinforcement mesh with spiral binders or tie wire at 4-inch nominal spacing with alternating single and double locked loops, or as detailed in the approved drawings.

(d) SRWU. Place the first course of wall units on top of and in full contact with the leveling pad. Place the units side by side for the full length of the wall such that adjoining units are located with minimal gaps. Place units to ensure only the front face of the unit is visible. Check for proper elevation and alignment every two courses. Install connection devices and alignment devices as required by the approved drawings. Fill voids in and around units with unit fill as recommended by the manufacturer's installation guidelines to meet the required connection strength. If the unit fill is required to meet connection strength specifications, completely fill each course of block before proceeding to the next course. Place reinforcement at a vertical spacing no more than two times the block depth or 24 inches, whichever is less. Remove excess material from the top of the units before installing each succeeding course.

255.05 Backfilling. Backfill the reinforced zone with the specified material according to Subsection 209.09. Place facing fill or unit fill as shown in the approved drawings. Place select granular backfill from the back of the wall face, facing fill, or unit fill to the end of the reinforcement plus the additional width shown in the plans. Ensure that no voids exist below the reinforcement. Compact each lift according to Subsection 209.10, except use an approved lightweight mechanical or vibratory compactor within 36 inches of the wall face. Consolidate facing fill or unit fill by rodding or other approved means to produce a uniform, tight fill. Where the reinforced zone supports spread footings for bridges or other structural loads, compact the top 5 feet to at least 100 percent of the maximum density.

Do not damage or disturb the facing or reinforcing elements. Do not operate equipment directly on top of the reinforcements. Place at least 6-inch loose lift of fill before operating rubber-tired equipment over the reinforcements. Limit equipment speeds to 5 miles per hour and limit turning maneuvers to a minimum. Install and maintain reinforcement taut, unwrinkled, and in full contact with the underlying surface. Correct damaged, misaligned, or distorted wall elements as directed before constructing subsequent layers.

Backfill and compact behind the reinforced zone with the specified material according to Subsections 209.09 and 209.10. At the end of the day's operation, slope the last lift of backfill away from the wall face to direct surface runoff away from the wall. Do not allow surface runoff from adjacent areas to enter the wall construction area.

255.06 Acceptance. See Table 255-2 for sampling, testing, and acceptance requirements.

Material for MSE walls will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of facing units.

Construction of MSE walls will be evaluated under Subsections 106.02 and 106.04.

Concrete leveling pads will be evaluated under Section 601.

Excavation and backfill will be evaluated under Section 209.

Gabions will be evaluated under Section 253.

Precast concrete elements will be evaluated under Section 578.

Survey will be evaluated under Section 152.

Temporary works will be evaluated under Section 562.

Underdrain systems and geocomposite sheet drain systems will be evaluated under Section 605.

Measurement

255.07 Measure the Section 255 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring MSE walls by the square foot, measure the front face of wall excluding footings and leveling courses.

When measuring select granular backfill within the reinforced zone by the cubic yard, measure in place.

Payment

255.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 255 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 255-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Select granular backfill (704.03)	Measured & tested for conformance (106.04 & 105)	Gradation	–	AASHTO T 27 & T 11	1 per soil type	Source of material	Yes	Before using in work	Not required if using Government-furnished source
		Angle of internal friction	–	AASHTO T 236 and Subsection 704.03(a)(2)	"	"	"	"	"
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	"
		Plasticity index	–	AASHTO R 58, T 89, & T 90	"	"	"	"	"
		Resistivity[(1)]	–	AASHTO T 288	"	"	"	"	"
		pH[(1),(2)]	–	AASHTO T 289	"	"	"	"	"
		Sulfate content[(1),(3)]	–	AASHTO T 290	"	"	"	"	"
		Chloride content[(1),(3)]	–	AASHTO T 291	"	"	"	"	"

Table 255-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Select granular backfill (704.03)	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 99, Method C[4]	1 per soil type	Source of material	Yes	Before using in work	–
		Density	–	AASHTO T 310 or other approved procedures	1 per lift per 75 linear feet of wall but not less than 2 per lift	In-place	No	Before placing next lift	–

(1) Required for MSE walls with metallic reinforcements.
(2) Required for MSE walls with geosynthetic reinforcements.
(3) Tests for sulfate and chloride content are not required if resistivity is greater than 5000 ohm centimeters.
(4) At least 5 points per proctor.

Section 256. — PERMANENT GROUND ANCHORS

Description

256.01 This work consists of providing and installing permanent drilled and grouted ground anchors.

Material

256.02 Conform to the following Subsections:

Anchor tendons	722.02
Galvanized coatings	717.07
High-strength low-alloy structural steel (bearing plates)	717.01(b)(3)
Neat hydraulic cement grout	701.04(a)
Steel pipe	717.06

Construction Requirements

256.03 Qualifications. Provide an engineer or geologist, drill foreperson, and drill operators with experience installing permanent ground anchors. At least 30 days before starting permanent ground anchor work, submit the following for approval:

(a) Drill foreperson. A résumé for each drill foreperson describing at least 2 years' experience supervising construction of ground anchors of similar lengths and scope to those shown in the plans and in similar geotechnical conditions described in the geotechnical report. Include experience as the direct supervisor responsible for on-site construction operations;

(b) Drill operator. A résumé for each drill operator describing at least 1 year's experience in the construction of ground anchors;

(c) Professional engineer or geologist. A résumé for a professional engineer or professional geologist with at least 5 years' experience in the design and construction of ground anchors to log ground anchor installation; and

(d) Geotechnical engineer or geologist. If applicable, a résumé for a geotechnical engineer or engineering geologist working under the direct supervision of the professional engineer or professional geologist described in Subsection 256.03(c), to log ground anchor installation. Include at least 2 years' experience in the design and construction of ground anchors.

256.04 Submittals. At least 30 days before starting ground anchor work, submit the following according to Subsection 104.06:

(a) Start date and schedule;

(b) Method of excavation and ground anchor construction sequence to ensure site safety and maintain slope stability;

(c) Plan and profile drawings showing contractor-located buried utilities according to Subsection 107.02(d) and locations of ground anchors relative to those utilities;

(d) Ground anchor types, sizes, horizontal and vertical spacings, total length and depths, installation angles from horizontal, ultimate tendon strengths for the range of material to be encountered, proposed drill hole diameter and the minimum bond zone length for factored design loads shown in the plans. Include calculations for minimum bond zone lengths;

(e) Tendons, couplers, bearing plates, facing items, and additional hardware with the manufacturer's SDS, product data sheets, specifications;

(f) Manufacturer's recommendations for tendon and hardware handling, storing, assembly, and working temperature ranges;

(g) Grout type, mix design, mixing equipment, placement procedures, and 7-day grout compressive strength test results;

(h) Procedures and material for repairing corrosion protection coatings in the field;

(i) Drilling methods and equipment;

(j) Drill hole diameters to achieve the specified pullout resistance;

(k) Alternative drilling and grouting methods (such as grout additives or pressure grouting);

(l) Additional material needed to achieve required bond capacities (such as grout socks and post-grout tubes);

(m) Methods to ensure borehole stability during excavation and grout placement;

(n) Ground anchor testing methods and equipment including type and capacity of reaction load system, drawings, supporting calculations for structural components of the ground anchor load test apparatus, and calculations for soil bearing and settlement below the reaction frame; and

(o) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

256.05 Tendon Fabrication.

(a) General. Size tendons to ensure:

(1) The design load is no more than 60 percent of the minimum ultimate tensile strength of the tendon; and

(2) The maximum test load is no more than 80 percent of the minimum ultimate tensile strength of the tendon.

Use the anchor tendon type shown in the plans. Protect anchors and the anchor head assembly against corrosion using Class I Corrosion Protection as recommended in PTI, *Guide Specification for Post-Tensioning Materials*.

(b) Bond length. Determine the bond length necessary to develop the design load shown in the plans. Do not use a bond length less than the minimum bond length shown in the plans. Provide corrosion protection of the tendon bond length with a cement grout cover.

Where encapsulation of the tendon is required, protect the tendon bond length from corrosion by encapsulating it in a grout-filled corrugated plastic or deformed steel tube or with a corrosion protection coating according to ASTM A775, A934, A153 or A143. Place the grout inside the tube either before or after the tendon is placed in the drill hole. Centralize the tendon within the tube with at least ⅛ inch grout cover.

(c) Centralizers. Use spacers along the tendon bond length of a multi-element tendon to separate each of the individual elements of the tendon. Use centralizers to ensure at least ½ inch of grout cover over the tendon bond length or tendon bond length encapsulation as appropriate. Use centralizers that do not impede the free flow of grout up the bore hole. Position centralizers no more than 5 feet from the top of the tendon bond length, no more than 12 inches from the bottom of the tendon bond length, and with center-to-center spacing of no more than 10 feet.

Centralizers are not required on hollow-stem-augured tendons if the ground anchor is grouted through the auger and the hole is maintained full of a grout with a slump less than 9 inches during extraction of the auger.

(d) Unbonded length. Provide the unbonded length as shown in the plans.

(1) If the drill hole is grouted in one operation, provide corrosion protection of the unbonded length with a PVC sheath filled with corrosion-inhibiting grease, corrosion-inhibiting grout, or a heat-shrinkable tube internally coated with an elastic adhesive.

If grease is used under the sheath, coat the unbonded tendon length, fill spaces between individual elements of multi-element tendon with grease, and provide measures to prevent grease from escaping at the ends of the sheath.

If the sheath is grout filled, provide a separate bond-breaker along the unbonded length of the tendon.

(2) If a grease-filled sheath corrosion protection is provided and the drill hole above the bond length is grouted after the ground anchor is locked off, grout the tendon inside a second sheath.

Where restressable ground anchors are used, provide restressable anchorage compatible with the post-tensioning system provided.

If multi-element tendons are used, properly seat the wedges according to the manufacturer's recommendations for the post-tensioning system provided.

(e) Bearing plates. Size the bearing plates according to the manufacturer's specifications and ensure:

(1) The bending stresses in the plate do not exceed the yield strength of the steel when a load equal to 95 percent of the minimum specified ultimate tensile strength of the tendon is applied; and

(2) The average bearing stress of the bearing plate is no more than recommended in the PTI, *Guide Specification for Post-Tensioning Materials*.

Weld trumpet to bearing plate. Make the inside diameter of the trumpet at least the size of the hole in the bearing plate. Make the trumpet long enough to accommodate movements during stressing and testing. For multiple or single element tendons with encapsulation over the unbounded length, make the trumpet at least 24 inches beyond the structural fascia and soil backslope interface. Fill the trumpet of restressable ground anchors with corrosion-inhibiting grease. Provide a permanent Buna-N synthetic rubber seal between the trumpet and the unbonded length corrosion protection.

Fill the trumpets of non-restressable ground anchors with grout after anchor load lock-off is accepted. Provide a 12-inch minimum tightly-fitting temporary seal between the trumpet and the unbonded length corrosion protection.

256.06 Handling and Storing Material. Protect ground anchors and tendons from corrosion during the storage, fabrication, and handling before insertion in the borehole. Provide proper care to avoid prolonged exposure to the elements and to avoid mechanical or physical damage which would reduce or impair the future ability of the components to resist corrosive conditions encountered during the service life. Replace tendons exhibiting abrasions, cuts, welds, weld splatter, corrosion, or pitting. Repair or replace tendons exhibiting damage to encapsulation or sheathing. Degrease the bond length of tendons and remove solvent residue before installation.

256.07 Installation.

(a) Drilling. Drill ground anchor holes within 12 inches of the required location. Drill the longitudinal axis of the drill hole parallel to the longitudinal axis of the tendon. Install the ground anchor within 3 degrees of the required inclination from horizontal. Install the ground anchor with a horizontal angle within 3 degrees of a line drawn perpendicular to the plane of the structure. Do not extend ground anchors beyond the right-of-way or easement limits as shown in the plans. Do not damage existing utilities in the project site.

Insert the tendon in the drill hole to the required total length without driving or forcing. If the tendon cannot be completely inserted, remove the tendon and clean or redrill the hole to allow insertion.

Provide a professional engineer or professional geologist to observe advancement of ground anchors. Record material types, drilling depth of condition and material changes, drilling down-force pressure, production rates, and estimated water flows encountered during drilling. Submit drill logs to the CO at the end of each shift.

(b) Grouting.

(1) Equipment. Use a positive displacement grout pump equipped with a pressure gauge able to measure pressures of at least 150 pounds per square inch or twice the required grout pressure, whichever is greater. Provide a secondary pressure capability of at least 1000 pounds per square inch to clean out grout or dirt blockages in hoses, tremie tubes, or casings. Use a high speed, high shear grout mixer with a minimum operating speed of 1500 revolutions per minute to produce a well-mixed grout that is free of lumps or other indications of prior cement hydration. Provide holding tanks with a variable speed high-efficiency paddle that maintains a thoroughly mixed grout for pumping.

(2) Procedures. Grout tendons into drill holes using a neat hydraulic cement grout placed in one continuous operation. Inject the grout from the lowest point of the drill hole. The grout may be placed either before or after insertion of the tendon. Record the quantity of the grout and the grout pressure for each ground anchor. Control the grout pressures to avoid excessive heaving or fracturing. Inject grout within 45 minutes of adding the cement to the water or within 15 minutes after mixing when the ambient temperature is 90 °F or higher. Do not allow the grout temperature to exceed 90 °F.

Except as indicated below, the grout above the top of the bond length may be placed at the same time as the bond length grout, but do not place it under pressure. Do not place grout at the top of the drill hole in contact with the back of the structure or the bottom of the trumpet.

Use pressure grouting for grout protected tendons anchored in rock. After sealing the drill hole, pressure inject grout until a 50-pound per square inch grout pressure at the top of the drill hole is maintained for 5 minutes.

(c) Finishing. After grouting of tendon is complete, fill the grout tube with grout if it will remain in the hole. Wait at least 3 days before loading the tendon.

Extend the corrosion protection surrounding the unbonded length up beyond the bottom seal of the trumpet or 12 inches into the trumpet if no trumpet seal is provided.

Trim the corrosion protection surrounding the tendon so it does not contact the bearing plate of the anchor head during testing and stressing.

Place the bearing plate and anchorhead so the axis of the tendon is within three degrees of perpendicular to the bearing plate and the axis of the tendon passes through the center of the bearing plate without bending the tendon.

If grout protected tendons or corrosion protection coated encapsulations are used, electronically isolate the bearing plate, anchorhead, and trumpet from the surrounding concrete, soldier pile, or metallic element embedded in the structure.

Place trumpet grease during construction. Place trumpet grout after the ground anchor has been tested and stressed.

Completely cover anchorages permanently exposed to the atmosphere with a corrosion-inhibiting grease or grout.

Inspect the trumpet and anchorage grout levels 24 hours after initial grout placement. If needed, refill the trumpet or anchorage with grout.

256.08 Testing and Stressing.

(a) Testing equipment. Conform to the following:

(1) Dial gauges. Use two dial gauges that can measure to 0.001 inch and has sufficient travel to measure the theoretical elastic elongation of the total length at the maximum test load without resetting, accounting for elongation in both the bonded and unbonded zones. Align the gauges parallel to the axis of the anchor or pile and support the gauges independently from the hydraulic jack, ground anchor, or reaction frame.

(2) Hydraulic jack, pressure gauge, and load cell. Apply test loads with a hydraulic jack and measure with a calibrated pressure gauge and electronic load cell. Use a hydraulic jack and pressure gauge with a pressure range no more than twice the anticipated maximum test pressure and calibrated as a unit by an independent firm within 90 days of the start of work. Use a pressure gauge graduated in 100-pound per square inch increments or less. Use a jack with ram travel sufficient to allow testing without resetting.

(3) Reference gauge. Calibrate the reference gauge with the test jack and pressure gauge. Keep the reference gauge at the project site.

(4) Reaction frame. Provide a reaction frame designed by a professional engineer to meet the requirements of the site, resist the maximum test loads, and prevent excessive deformation of the bearing surface.

(b) Stressing. Place testing equipment over the ground anchor tendon to ensure the jack, bearing plates, load cells, and stressing assembly are axially aligned with the tendon and the tendon is centered within the equipment. Do not apply loads greater than 80 percent of the minimum ultimate tensile strength of the tendon.

Place the reference pressure gauge in series with the pressure gauge, jack, and load cell so they need not be unloaded and repositioned during a test. Raise the load from one increment to another. Hold the load just long enough to measure and record the ground anchor movement to the nearest 0.001 inch with respect to an independent fixed reference point. Repump the jack as necessary to maintain a constant load. Monitor the load with a pressure gauge. If the load measured by the pressure gauge and the load measured by the reference pressure gauge differ by more than 10 percent, recalibrate the jack, pressure gauge, and reference pressure gauge.

Monitor the pile during stressing of ground anchor tendons. Immediately stop the test if the pile deflects more than 1 inch inward.

Provide certified calibrations for torque wrenches, hydraulic jacks, and related equipment dated no more than 90 days before use on the project. Verify the calibration of torquing or jacking equipment upon request.

(1) Performance tests. Performance tests include the installation of the sacrificial ground anchor. The CO will designate locations for sacrificial ground anchors for performance tests. Test according to Tables 256-1 and 256-2.

Table 256-1
Performance Test Load Sequence

Test Sequence	Test Load Increment					
	AL(1)	**0.25FDL(2)**	**0.50FDL(2)**	**0.75FDL(2)**	**1.00FDL(2) (Load-Hold Test)**	**Adjust to Lock-Off Load**
1	Yes	Yes	–	–	–	–
2	Yes	Yes	Yes	–	–	–
3	Yes	Yes	Yes	Yes	–	–
4	Yes	Yes	Yes	Yes	10 minutes(3)	–
5	Yes	–	–	–	–	Yes

(1) AL = Alignment load (no greater than 5 percent of FDL (0.05FDL) applied to the ground anchor before setting the movement recording devices. Zero dial gauges after the first setting of AL).
(2) FDL = Factored design load.
(3) Hold the load to within 2 percent and measure and record the ground anchor movement during the load-hold test at 1, 2, 3, 4, 5, 6, and 10 minutes. When the ground anchor movement between 1 minute and 10 minutes exceeds 0.04 inch, maintain the maximum test load an additional 50 minutes and record the movement at 20, 30, 40, 50, and 60 minutes.

(2) Proof tests. Test according to Tables 256-2 and 256-3.

Table 256-2
Proof Test Load Sequence

Test Sequence	Test Load Increment					
	AL(1)	**0.25FDL(2)**	**0.50FDL(2)**	**0.75FDL(2)**	**1.00FDL(2) (Load-Hold Test)**	**Adjust to Lock-Off Load**
1	Yes	Yes	Yes	Yes	10 minutes(3)	–
2	Yes	–	–	–	–	Yes

(1) AL = Alignment load. See alignment load note in Table 256-1.
(2) FDL = Factored design load.
(3) Hold the load to within 2 percent and measure and record the ground anchor movement during the load-hold test at 1, 2, 3, 4, 5, 6, and 10 minutes. When the ground anchor movement between 1 minute and 10 minutes exceeds 0.04 inch, maintain the maximum test load an additional 50 minutes, recording movement at 20, 30, 40, 50, and 60 minutes.

(c) Lock-off. Adjust the load to the specified lock-off load shown in the plans and transfer the load to the anchorage device. After transferring the load and before removing the jack, measure the lift-off load. If the load is not within 10 percent of the specified lock-off load, reset the anchorage and remeasure the lift-off load. Repeat as necessary.

256.09 Test Results and Reporting. Identify each ground anchor with a letter and a number based on the row and level respectively. Submit a plan sheet of the wall elevation with the proposed ground anchor identification methodology showing the row letter and level number. Plot the ground anchor movement versus the maximum load for each test sequence as shown in Tables 256-1 and 256-2 and plot the residual movement of the tendon at each alignment load versus the highest previously applied load.

Provide preliminary results to the CO for each ground anchor tested before testing personnel leave the site at the end of each testing day. Submit detailed verification and proof test load and deflection data in a tabular format within 5 days. Submit a graph that plots total ground anchor head movement versus load, the A-line, and the B-line. The A-line is defined as 0.8 multiplied by the theoretical free test length elastic elongation. The B-line is defined as the theoretical free test length elastic elongation plus 0.50 multiplied by the theoretical bonded length elastic elongation. Allow 5 days for the CO to conduct a review of the data and approve ground anchor installation.

Replace ground anchors with unacceptable performance or proof test results. Do not retest failed ground anchors unless post-grouting has been performed.

256.10 Acceptance. See Table 256-3 for sampling, testing, and acceptance requirements.

Material for ground anchors will be evaluated under Subsections 106.02 and 106.03. Submit a production certification for the ground anchor material.

Construction of ground anchors will be evaluated under Subsections 106.02 and 106.04.

Installed ground anchors will be evaluated based on one of the following performance or proof test results:

(a) After a 10-minute hold, the ground anchor carries the maximum test load with less than 0.04 inch of movement between 1 and 10 minutes and the total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

(b) After a 60-minute hold, which is only conducted after 10-minute hold test fails, the ground anchor carries the maximum test load with a movement rate that does not exceed 0.08 inch per log cycle of time and the total movement at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the unbonded length.

Measurement

256.11 Measure the Section 256 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure linear footage or quantity of sacrificial ground anchors.

Do not measure failed performance tests.

Do not measure anchors that failed proof testing.

Payment

256.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 256 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 256-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (fine) (703.01)	Measured & tested for conformance (106.04 & 105)	Quality	–	AASHTO M 6	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Neat hydraulic cement grout[(1)] (701.04(a))	Measured & tested for conformance (106.04)	Flow	–	ASTM C939	1 per mix design	"	Yes, if requested	"	–
		Compressive strength (7-day)	–	AASHTO T 106 ASTM C109	"	"	"	"	–
Production									
Performance test ground anchor	Measured & tested for conformance (106.04)	Deformation	–	Subsection 256.08(b)(1)	5% or 3 minimum	Installation	No	5 days	–
Proof test ground anchor	"	"	–	Subsection 256.08(b)(2)	Each anchor	"	"	"	–

(1) Make grout cubes for testing from random batches of grout as directed. Normally, strength testing for permanent ground anchors will not be required as system performance will be measured by load holding each anchor. Grout cube testing will be required if admixtures are used or irregularities occur in anchor testing.

Section 257. — CONTRACTOR-DESIGNED RETAINING STRUCTURES

Description

257.01 This work consists of designing various types of retaining structures, including walls, reinforced soil slopes, and rockeries.

Material

257.02 Conform to the following Sections:

Driven piles	551
Gabions and revet mattresses	253
Mechanically stabilized earth walls	255
Micropiles	567
Permanent ground anchors	256
Reinforced concrete retaining walls	258
Reinforced soil slopes	261
Rockery, special rock embankment, and rock buttress	252
Soldier pile retaining walls	254
Soil nail retaining walls	259

Construction Requirements

257.03 Qualifications. Provide a wall designer who is a professional engineer proficient in the applicable design field and licensed in the state where the project will be constructed. At least 30 days before starting the design of retaining structures, submit examples of at least three similar retaining structures designed by the wall designer. Submit photos of each retaining structure with narrative descriptions of design method used, materials used, proprietary systems used (if any), constructability issues, and other pertinent information. Include the name, address, and telephone number for project owners.

257.04 Submittals. At least 30 days before starting Contractor-designed retaining structure construction, submit the following according to Subsection 104.06:

(a) Plan and elevation drawings for each structure containing the following:

(1) A plan view of the structure showing:

(a) Horizontal offset from the construction centerline to the face of the structure at defining points along the base. Include begin and end stations;

(b) Location, length, coverage ratio, and type of reinforcement or anchorage as applicable (such as strip, mesh, grid, geosynthetic fabric, and anchor);

(c) Centerline and size of drainage structures, drainage pipe, and other utilities behind, passing through, or passing under the structure; and

(d) Location, length, and offset from the face of wall to guardrail, guardwall, or parapet structures.

(2) An elevation view of the structure showing:

(a) Elevation and station at horizontal and vertical break points and at least every 50 feet along the top of the structure at the face;

(b) Elevation and station at the top of leveling pads and footings, at the top and tip of piling, and at least every 50 feet along the structure base;

(c) Length and type of reinforcement, anchorage, structure module, and lagging;

(d) Distance and elevation along the structure face to all steps in the base, footings, leveling pads, or lagging;

(e) Distance along the structure face to where changes in reinforcement or anchor lengths occur;

(f) Construction joints;

(g) Original and final ground-line;

(h) 1H:1V scale; and

(i) Location, length, minimum slope for drainage, and type of structure underdrain system.

(3) A typical cross-section view showing:

(a) Type and depth of facing elements and structural connections to reinforcing and anchorage elements;

(b) Structure batter or face slope;

(c) Length, spacing, and type of reinforcement, anchorage, structure module and corresponding limits of excavation, and reinforced fill placement zones;

(d) Location of guardrail or guardwall features or parapet structures. Include embedment depths, offset from structure facing, connection details with structure reinforcement or anchorage, and blockouts or other provisions to prevent damage to wall elements during guardrail construction;

(e) Original and final ground-line, including right-of-way limits; and

(f) Estimated or known location of subsurface soil and rock units.

(4) General construction notes;

(5) Horizontal and vertical curve data affecting the structure, including match lines or other details to relate structure stationing to centerline stationing; and

(6) Material list and summary of pay item quantities.

(b) Dimensions and schedules of reinforcing steel. Include reinforcing bar bending details, dowels, studs, or both for attaching the facing;

(c) Details and dimensions for foundations and leveling pads. Include steps in the footings or leveling pads;

(d) Details and dimensions for:

(1) Panels, modules, soldier piles, and lagging necessary to construct the structure;

(2) Reinforcing steel in structural elements;

(3) Details of proposed splices in reinforcements;

(4) Location of mesh, strip attachment, or anchor devices embedded in facing panels;

(5) Anchor no-load lengths, anchor bond lengths, anchor spacing, anchor angles and skews, centralizers, and anchor sheathing and corrosion protection; and,

(6) Piles, pile spacing, pile embedment depth, pile installation method, and pile corrosion protection.

(e) Details for the installation of structure drainage and underdrain systems;

(f) Details for constructing structures around drainage features, utilities, lighting foundations, traffic barriers, and other obstructions;

(g) Details for terminating structures and adjacent slope construction;

(h) Architectural treatment details;

(i) Design notes, a description of symbols, terminology, and computer programs used in the design of the structure; specify the bearing pressure beneath the structure footing, reinforced soil zone, or piles;

(j) Design criteria, loads, load and resistance factors, and soil, rock, and reinforcement parameters for each structure.; and

(k) Design calculations, assessment of temporary excavation stability, internal and external stability of earth retaining structures and reinforced soil slopes, joint, splice, and facing connection capacities, and relevant references for data used in the design.

Submit a checklist showing that each item specified in these requirements has been addressed in the design.

Update drawings when plan dimensions are revised due to field conditions or for other reasons.

257.05 General. Ensure that the wall designer and wall material suppliers take full responsibility for the success of the components provided by each party, and do not qualify the responsibility for the design information or calculations provided by the wall designer. Indemnify the Government from claims for infringement of proprietary rights by others without the consent of the patent holders or licensees.

Survey according to Section 152 and verify the limits of structure installation.

Arrange and conduct a pre-design conference following selection of the structure designer or supplier and before design work starts to discuss structure selection, constructability, design parameters, methods, and limitations. Include the CO, subcontractors, supplier, and the supplier's design engineer.

257.06 Design and Construction. Unless otherwise stated, design retaining structures according to AASHTO, *LRFD Bridge Design Specifications*. Design and construct retaining structures according to the approved drawings, and the following as applicable:

(a) Rockeries. Conform to Section 252. Design according to FHWA-CFL/TD-06-006, *Rockery Design and Construction Guidelines*, November 2006.

(b) Gabions. Conform to Section 253.

(c) Soldier pile retaining walls. Conform to Section 254.

(d) MSE walls. Conform to Section 255.

(e) Permanent ground anchors. Conform to Sections 256 and 552.

(f) Reinforced concrete retaining walls. Conform to Section 258.

(g) Soil nail retaining walls. Conform to Section 259.

(h) Reinforced soil slopes. Conform to Section 261. Design according to FHWA-NHI-10-025, *Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes – Volume II*.

(i) Micropiles. Conform to Section 567.

257.07 Acceptance. Design of the retaining structures will be evaluated under Subsection 106.02 and the applicable Sections listed in Subsection 257.06.

Survey will be evaluated under Section 152.

Measurement

257.08 Measure the Section 257 pay items listed in the bid schedule according to Subsection 109.02.

Payment

257.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 257 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for Contractor-designed retaining walls by the lump sum will be paid as follows:

(a) 50 percent of the pay item amount will be paid after the design submittal is approved.

(b) An additional 25 percent of the pay item amount will be paid after 50 percent of the retaining wall construction is completed.

(c) The remaining portion of the pay item amount will be paid after retaining wall construction is completed.

Section 258. — REINFORCED CONCRETE RETAINING WALLS

Description

258.01 This work consists of constructing reinforced concrete retaining walls.

Material

258.02 Conform to the following Subsections:

Geocomposite drain	714.02
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01
Soil and soil-aggregate materials	704.01

Construction Requirements

258.03 General. Survey according to Section 152 and verify the limits of wall installation. Design and construct temporary works according to Section 562. Conform to Section 257 for Contractor-designed reinforced concrete retaining walls.

Excavate and backfill according to Section 208.

258.04 Reinforcing Steel. Submit order lists and bending diagrams according to Subsection 104.06. Provide and place reinforcing steel according to Section 554.

258.05 Structural Concrete. Provide, place, finish, and cure structural concrete according to Section 552.

258.06 Backfilling. Install geocomposite sheet drain system according to Subsection 605.05. Backfill the area behind the wall with structural backfill according to Subsection 208.09. Compact each lift according to Subsection 208.10, except use an approved lightweight mechanical or vibratory compactor within 36 inches of the wall.

Do not place structural backfill against concrete until 80 percent of the design strength is attained.

258.07 Acceptance. Material for reinforced concrete retaining walls will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of reinforced concrete retaining walls will be evaluated under Subsections 106.02 and 106.04.

Concrete will be evaluated under Section 552.

Reinforcing steel will be evaluated under Section 554.

Excavation and backfill will be evaluated under Section 208.

Survey will be evaluated under Section 152.

Temporary works will be evaluated under Section 562.

Measurement

258.08 Measure the Section 258 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring retaining walls by the square foot, measure by the front face of wall excluding footings.

Payment

258.09 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the Section 258 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for reinforced concrete retaining wall will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is calculated as follows:

$$PF_{material} = 1 - 0.5\,(1\text{-}PF)$$

where:

$PF_{material}$ = Material pay factor
PF = Pay factor for concrete as determined under Section 552.

Section 259. — SOIL NAIL RETAINING WALLS

Description

259.01 This work consists of constructing soil nail retaining walls.

259.02 Definition. For soil nail retaining walls, a lift is defined as a stable height of unsupported excavation before application of shotcrete, typically midpoint between rows of soil nails.

Material

259.03 Conform to the following Subsections:

Bolts and nuts	717.01(d)
Centralizers and spacers	722.02(e)
Geocomposite drain	714.02
Neat hydraulic cement grout	701.04(a)
Soil nails	722.04
Soil and soil-aggregate materials	704.01
Structural carbon steel (bearing plates)	717.01(a)(4)
Welded stud shear connectors	717.05

Construction Requirements

259.04 Qualifications. Provide a professional engineer, an on-site supervisor, and installation personnel with experience installing and testing soil nails. At least 30 days before starting soil nail retaining wall work, submit a résumé and copies of applicable certifications for each individual describing their experience on at least five soil nail retaining wall projects of similar complexity within the past 5 years for approval. Include project names, locations, and contact information for project owners.

259.05 Submittals. At least 30 days before starting soil nail retaining wall work, submit the following according to Subsection 104.06:

(a) Start date;

(b) Method of excavation to ensure wall and slope stability;

(c) Retaining wall construction sequence;

(d) Soil nail types, sizes, spacings, depths, and installation angles, bond zone lengths, and ultimate tendon strengths for the range of material to be encountered;

(e) Tendons, couplers, bearing plates, facing items, and additional hardware with the manufacturer's product technical data sheets, specifications, catalog cuts, and mill certificates;

(f) Manufacturer's recommendations for tendon and hardware handling, storing, assembly, and working temperature ranges;

(g) Grout type, mix design, mixing equipment, placement procedures, and 3-day and 28-day grout compressive strength test results;

(h) Procedures and material for repairing corrosion protection coatings in the field and for applying epoxy finish coatings on end hardware;

(i) Drilling methods and equipment;

(j) Drill hole diameter to achieve the specified pullout resistance;

(k) Alternative drilling and grouting methods (such as grout additives);

(l) Additional material needed to achieve required bond capacities (such as grout socks);

(m) Methods to ensure borehole stability during excavation and grout placement;

(n) Soil nail testing methods and equipment. Include type and capacity of reaction load system, load test increments, drawings, and supporting calculations for structural components of the soil nail load test apparatus; and

(o) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

259.06 General. Conform to Section 257 for Contractor-designed soil nail retaining walls. Survey according to Section 152 and verify the limits of wall installation.

Clear the work area of vegetation and obstructions according to Sections 201 and 203. Excavate according to Section 209 for the wall in staged lifts concurrent with soil nail installation and shotcrete placement. Do not allow the exposed unsupported final excavation face cut height to exceed the vertical soil nail spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Do not excavate to the next lower lift until soil nail installation, reinforced shotcrete placement, attachment of bearing plates and nuts, and soil nail testing have been completed and approved for the current lift. Cure grout and shotcrete at least 72 hours or attain the specified 3-day compressive strength before excavating the next underlying lift. Application of the shotcrete may be delayed up to 24 hours if it can be demonstrated the delay will not adversely affect the excavation face stability.

Handle and store material according to Subsection 256.06.

259.07 Tendon Fabrication. Provide tendons designed to carry loads consistent with the approved drawings. Provide threaded tendon ends so they can withstand the approved test loads in addition to accommodating the attachment of the bearing plate, beveled washer, nut, or other appurtenances. Limit coupling of tendons to two per installation. Use couplers manufactured with a center stop to ensure equal length of thread connects each section. Do not use couplers that interfere with the flow of grout. Protect couplings from corrosion using the same corrosion protection used on the soil nail tendon assembly. Use centralizers to position the tendon within 1 inch of the center of the drill hole. Use centralizers that do not impede the free flow of grout into the drill hole. Position centralizers within 24 inches from the top and bottom of the tendon and with center-to-center spacing of 10 feet or less. Secure centralizers to the tendon to prevent shift during handling or inserting into the drill hole.

259.08 Installation.

(a) Drilling. Drill soil nail holes at the required locations and orientations. Use drilling equipment and methods suitable for the ground conditions. Do not use water, drilling slurry, or other fluids for drilling or removing cuttings.

Insert the soil nail tendon into the hole. Clean or redrill holes if the tendon with centralizers cannot be completely inserted without forcing or driving.

(b) Grouting. Use a positive displacement grout pump according to Subsection 256.07(b)(1).

Grout tendons into holes using a neat hydraulic cement grout. Mix grout as recommended by the cement supplier at the specified water-to-cementitious material ratio. Inject grout within 45 minutes of adding the cement to the water or within 15 minutes after mixing when the ambient temperature is 90 °F or higher. Do not allow the grout temperature to exceed 90 °F.

Grout the hole within 2 hours of completing drilling.

Inject the grout at the lowest point of each hole. Place primary and secondary grout stages in one continuous operation. Keep the outlet end of the grout tube below the surface of the grout as the tube is withdrawn to prevent voids. Control grout pressures to avoid ground heaving or fracturing. Record the quantity of injected grout and the grout pressure for each soil nail installation. After grouting is complete, fill the grout tube with grout if it will remain in the hole.

Maintain the temporary unbonded length of proof test soil nails open for later grouting. If the unbonded test length of production proof test soil nails cannot be satisfactorily grouted after testing, install a new soil nail in its place.

259.09 Testing and Stressing.

(a) Testing equipment. Provide equipment conforming to Subsection 256.08(a).

(b) Stressing. Place stressing equipment over the soil nail so that the jack, bearing plates, load cells, and stressing assembly are axially aligned with the tendon and the tendon is centered within the equipment. Do not apply loads greater than 80 percent of the minimum guaranteed ultimate tensile strength of the tendon for Grade 150 bars, or 90 percent of the minimum guaranteed ultimate tensile strength of the tendon for Grade 60 or 75 bars. Do not test soil nails until the soil nail grout and shotcrete facing have cured for at least 72 hours and attained the specified 3-day compressive strength.

Place the reference pressure gauge in series with the pressure gauge and jack so they need not be unloaded and repositioned during a test. Raise the load from one increment to another. Hold the load for the required time starting immediately after the load is applied and record the soil nail head movement to the nearest 0.001 inch with respect to an independent fixed reference point. Repump the jack as necessary to maintain a constant load. Monitor the load with a pressure gauge. If the load measured by the pressure gauge and the load measured by the reference pressure gauge differ by more than 10 percent, recalibrate the jack, pressure gauge, and reference pressure gauge.

(1) Verification test. Perform sacrificial verification tests at locations shown in the plans or as directed.

Provide verification test soil nails with a minimum unbonded length of 3 feet and a minimum bonded length of 10 feet. Grout with the same methods, equipment, and materials as will be used for the production nails.

Use the following formula to determine the maximum bonded length for Grades 60 or 75 steel:

$$L_{B\ VT\ max} = \frac{A_t \times f_y \times C_{RTY}}{R_{PO}}$$

Use the following formula to determine the maximum bonded length for Grade 150 steel:

$$L_{B\ VT\ max} = \frac{A_t \times f_u \times C_{RTU}}{R_{PO}}$$

where:

$L_{B\ VTmax}$ = Maximum verification test soil nail bonded length (ft)

C_{RTY} = Reduction coefficient for mild grade steel = 0.9 for grades 60 or 75 bars

C_{RTU} = Reduction coefficient for high strength steel = 0.8 for grade 150 bars

f_y = Yield strength of test tendon for mild steel (psi)

f_u = Ultimate tensile strength of test tendon for high-strength steel (psi)

A_t = Cross-sectional area of the test tendon (in^2)

R_{PO} = Nominal pullout resistance (per unit length) of soil nail = $\pi \times q_u \times D_{dh}$

Determine the design test load by the following equation:

VTL = $L_{B\ VT} \times R_{PO}$

where:

VTL = Verification test load (lb)

$L_{B\ VT}$ = Bonded test length (ft) as determined from test residual elongation

Provide a larger bar size if necessary for safety. Test according to Table 259-1 and see Table 259-5 for acceptance criteria.

Table 259-1
Verification Test Load Schedule

Test Load Increment	Hold Time (minutes)[(2)]
AL[(1)]	1 (Record at 0, 1)
0.10VTL	10 (Record at 0, 1, 2, 4, 5, 10)
0.20VTL	10 (Record at 0, 1, 2, 4, 5, 10)
0.30VTL	10 (Record at 0, 1, 2, 4, 5, 10)
0.40VTL	10 (Record at 0, 1, 2, 4, 5, 10)
0.50VTL	10 (Record at 0, 1, 2, 4, 5, 10)
0.60VTL	10 (Record at 0, 1, 2, 4, 5, 10)
0.70VTL	10 (Record at 0, 1, 2, 4, 5, 10)
0.80VTL (Creep Test)	60 (Record at 0, 1, 2, 4, 5, 10, 20, 30, 50, 60)
0.90VTL or failure	10 (Record at 0, 1, 2, 4, 5, 10)
1.00 VTL or failure (Maximum acceptance load)	10 (Record at 0, 1, 2, 4, 5, 10)
AL[(1)]	1 (Record at 0, 1)

(1) No greater than 2.5 percent of VTL (0.025VTL) applied to the soil nail before setting the movement recording devices. Zero dial gauges after the first setting of AL.
(2) Hold the load to within 2 percent of the test load increment and measure.

Provide a written report confirming soil nail geometry, construction, testing details, and verification test results for approval before installing production soil nails.

(2) Proof tests. The CO will designate production soil nails for proof testing, including 5 percent of the nails in a row and at least one per each day of production.

Provide production proof test soil nails with a minimum temporary unbonded length of 3 feet and a minimum bonded length of 10 feet.

Use the following formula to determine the maximum bonded length for Grades 60 or 75 steel:

$$\mathrm{L}_{\mathrm{B\ PT\ max}} = \frac{\mathrm{A_t} \times \mathrm{f}_y \times \mathrm{C_{RTY}}}{R_{\mathrm{PO}} \times 0.75}$$

Use the following formula to determine the maximum bonded length for Grade 150 steel:

$$\mathrm{L}_{\mathrm{B\ PT\ max}} = \frac{\mathrm{A_t} \times \mathrm{f_u} \times \mathrm{C_{RTU}}}{R_{\mathrm{PO}} \times 0.75}$$

where:

$L_{B\ PTmax}$ = Maximum verification test soil nail bonded length (ft)

C_{RTY} = Reduction coefficient for mild grade steel = 0.9 for grades 60 or 75 bars

C_{RTU} = Reduction coefficient for high strength steel = 0.8 for grade 150 bars

f_y = Yield strength of test tendon for mild steel (psi)

f_u = Ultimate tensile strength of test tendon for high-strength steel (psi)

A_t = Cross-sectional area of the test tendon (in^2)

R_{PO} = Nominal pullout resistance (per unit length) of soil nail = $\pi \times q_u \times D_{DH}$

q_u = Bond strength

D_{DH} = Drill hole diameter

Determine the design test load by the following equation:

$$PTL = L_{B\ PT} \times R_{PO} \times 0.75$$

where:

PTL = Proof test load (lb)

$L_{B\ PT}$ = Bonded test length (ft) as determined from test residual elongation

Test according to Table 259-2 and see Table 259-6 for acceptance criteria.

Table 259-2
Proof Test Load Schedule

Test Load Increment	Hold Time (minutes)
AL(1)	1 (Record at 0, 1)
0.10PTL(2)	Until movement stabilizes(3)
0.30PTL(2)	"
0.50PTL(2)	"
0.70PTL(2)	"
0.80PTL(2)	"
1.00PTL (Creep Test)	60(4)
AL(1)	1 (Record at 0, 1)

(1) No greater than 2.5 percent of PTL (0.025PTL) applied to the soil nail before setting the movement recording devices. Zero dial gauges after the first setting of AL
(2) Times are measured at the and after the target load value has been achieved in each increment.
(3) Hold each load increment for 10 minutes and to record the soil nail movement at 1, 2, 5, and 10 minutes if the movement does not stabilize after 1 minute.
(4) Hold the load to within 2 percent and measure and record soil nail movement at 1, 2, 3, 5, 6, and 10 minutes. When the soil nail movement between 1 and 10 minutes exceeds 0.04 inch, continue measuring and recording soil nail movement at 20, 30, 50, and 60 minutes.

(c) Test results and reporting. Provide preliminary results to the CO for each soil nail tested before testing personnel leave the site. Submit detailed verification and proof test load and deflection data in a tabular format. Submit a graph that plots total soil nail movement versus load, the A-line, and the B-line. The A-line is defined as 0.8 multiplied by the theoretical free test length elastic elongation. The B-line is defined as the theoretical free test length elastic elongation plus 0.50 multiplied by the theoretical bond length elastic elongation. Allow 5 days for the CO to conduct a review of the data and approve ground anchor installation.

259.10 Wall Drainage Network. Install required elements of the wall drainage network before applying shotcrete to each lift.

Install geocomposite sheet drain system according to Subsection 605.05. Center geocomposite sheet drains between soil nail columns with the geotextile filter side against the ground. Install additional sheet drains at wet locations and as requested. Secure sheet drains to the excavated face to prevent shotcrete from contaminating the ground side of the geotextile. Construct sheet drain splices according to the manufacturer's recommendations.

Install underdrains at the bottom of the wall according to Section 605.

259.11 Wall Construction. Place welded wire steel mesh and reinforcing steel according to Section 554.

Construct a shotcrete construction facing according to Section 566. Completely fill ungrouted zones of soil nail drill holes or other voids with shotcrete.

Attach a bearing plate and nut to each soil nail head. Uniformly seat the plate by tightening the nut with a hand wrench while the shotcrete is still plastic. Where uniform contact between the plate and the shotcrete cannot be provided, set the plate in a bed of grout and tighten the nut with a hand wrench after the grout has set for 24 hours.

Construct wall elements to the tolerances shown in Table 259-3.

Table 259-3
Wall Element Construction Tolerances

Wall Element	Tolerance
Horizontal location of headed studs, from plan location	⅜ inch
Location of headed studs on bearing plate, from plan location	¼ inch
Soil nail head bearing plate, deviation from parallel to wall face	10 degrees

259.12 Permanent Wall Facing. Construct the permanent wall facing according to the applicable Section below.

(a) Shotcrete-faced walls. Construct according to Section 566 and to the construction tolerances shown in Table 259-4.

(b) Concrete-faced walls. Construct according to Section 258.

(c) Simulated stone masonry. Construct according to Section 613.

(d) Stone masonry. Construct according to Section 620.

(e) Precast concrete panels. Construct according to Section 578. Use concrete class A(AE). Erect panels by lifting devices connected to the upper edge of the panel. Construct joints between panels according to the manufacturer's recommendations.

Table 259-4
Permanent Shotcrete Facing Construction Tolerances

Facing Finish	Tolerance, inch
Complete thickness of shotcrete, from plan dimension:	
Troweled or screeded finish	±⅝
Shot finish	±1⅛
Planeness of finish face, surface gap under a 10-foot straightedge:	
Troweled or screeded finish	⅝
Shot finish	1⅛

259.13 Backfilling Behind Wall Facing Upper Cantilever Section. Backfill behind the wall with structural backfill according to Subsection 209.09. Use light mechanical tamper to compact within

36 inches behind the wall facing section. Do not compact behind cantilever until permanent facing concrete or shotcrete has cured at least 7 days.

259.14 Acceptance. See Table 259-7 for sampling, testing, and acceptance requirements.

Material for the soil nails will be evaluated under Subsections 106.03 and 106.04. Submit a production certification with each shipment of soil nails.

Construction of soil nail retaining walls will be evaluated under Subsections 106.02 and 106.04.

Clearing of vegetation will be evaluated under Section 201.

Reinforcing steel will be evaluated under Section 554.

Removal of obstructions will be evaluated under Section 203.

Excavation and backfill will be evaluated under Section 209.

Survey will be evaluated under Section 152.

Underdrains will be evaluated under Section 605.

Installed soil nails will be evaluated based on the criteria in Table 259-6.

Verification test soil nails will be evaluated based on the criteria in Table 259-5.

Table 259-5
Verification Test Soil Nail Criteria

Total Load-Test Hold Movement at 0.80 VTL	Total Movement at Maximum Load	Pullout Failure(2)
< 0.080 inch between 6 and 60 minutes(1)	A-line criteria: Greater than 80% of the apparent elastic elongation of the test soil nail unbonded length.	No pull-out at 1.00 VTL
	B-line criteria: Less than the apparent elastic elongation of the test soil nail unbonded length and half of the bond length.	

(1) And the rate of movement is linear or decreasing throughout the load-hold period.
(2) Pullout failure is the inability to further increase the test load while there is continued pullout movement of the test soil nail. Record the pullout failure load as part of the test data.

If the soil nail verification is unacceptable, establish the cause and make design or construction modifications. Submit modifications requiring changes to the structure and retest the new system as directed.

Table 259-6
Proof Soil Nail Acceptance Criteria

Total Load-Hold Movement at PTL	Total Movement at Maximum Load	Pullout Failure[(2)]
< 0.040 inch between 1 & 10 minutes or < 0.080 inch between 6 & 60 minutes[(1)]	A-line criteria: Greater than 80% of the apparent elastic elongation of the test soil nail unbonded length.	No pull-out at 1.00 PTL
	B-line criteria: Less than the apparent elastic elongation of the test soil nail unbonded length & half of the bond length.	

(1) And the rate of movement is linear or decreasing throughout the load-hold period.
(2) Pullout failure is the inability to further increase the test load while there is continued pullout movement of the test soil nail. Record the pullout failure load as part of the test data.

If a proof-tested soil nail is unacceptable, replace some or all the installed production soil nails between the unacceptable proof test soil nail and the next proof test soil nail in the row as directed. Alternatively, install additional proof test soil nails within this area to ensure that the acceptance criteria are met within this area. Propose alternative installation and testing methods before installing additional soil nails. If ground conditions, soil nail installation methods, or testing procedures change, conduct additional verification testing before proceeding with production soil nail installation.

Measurement

259.15 Measure the Section 259 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring soil nail retaining walls by the square foot, measure the front wall face.

When measuring verification test soil nails by the each, do not measure failed verification test soil nails or additional verification test soil nails installed to verify alternative soil nail installation methods proposed by the Contractor.

When measuring production soil nails by the linear foot, measure along bar centerline from the line of the wall excavation face to the tip of the soil nail.

Payment

259.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 259 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 259-7
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Neat hydraulic cement grout (701.04(a))	Measured & tested for conformance (106.04)	Compressive Strength(1)	–	AASHTO T 106	1 per mix design	Source of material	Yes	30 days before production	–
Production									
Neat hydraulic cement grout (701.04(a))	Measured & tested for conformance (106.04)	Compressive Strength(1)	–	AASHTO T 106	1 per row or day(2)	Source of material	Yes	28 days	–
Verification test soil nail	Measured & tested for conformance (106.04)	Performance	–	Subsection 259.09(b)(1)	Each soil nail	Installed	No	7 days	–
Proof test soil nail	"	"	–	Subsection 259.09(b)(2)	"	"	"	5 days	–

(1) At 3-day and 28-day.
(2) If three successive samples are tested and compliance to the specifications is indicated, screening tests may be reduced to an approved frequency.

Section 260. — ROCK BOLTS AND DOWELS

Description

260.01 This work consists of providing and installing rock bolts and dowels.

260.02 Definitions.

(a) Rock bolt. Fully grouted, deformed steel bars that are post-tensioned, installed entirely in rock, and actively reinforce a rock mass.

(b) Rock dowels. Fully grouted, deformed steel bars that are untensioned, installed entirely in rock, and passively reinforce a rock mass.

Material

260.03 Conform to the following Subsections:

Non-shrink grout	701.04(b)(2)
Rock bolts and rock dowels	722.03
Water for cementitious materials	725.01(a)

Construction Requirements

260.04 Qualifications. Provide an on-site drill foreperson and drill operators with experience installing and testing rock bolts and dowels. At least 21 days before starting rock bolt and dowel work, submit the following for approval:

(a) Drill foreperson. A résumé for the drill foreperson describing five projects within the past 5 years that the drill foreperson has completed with at least 3000 linear feet of rock bolts and dowels installed according to similar contract requirements;

(b) Drill operators. A résumé for each drill operator describing three projects within the past 5 years that each drill operator has completed safely and satisfactorily with at least 1000 linear feet of rock bolts and dowels installed according to similar contract requirements; and

(c) Rope supported laborers. A résumé for rope supported laborers conforming to Subsection 262.02.

260.05 Submittals. At least 21 days before starting rock bolt and dowel work, submit the following according to Subsection 104.06:

(a) Proposed construction sequence and schedule;

(b) Proposed drilling methods and equipment;

(c) Proposed drill hole diameter and the minimum bond zone length for design loads shown in the plans. Design minimum bond zone lengths according to PTI, *Recommendations for Prestressed Rock and Soil Anchors*;

(d) Proposed rock bolt and dowel type, couplers, bearing plate, washers (flat and beveled), nut, stressing anchorages, centralizers, and bond breakers (if applicable) with specifications including manufacturer's data sheets, and brochures. Include manufacturer's verification for the bearing plate thickness for the specified rock bolt and dowel capacities;

(e) Manufacturer's recommendations for bar and hardware handling, storing, and working temperature ranges;

(f) Non-shrink cement grout type, mix design, 3-day and 7-day compressive strength test results, placement procedures, manufacturer's SDS and brochures, and mixing equipment for each of the following stages of non-shrink cement grouting:

(1) Two-stage grouting. Means for determining the level of primary (first-stage) grout in the hole;

(2) Single-stage grouting. Fabrication details for proposed bond-breaker in the free stressing zone including corrosion inhibiting compounds, if applicable;

(g) Manufacturer certification for corrosion-resistant bar coating and procedures and material for repairing corrosion protection coatings in the field;

(h) If open joints, seams, or loose material is encountered, the methods, equipment, and materials used to control excessive grout injection volumes;

(i) Details for placing, stressing, and testing rock bolts and dowels. Schedule of a test installation to demonstrate rock bolt and dowel installation, testing equipment, and procedures. The proposed rock bolt stressing equipment, setup, and procedures that will be used for the performance and proof testing;

(j) If required, a detailed procedure for placing the anchor head assembly (bearing plate and nut) below the exposed rock surface or for removing the anchor head assembly following final lock-off without impacting the bar design load. Include details for a countersink or flush-cut with a colored grout patch, if applicable;

(k) Special installation methods (such as upwardly inclined rock bolts and dowels, techniques for constructing bearing pads, grouting across open joints and debris-filled discontinuities) if applicable;

(l) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell to be used for testing. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 90 days; and

(m) Report documentation examples including installation and testing report formats.

260.06 Rock Bolt and Dowel Fabrication.

(a) General. Fabricate rock bolts and dowels according to PTI, *Recommendations for Prestressed Rock and Soil Anchors*. Deliver rock bolts and dowels to the job site in bulk lengths and field cut to the appropriate lengths after drilling for each rock bolt and dowel. Do not precut rock bolts and dowel steel bars at the factory. Size bars to ensure:

(1) The design load does not exceed 60 percent of minimum ultimate tensile strength of the bar; and

(2) The maximum test load does not exceed 80 percent of the minimum ultimate tensile strength of the bar.

(b) Couplers. Couple only fully-grouted anchors. Couple sections together only if the design length exceeds the standard commercially available bar lengths. Use couplers with a center stop to ensure equal length of thread connects each section. Do not use couplings that interfere with the flow of grout.

(c) Anchorage. For the stressing anchorage, use a steel bearing plate, washers (flat hardened, beveled or, spherical, as required), and a nut that can develop 95 percent of the minimum ultimate tensile strength of the bar.

(d) Centralizers. For cement grouted rock bolts and dowels, place centralizers along the bar at 10-foot centers, with at least one centralizer per rock bolt or dowel. Locate the lowermost centralizer within 12 inches of the end. Use centralizers of sufficient strength to support the bar in the drilled hole and provide at least 0.5 inch of grout cover around it. Do not place centralizers on the bond breaker.

260.07 Handling and Storing Material. Handle and store bars according to ASTM A767 and D3963 guidelines and the manufacturer's recommendations. Repair or replace bars with damage to corrosion protection coatings as required by ASTM A767 and D3963.

Handle, transport, and store hardware material according to the manufacturer's recommendations. Protect finishes from abrasions that remove the darkened color.

Repair minor damages to epoxy coated, galvanized, and weathered surfaces. Repair galvanized finishes according to Section 563.

260.08 Installation. Before installing rock bolts and dowels, complete on-slope rock stabilization work as applicable.

Perform safety scaling that the Contractor deems necessary according to Section 262.

If applicable, treat exposed galvanized steel surfaces according to Section 563.

Provide and install rock bolts and dowels with a minimum design capacity as shown in the plans.

(a) Drilling. Provide equipment able to drill straight, uniform-diameter holes no larger than 4 inches in diameter. Do not use water or drilling slurry. Drill rock bolt and dowel holes to the minimum depths shown in the plans, and within 6 inches of the required location. Adjust total bolt and dowel lengths to address existing subsurface conditions encountered. Unless otherwise shown in the plans, drill rock bolts and dowels perpendicular to rock faces or inclined slightly downward (0 to 5 degrees) from the axis perpendicular to the rock face. Size drill hole diameters to provide at least 0.5 inch of grout cover around bars. Clean drill holes of cuttings, sludge, and debris. If rock bolts and dowels cannot be installed in a drilled hole, re-drill the hole. Do not use hand drills to advance holes unless approved.

(b) Grouting. Install rock bolts or dowels no more than 24 hours after completing drill holes. Orient reinforcement no more than 5 degrees outside of the specified angle. Complete first-stage grouting no more than one week after rock bolt and dowel installations. Tension each rock bolt and dowel no more than one week after completing first stage grouting. Complete second stage grouting no more than 3 days after successful post tensioning, wherever two-stage grouted rock bolts are installed.

Use positive displacement grout pumps according to Subsection 256.07(b)(1).

Install steel bars and grout according to the manufacturer's recommendations. Incorporate an acceptable bond breaker where rock bolts are grouted in a single stage. Where grouting rock bolts in two stages, completely fill the minimum bond zone length under stage one, and after successful post tensioning of the bolt fill the free-stressing (unbonded) length with grout under stage two. Control grout pressures to avoid ground heaving or fracturing, and fill grout tube with grout when it will remain in the hole.

Flush surplus water and diluted grout from lines before injection and replace leaky fittings before continuing grouting operations. Clean excess grout off rock surfaces, rock bolts and dowels, and bearing plates. Perform QC of the grout by performing minimum compressive strength tests, and submit test results to the CO.

Record the quantity of injected grout and the grout pressure for each installation. Notify the CO of grout quantity overruns including the reason for the overrun and proposed actions to minimize future overruns. Obtain approval for alternative grouting methods.

(c) Bearing plate installation. Install bearing plates so at least three-quarters of the plate's surface is in contact with a rock face. If rock faces are irregular or unsound, chip out surrounding rock or construct an approved bearing pad. Ensure that the rock bolt or dowel axis is within 20 degrees of being perpendicular to the bearing plate and that the bar passes through bearing plate center without bending. Use beveled washers where the bar axis is more than 5 degrees from the bearing plate perpendicular. Allow at least 6 inches of bolt and dowel length beyond the nut and washers. Use oversized bearing plates as approved where rock surfaces are weak or highly weathered.

After load-testing and acceptance, tension and lock-off the rock bolts, place the second stage of non-shrink grout in the entire free stressing length, and remove excess grout from rock faces and anchorage assembly hardware.

Ensure the bar is fully encapsulated in grout to the collar of the hole. Check grout levels through key-holes the day after grout filling and fill the annulus space with grout as needed using a tremie tube. Repeat grout level checks and grout filling procedures until a fully grouted annulus space is achieved.

260.09 Rock Bolt Testing, Stressing, and Finishing. Conduct testing of tensioned and untensioned rock bolts according to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

If applicable, trim the corrosion protection surrounding the free stressing length of the bar so it does not contact the bearing plate during testing and stressing. For single stage cement grouted rock bolts, tension the bar after the bond zone grout is set and attains sufficient pull-out strength. For two-stage cement grouted rock bolts, tension the bar after the bond zone grout is set and attains sufficient pull-out strength and before the free stressing length is grouted.

(a) Performance tests. Before starting production bolting, design rock bolts and construct test bolts for each rock type according to the approved submittal drawings. Do not start production bolting for a rock type until the CO approves the constructed test bolt, rock bolt design, and construction methods for that rock type. Perform at least two successful performance tests for each different rock unit, anchor type, and proposed drilling-installation-grouting method before starting production rock bolt installation. Performance tests may be required on bolts shown in the plans, or in sacrificial locations, if reasonable access for inspection is not provided according to FAR Clause 52.246-12 Inspection of Construction.

Use a calibrated hollow-ram hydraulic jack and gauge with graduations of 200 pounds per square inch or less to tension rock bolts. Tension rock bolts to 133 percent of the design load, and maintain the tension at least 10 minutes, and no more than 60 minutes if needed, with a maximum load tolerance of 200 pounds per square inch. Apply loads and record extensions under loads with a tool that can measure to 1 mil. Conduct loading according to Table 260-1. The Design Load (DL) during the testing is as shown in the plans. The alignment load (AL) is the minimum load required to align the testing apparatus and should not exceed 10 percent of the DL.

Table 260-1
Performance Test Loading Schedule

Load	Hold Time
AL	Obtain reading
0.25DL	Obtain reading
0.50DL	Obtain reading
0.75DL	Obtain reading
1.00DL	Obtain reading
1.20DL	Obtain reading
1.33DL	Obtain reading
"	1 minimum
"	2 minimum
"	3 minimum
"	4 minimum
"	5 minimum
"	6 minimum
"	10 minimum
"	60 minimum (if needed)
AL	Obtain reading
DL	Lockoff

Submit rock bolt test results to the CO for further analysis. Rock bolts are acceptable when the following conditions are met:

(1) The total elastic movement obtained at the maximum test load exceeds 80 percent of the theoretical elastic elongation of the free stressing length;

(2) The total elastic movement obtained at the maximum test load does not exceed the theoretical elastic elongation of 100 percent the free stressing length plus 50 percent of the bond length plus the jack length;

(3) The rock bolt carries the maximum test load with a creep rate less than 0.04 inch from the 1-minute reading to the 10-minute reading, or 0.08 inch per log cycle of time from the 6-minute reading to the 60-minute reading; and

(4) The CO approves submitted test results in writing.

Perform additional performance tests if installations fail to meet the test criteria.

(b) Proof testing. Proof test each rock bolt by tensioning bolts applying and maintaining 133 percent of the design load for 10 minutes. Rock bolts are acceptable when no loss of load occurs during the proof test. Replace failed rock bolts at no additional cost to the Government and document the expected reasons for failure to address and rectify deficiencies in the rock bolt installation methods used for given site conditions. Adjust rock bolt installation methods as approved before installing additional rock bolts.

After rock bolts are acceptable, lower the tension and lock off the load at 100 percent of the design load with a nut and a flat or beveled washer as needed to ensure that the nut is flush against the bearing plate. Grout the remaining portion of the rock bolt no more than 72 hours after re-tensioning and lock off.

(c) Finishing. Trim completed rock bolt ends to within 6 inches of the rock face. Treat field cuts, repair damages to galvanization, and repair and finish exposed steel surfaces according to Section 563.

260.10 Rock Dowel Lift-Off Testing and Finishing. Test rock dowels according to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

Test only fully grouted dowels. Conduct at least two successful lift-off tests for each different rock unit, anchor type, and proposed method of drilling, installation, and grouting. Gradually load lift-off test reinforcements to 60 percent of the minimum ultimate tensile strength of the dowel bar and monitor the pressure gauge to verify the anchor is holding the design load for at least 10 minutes. Test 5 percent of the remaining dowels if the anchors do not pull out. Replace the dowel and conduct lift-off tests on remaining rock dowels when pressure gauge drops are due to anchorage movements. Apply 100 foot-pounds of torque to ensure proper seating against the rock face. Trim completed rock dowel ends to within 6 inches of the rock face.

260.11 Drilling Logs, Test Results, and Reporting. Submit drilling logs and test results to the CO for review. Maintain daily records of rock bolt and dowel work including the following:

(a) Drawings depicting the location of each anchor on post-scaled photographs, noting anchor designation, date drilled, general drilling logs that note the drilling conditions and materials encountered, the location of significant drilling changes (geologic contacts, voids, or open fractures), dates of grouting operations, total anchor length, bonded length, free stressing length, grout mix, grout volume, average grout pressure, hole diameter, size of bar, bar inclination, and installation comments. Submit as-built drawings according to Subsection 104.06(c).

(b) Performance and proof test data forms, including the anchor designation, bonded length, free stressing length, stressing length, date of stressing operation, signature of stressing operator or inspector, required elongation and associated gauge pressure, actual elongation and associated gauge pressure, identification numbers of jacking equipment, comments, and a table including incremental jack pressure, jack load, and movement.

260.12 Acceptance. See Table 260-2 for sampling, testing, and acceptance requirements.

Material for rock bolts and dowels will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of rock bolts and dowels will be evaluated under Subsections 106.02 and 106.04.

Grouting will be evaluated under Subsections 106.02 and 106.04.

Safety scaling will be evaluated under Section 262.

Treating exposed surfaces and repairing galvanized surfaces will be evaluated under Section 563.

Measurement

260.13 Measure the Section 260 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring rock bolts and dowels by the linear foot, measure from the trimmed steel end to 6 inches from the slope face. Do not measure rock bolts and dowels that failed testing.

Payment

260.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 260 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 260-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (fine) (703.01)	Measured & tested for conformance (106.04 & 105)	Quality	–	AASHTO M 6	1 per Material type	Source of material	Yes	Before producing	–
Mix Design									
Non-shrink grout (701.04(b)(2))	Measured & tested for conformance (106.04)	Flow	–	AASHTO C939	1 per mix design	Source of material	Yes, if requested	Before producing	–
		Compressive Strength (3-day & 7-day)	–	ASTM C109	1 per mix design	Source of material	Yes, if requested	Before producing	–
Production									
Non-shrink grout (701.04(b)(2))	Measured & tested for conformance (106.04)	Compressive Strength (3-day & 7-day)	–	ASTM C109	1 set from each batch of grout	Source of material	Yes, if requested	Within 24 hours after completion of test	–
Performance test for rock bolts	Measured & tested for conformance (106.04)	Deformation	–	Subsection 260.09(a)	Subsection 260.09(a)	Installation	No	Within 24 hours after completion of test	–
Proof test for rock bolts	Measured & tested for conformance (106.04)	Deformation	–	Subsection 260.09(b)	Each bolt	Installation	No	Within 24 hours after completion of test	–
Lift-off test for rock dowel	Measured & tested for conformance (106.04)	Deformation	–	Subsection 260.10	Subsection 260.10	Installation	No	Within 24 hours after completion of test	–

Section 261. — REINFORCED SOIL SLOPES

Description

261.01 This work consists of constructing reinforced soil slopes.

Material

261.02 Conform to the following Subsections:

Crushed aggregate	703.06
Reinforcement geotextile and geogrid	714.04
Soil and soil-aggregate materials	704.01
Wall facing fill	705.09
Wire facing and backing mat	720.01(b)

Construction Requirements

261.03 Submittals. At least 30 days before starting reinforced soil slope work, submit the following according to Subsection 104.06:

(a) Manufacturer's certification. Certification and test results indicating the proposed reinforcement material and facing material meets requirements; and

(b) Facing details. Provide installation methods and connection details for facing system.

261.04 General. Conform to Section 257 for Contractor-designed reinforced soil slope systems.

Survey according to Section 152 and verify the limits of the reinforced soil slope installation.

Excavate and prepare foundation soils for the reinforced soil slope according to Section 204. Conserve topsoil according to Subsection 204.05.

Grade the foundation soils supporting the reinforced soil slope for a width equal to the length of the lowest soil reinforcement level. Step the reinforced soil slope into existing slopes according to Subsection 204.09(d).

Construct a leveling pad from crushed aggregate or the specified material if shown in the plans.

Install underdrain system according to Section 605 if shown in the plans.

261.05 Soil Reinforcement and Facing. Lay each layer of soil reinforcement flat, pull tight, and hold in place with pins, soil piles, or other approved methods. Construct the reinforced soil slope to achieve the slopes specified and roadbed tolerances according to Subsection 204.13(c).

Grade and compact RSS backfill according to Subsections 204.09 and 204.11 before placing the next soil reinforcement layer. Maintain a minimum cover of 6 inches over the reinforcement during spreading and compacting of fill material. Avoid sudden stops, starts, and turns of the equipment. Do not use sheepsfoot rollers. Use lightweight mechanical tampers, rollers, vibratory systems, or other methods for compaction within 36 inches of the slope face.

Tension the reinforcement during RSS backfill placement. Work from the slope face to the back of reinforcement.

Do not leave reinforcement exposed at end of shift. At the end of each shift, shape to drain and compact the work area to a uniform cross-section. At the end of the day's operation, slope the last lift of backfill away from the slope face to direct surface runoff away from the slope.

261.06 Acceptance. Material for reinforced soil slopes will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of reinforced soil slopes will be evaluated under Subsections 106.02 and 106.04.

Excavation will be evaluated under Section 204.

Survey will be evaluated under Section 152.

Underdrains will be evaluated under Section 605.

Measurement

261.07 Measure the Section 261 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring RSS backfill within the stabilized volume by the cubic yard, measure in place.

Payment

261.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 261 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 262. — SLOPE SCALING

Description

262.01 This work consists of removing and disposing of loose or detached blocks of rock from existing rock slopes and natural rock outcrops by slope scaling.

Construction Requirements

262.02 Qualifications. Provide an on-site supervisor and personnel with slope scaling project experience of similar scope and complexity to those shown in the plans and in similar conditions described in the geotechnical or geological reports. At least 30 days before starting slope scaling work, submit the following for rope supported laborers:

(a) Scaling foreperson. A résumé for scaling foreperson describing at least 2000 hours' scaling experience and 3 years' experience as a slope scaling foreperson on similar projects. Include required certifications;

(b) Journeyman scaler. A résumé for journeyman scalers describing at least 1500 hours' scaling experience and at least 1 year's experience on similar projects. Include required certifications; and

(c) Apprentice scaler. If apprentice scalers are proposed, provide certification of training.

262.03 Submittals. At least 30 days before starting slope scaling work, submit the following according to Subsection 104.06:

(a) Proposed construction sequence and schedule;

(b) Describe the method of rope work used and training for rope supported laborers and scaling foreperson (such as Professional Climbing Instructors Association (PCIA), Society of Professional Rope Access Technicians (SPRAT), or equivalent internal training certification program);

(c) Identify and provide contact information for the municipal emergency responders that will perform rescue. Include mapped travel routes for rescue team, rendezvous sites and estimated response time;

(d) Examples of worksheets for evaluating slope safety before rope entry (such as a Slope Access Safety Evaluation or Slope Scaling Assessment);

(e) The types of equipment and tools to be used;

(f) The number of slope scalers for the project;

(g) Removal and disposal plan for existing ditch debris (if present) and rock and debris generated from the slope scaling and vegetation removal work, and;

(h) Rockfall protection plan including provisions to protect the roadway and traffic according to Section 156, and facilities and existing utilities according to Subsection 107.02(d).

262.04 General. Before starting scaling work, provide temporary roadway protection and public safety measures according to the approved Rockfall Protection Plan.

Conduct a pre-slope scaling preparatory phase meeting at least 7 days before the start of slope scaling operations according to Subsection 153.06(a) to evaluate approaches to the slope and site geology conditions and constraints.

The CO will require that the Contractor remove any slope scaler working or directing others to work in an incompetent, careless, or unsafe manner in according to FAR Clause 52.236-5 Materials and Workmanship.

Perform general scaling within the limits shown in the plans and as directed.

If applicable, specific unstable blocks to be removed and areas requiring greater scaling efforts are identified in the plans as intensive scaling areas. Intensive scaling areas are portions of the slope that may need additional time or specific equipment to address.

Perform vegetation removal from slope brows and rock slope faces, including the removal of trees, shrubs, and other vegetation.

Perform slope scaling and tree and vegetation removal before other slope stabilization work or permanent rockfall mitigation work.

Dispose of scaled debris and vegetation according to Subsection 203.07.

262.05 Equipment. Perform slope scaling using rope supported laborers with hand tools.

Include scaling bars, portable hydraulic wedges, and air bag jacks. Provide air bag jacks or hydraulic wedges with a lift capacity of at least 15 tons. Provide rope supported laborers in compliance with Subsection 262.02.

262.06 Safety Scaling. Provide safety scaling beyond scaling and tree removal limits as needed to safely perform the prescribed work.

262.07 Slope Scaling Operations. Comply with the following:

(a) Perform slope scaling only when the scaling foreperson is present. Perform slope scaling only when the scaling foreperson has continuous visual contact with all scalers on the slope. Additional scaling forepersons may be required. The scaling foreperson may not be actively scaling with the on-slope scalers but can access the site as necessary to supervise scaling operations.

(b) Assign two journeyman scalers for each individual apprentice scaler. Allow apprentice scalers to work only when under the direct supervision of two journeyman scalers.

(c) Adjust operations to allow emergency traffic through the work site according to Section 156.

(d) Cut the identified trees and other vegetation as shown in the plans. Cut trees and large woody shrubs as close as possible to the ground surface while leaving the root wad intact. Remove vegetation before starting slope scaling operations.

(e) Establish anchors for rope access within the construction limits unless otherwise approved.

(f) Perform slope scaling working in a top to bottom sequence. As the work progresses remove loose rocks, detached rocks, and rocks.

(g) Remove scaling debris from the slope. The CO will review the scaled area to determine when the rock slope scaling and vegetation removal has been completed based on the site geology. If additional vegetation or loose or unstable rocks are identified for removal, continue to scale the slope until the scaling has been completed to the satisfaction of the CO.

(h) If the roadway will be open to traffic, do not leave accumulated scaling debris on the roadway, in the roadside ditch, or in pullouts adjacent to the roadway overnight or at the end of a work shift.

262.08 Acceptance. Slope scaling will be evaluated under Subsection 106.02.

Measurement

262.09 Measure the Section 262 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Slope scaling will be measured by the scaler hour of production time of each scaler for all slopes. Hour measurements for each journeyman scaler or apprentice scaler starts when each scaler is equipped and starts to actively scale the slope and ends when each scaler has descended to the bottom of the rock slope at the end of the work shift.

Do not measure hours for safety scaling.

Do not measure hours for the scaling foreperson.

Do not measure disposal of scaled debris and vegetation.

Payment

262.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 262 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 263. — DRAPED ROCKFALL PROTECTION

Description

263.01 This work consists of installing draped rockfall protection.

Material

263.02 Conform to the following Subsections:

Anchorage devices	722.01
Draped rockfall protection fabric	710.09
Hollow-core self-drilling anchors	722.07(a)
Non-shrink grout	701.04(b)(2)
Rockfall protection hardware	717.01(f)
Water for cementitious materials	725.01(a)
Wire rope	709.03
Wire rope anchors	722.07(b)

Construction Requirements

263.03 Qualifications. At least 30 days before starting rockfall protection work, submit the following for approval:

(a) On-site supervisor. A résumé describing experience on at least five projects installing draped rockfall protection systems on steep slopes within the past 5 years. Include project names, locations, and contact information for project owners;

(b) Drill operators. A résumé describing experience installing at least 1000 linear feet of ground anchors on steep slopes within the past 3 years. Include project names, locations, and contact information for project owners;

(c) Rope supported laborers. A résumé for rope supported laborers conforming to Subsection 262.02; and

(d) Draped rockfall protection fabric material supplier. Include the following:

(1) Documentation showing the manufacturer has at least 5 years' experience manufacturing the specified products used in similar system applications and capacities. Include details of the manufacturer's testing procedures and certification of a QA program; and

(2) Include summaries of at least 5 past projects with similar site conditions where draped rockfall protection systems were installed using the supplier's cable nets and steel fabric material, as applicable. Include owner names and contact information.

263.04 Submittals. At least 30 days before starting draped rockfall protection work, submit the following according to Subsection 104.06:

(a) Design. Submit the proposed draped rockfall protection design and calculations.

(b) Materials. Do not order material until the applicable material submittals are approved.

(1) An inclusive list with technical data sheets for each proposed system component including draped rockfall protection fabric, grout, tendon anchors, wire ropes, wire rope anchors, thimbles, ferrules, and other fastening hardware.

(2) Drawings for temporary yokes or load frames used for anchor proof testing including load cells, test jack and master gauges, and calibration data performed by an independent testing laboratory within 90 days of the submittal for each device used. Recalibrate each device used every 90 days from the originally submitted calibration date.

(c) Equipment.

(1) List of equipment to be used for rockfall protection work, including equipment capacities, intended uses, and rental rates.

(2) Provide calibration data, including a graph of torque versus tension for each torque wrench to be used. Include certifications showing calibration testing was conducted by an independent laboratory within 90 days of the date submitted.

(d) Work plan. Include the following in the work plan:

(1) Explain the safety procedures on how personnel and equipment will perform work so that the public, construction personnel, and equipment exposures to hazardous and potentially hazardous conditions are minimized. Include temporary rockfall mitigation measures, special designs, and installation procedures deemed necessary to safely perform the rockfall protection work;

(2) A list of materials, devices, and equipment used, and the methods that will be incorporated to protect existing underground and above-ground facilities, and minimize impacts to the environment;

(3) Description of how personnel and equipment will install draped rockfall protection fabric materials on the project slope locations, including temporary anchoring needed;

(4) A list of materials, equipment, and the methods for drilling, installing, grouting, and testing ground anchors; including the mix design for grouting operations; and

(5) Procedure for attaching draped rockfall protection fabric materials to upper support ropes, adjacent draped rockfall protection fabric panels, and other temporary and permanent supports. Include methods and equipment for delivering and placing on the designed slope locations.

263.05 General. Perform safety scaling that the Contractor deems necessary according to Section 262.

Before installing draped rockfall protection, complete work required according to Sections 260, 262, and 267, and other on-slope rock stabilization work as applicable.

If applicable, treat exposed steel surfaces according to Section 563. Verify the draped rockfall protection work limits. Perform required scaling, rock bolting and doweling, unlined and lined drain holes in rock, and other on-slope rock stabilization work before connecting the draped rockfall protection fabric to the ground anchors and support ropes.

Store, handle, and install draped rockfall protection without damaging the rockfall protection system, colored finish, or galvanized finish. Repair galvanized finishes according to Section 563. Replace damaged portions of the rockfall protection system.

Construct the draped rockfall protection system using panels comprised of double-twist wire mesh, high tensile strength wire mesh, or cable net with wire mesh backing as specified in the plans. Install the draped rockfall protection from the top working downward, contouring the draped rockfall protection fabric material with the existing ground topography to the bottom limits of the required installation, without creating loose draped rockfall protection fabric pockets that trap falling rocks. Trim draped rockfall protection fabric material as needed and treat field cuts according to Section 563.

263.06 Upper Support Ground Anchors. Permanently mark proposed anchor locations as approved. Install anchors only at approved locations. Install ground anchors by centering the anchors plumb or normal to the existing slope at least 2 inches off the bottom of the hole and according to the following field conditions as applicable.

(a) Type I soil installation. Excavate a minimum 5.5-foot deep, 12-inch diameter hole to receive the anchor. Install galvanized wire rope with the anchor end possessing a factory installed ferrule that has a minimum tensile strength equal to that of the wire rope used. Completely fill anchor holes with minor concrete, to encapsulate anchors within holes. Construct minor concrete according to Section 601.

(b) Type II soil installation. Use sacrificial drill bits to install hollow-core self-drilling anchors with a minimum diameter of 1¼ inches to a minimum depth of 5.5 feet, attached to ¾-inch diameter galvanized wire ropes with factory installed couplers that possess a minimum tensile strength equal to that of the wire ropes used. Completely fill drilled holes with non-shrink grout, to encapsulate anchors within drilled holes.

(c) Rock installation. Excavate a minimum 5.5-foot deep, 2-inch diameter hole to receive the anchor. Install the ferrule-end wire rope specified under Subsection 263.06(a). Use non-shrink grout to fill anchor holes according to Subsection 263.06(b).

After filling anchor holes with non-shrink grout or concrete, allow cementitious material to cure, and do not disturb or apply loads to anchors for at least 3 days.

263.07 Testing Ground Anchors. Perform axial pullout proof tests on 5 percent of the installed upper support ground anchors, with at least three tests performed. Complete testing before connecting system components to anchors. Perform the test by applying a 20-kip test load to the anchor for 10 minutes, using a temporary yoke or load frame that does not apply bearing pressures on the ground within 3 feet of the anchor. Proof tests for an anchor will be accepted when the anchor maintains the test load for 10 minutes with no loss of load.

Replace anchors that do not pass axial pullout proof testing at no additional cost to the Government.

263.08 Wire Ropes and Draped Rockfall Protection Fabrics. Install ground anchors by centering the anchors plumb or normal to the existing slope at least 2 inches off the bottom of the hole and according to the following field conditions as applicable. Attach tag lines to upper support ground anchors only after the required proof testing under Subsection 263.07 has been completed.

Set wire rope lengths in the field, terminating each wire rope run with a loop end. Attach support ropes to tag lines with the required shackles. Attach draped rockfall protection fabrics to support ropes, and the upper 12 feet of adjacent fabric panels by lacing wire rope through each draped rockfall protection fabric and panel cell and around adjacent support and seaming ropes.

Use ¼-inch diameter wire rope for lacing on draped rockfall protection systems consisting of double-twist wire mesh and high tensile strength wire mesh, and $^{5}/_{16}$-inch diameter wire rope for draped rockfall protection systems consisting of cable nets with wire mesh backing.

On draped rockfall protection systems consisting of double-twist wire mesh, overlap adjacent draped rockfall protection fabric panels at least 3 inches.

On draped rockfall protection systems consisting of high tensile strength wire mesh or cable net with wire mesh backing, connect adjacent draped rockfall protection fabric panels according to the manufacturer's recommendations at horizontal and vertical seams.

Increase overlaps as needed to cover the work limits and minimize field cuts. Lace additional wire ropes through draped rockfall protection fabric cells to join overlapping draped rockfall protection fabrics overlapping greater than 3 inches.

Do not use hog ring fasteners to join overlapping draped rockfall protection fabrics consisting of cable nets with wire mesh backing panels.

Set the bottoms of draped rockfall protection fabric panels, between 3 and 8 feet above the ditch line, and attach fabric bottoms to the existing slope according to the manufacturer's recommendations.

263.09 Acceptance. See Table 263-1 for sampling, testing, and acceptance requirements.

Material for draped rockfall protection will be evaluated under Subsections 106.02, 106.03, and 106.04. Submit a production certificate for wire ropes and tendon anchors.

Construction of draped rockfall protection will be evaluated under Subsections 106.02 and 106.04.

Drain holes in rock will be evaluated under Section 267.

Minor concrete will be evaluated under Section 601.

Rock bolts and dowels will be evaluated under Section 260.

Safety scaling will be evaluated under Section 262.

Treating exposed steel surfaces, treating galvanized steel field cuts, and repairing damaged galvanizing will be evaluated under Section 563.

Measurement

263.10 Measure the Section 263 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring draped rockfall protection by the square yard, measure the completed in place work performed on the ground surface, excluding overlaps and areas trimmed off.

Payment

263.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 263 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 263-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Non-shrink grout (701.04(b)(2))	Measured & tested for conformance (106.04)	Flow	–	ASTM C939	1 per mix design	Source of material	Yes, if requested	Within 24 hours after completion of test	–
		Compressive strength (3-day and 7-day)	–	ASTM C109	1 set from each batch of grout	Source of material	Yes, if requested	Within 24 hours after completion of test	–
Proof test for draped rockfall protection anchors	Measured & tested for conformance (106.04)	Deformation	–	Subsection 263.07	5% of installed anchors but not less than 3	Installation	No	Within 24 hours after completion of test	–

Note: Collect samples from the end of the grout line at the point of applications.

Section 264. — MIDSLOPE ROCKFALL ATTENUATOR

Description

264.01 This work consists of installing midslope rockfall attenuators.

Material

264.02 Conform to the following Subsections:

High-strength low-alloy structural steel	717.01(b)
Hollow-core self-drilling anchors	722.07(a)
Midslope rockfall attenuator materials	710.10
Non-shrink grout	701.04(b)(2)
Rockfall protection hardware	717.01(f)
Rockfall protection nuts and washers	717.01(g)
Structural carbon steel	717.01(a)
Threaded bar ground anchors	722.07(c)
Water for cementitious materials	725.01(a)
Wire rope	709.03
Wire rope anchors	722.07(b)

Construction Requirements

264.03 Qualifications. Provide an on-site supervisor with experience installing midslope rockfall attenuator systems, and drill operators with experience installing ground anchors. At least 30 days before starting rockfall protection work, submit the following for approval:

(a) On-site supervisor. A résumé describing experience on at least five projects installing midslope rockfall attenuator systems on steep slopes within the past 5 years. Include project names, locations, and contact information for project owners;

(b) Drill operators. A résumé describing experience installing at least 1000 linear feet of ground anchors on steep slopes within the past 3 years. Include project names, locations, and contact information for project owners;

(c) Rope supported laborers. A résumé for rope supported laborers conforming to Subsection 262.02; and

(d) Cable net panel and wire mesh backing suppliers. Include the following:

(1) Evidence showing the manufacturer has at least 5 years' experience manufacturing the specified products used in similar system applications and capacities. Include details of the manufacturer's testing procedures and certification of a QA program.

(2) A list of at least 5 past projects with similar site conditions where attenuators were installed using the supplier's cable nets and steel fabric material. Include owner names and contact information.

264.04 Submittals. At least 30 days before starting midslope rockfall attenuator work, submit the following according to Subsection 104.06:

(a) Materials.

(1) A list with brochures and data sheets for system appurtenances to be used including the cable nets and wire mesh backing, anchors, support system, lacing wire rope, wire mesh fasteners, anchor bars, wire rope anchors, grout, wire rope, clips, thimbles, ferrules, steel rings, and other fastening hardware; and

(2) Drawings for temporary yokes or load frames used for anchor proof testing. Include load cells, test jack and master gauges, and calibration data performed by an independent testing laboratory within 90 days of the submittal for each device used. Recalibrate each device that experiences damage or has been involved in an uncontrolled fall.

(b) Equipment.

(1) List equipment to be used for rockfall protection work, including equipment capacities and intended uses; and

(2) Identify the manufacturer of the cable tension meter that will be used during installation of the midslope rockfall attenuator. Provide documentation that the cable tension meter has been calibrated by an independent testing laboratory within 90 days of use on the project. Manufacturer's calibration with same certification requirements will be accepted in place of independent certification for new instruments. Provide an identification number for each component (or a set such as sheaves used as a unit).

(c) Work plan.

(1) A description of safety procedures minimizing exposure to hazardous and potentially hazardous conditions to the public, construction personnel, and equipment. Include temporary rockfall mitigation measures, special designs, and installation procedures deemed necessary to safely perform the rockfall protection work;

(2) A list of materials, devices, and equipment used, and the methods that will be incorporated to protect existing facilities (underground, on the ground surface, and above-ground) and minimize impacts to the environment according to Section 107;

(3) A list of materials, equipment, and the methods for drilling, installing, grouting, and testing ground anchors, including the mix design for grouting operations; and

(4) Procedures for attaching cable net panels with wire mesh backing to upper support ropes, adjacent steel fabric panels, and other temporary and permanent supports. Include methods and equipment for delivering and placing on the designed slope locations.

264.05 General. Do not order materials until the applicable material submittals are approved.

Before installing midslope rockfall attenuators, complete work required according to Sections 260, 262, and 267, and other on-slope rock stabilization work as applicable.

Perform safety scaling that the Contractor deems necessary according to Section 262.

Verify the midslope rockfall attenuator work limits. Perform required scaling, rock bolting and doweling, unlined and lined drain holes in rock, and other on-slope rock stabilization work before connecting the cable net panels with wire mesh backing to the ground anchor and support ropes.

If applicable, treat exposed steel surface according to Section 563. Store, handle, and install midslope rockfall attenuator systems without damaging the midslope rockfall attenuator, colored finish, or galvanized finish. Repair galvanized finishes and weathering agents according to Section 563. Replace damaged portions of the midslope rockfall attenuator.

Construct the midslope rockfall protection at the locations shown in the plans or as directed. Construct plates, holes, welds, swivels, and foundations for support posts as shown in the plans. Locate the posts, ropes, and wire rope anchors as shown in the plans. Install the midslope rockfall attenuator system within the required tolerances as shown in the plans for alignment and orientation. Construct midslope rockfall attenuators with a maximum top support wire rope length of 160 feet. If the required installation length is longer than 160-feet, use a connection post and start a new top support wire rope.

Install and attach the cable net panels and the wire mesh backing as shown in the plans. Use $^{9}/_{16}$-inch wire seaming rope for connecting the net panels to the horizontal top B rope, truncating the seaming rope at each post, and restarting it for the next span between posts as shown in the plans. Connect corner cable K to the end post swivel and at least two cells into the cable net fabric at a connection. Use a $^{9}/_{16}$-inch wire rope for corner cable K. Repair damaged galvanizing after erection according to Subsection 563.12(b).

Set the bottoms of attenuator net fabric panels as directed according to the geologic conditions.

(a) Foundations. Excavate and prepare new foundations according to Section 209. Use the post foundation shown in the plans. Space posts at 40 feet or less. Provide a proposed layout in plan between new post alignments that shows the angles in the vertical and horizontal alignment between posts and layout a profile showing the ground surface elevation and top attenuator support rope elevation for approval.

If threaded ground anchor bars cannot be inserted into the drill holes due to caving conditions, use a hollow-core self-drilling ground anchor with a sacrificial drill bit to advance the anchor into the ground as shown in the plans. Orient the hollow-core anchor bars as shown in the plans. Determine the required anchor length necessary to provide a minimum axial pullout capacity of 30-kips for each self-drilling anchor. Fully encapsulate each ground anchor in either non-shrink grout or minor concrete according to Section 601.

(b) Wire rope tightening. At every midslope rockfall attenuator post, tighten C ropes and F ropes until they are taut. A taut rope is defined as one that has the values shown in Table 264-1 as measured by a tension meter. Tighten C ropes and F ropes before loading and tightening the B rope.

Tighten the B rope to ensure that when the rope is loaded with the attenuator net, the vertical sag between posts is 12 to 18 inches from horizontal.

Table 264-1
Wire Rope Tension Meter Values

Rope F or C Vertical Angle (degrees)	Minimum Allowable Rope Tension (lbf)
30±2	370
45±2	550
50±2 to 60±2	770

Calibrate the cable tension meter at no more than a 180-day interval, or at any lesser time, due to site-specific conditions, wear, or abuse of any component.

264.06 Testing Anchors. Sample each grout batch used to construct anchors and submit required samples to an independent testing laboratory for 3-day and 7-day compressive strength testing. Submit results and samples for verification testing.

Verify the wire rope anchor capacities by conducting axial pullout tests on every 103-kip capacity anchor, and 25 percent of the 58-kip capacity anchors as selected by the CO. Provide a pullout test load that is 60 percent of the ultimate wire rope anchor capacity shown in the plans. For pullout proof testing, an anchor is acceptable when it sustains the specified capacity for 10 minutes with no loss of load. Test against a temporary yoke or load frame with no part of the yoke or load frame within 3 feet of the anchor. If a wire rope anchor fails during testing, test all wire rope anchors. Replace failed wire rope anchors. Complete wire rope anchor testing before connecting system components to the anchors.

Verify that the 1¼-inch diameter hollow-core self-drilling ground anchors provide at least 30-kip axial pullout capacity for each anchor. Conduct the axial pullout test on at least one ground anchor, as selected by the CO, from each foundation where hollow-core self-drilling ground anchors are used. Provide a pullout proof test load that is 60 percent of the minimum pullout strength requirement. An anchor is acceptable when it sustains the specified capacity for 10 minutes with no loss of load. Test against a temporary yoke or load frame with no part of the yoke or load frame within 3 feet of the anchor or the other four ground anchors associated with that post foundation if already installed. If a hollow-core self-drilling ground anchor fails, test all anchors associated with that post foundation. Modify and replace failed ground anchors and then retest. Complete anchor testing before constructing the remaining portion of the foundation. Replace failed ground anchors.

264.07 Acceptance. See Table 264-2 for sampling, testing, and acceptance requirements.

Material for midslope rockfall attenuator will be evaluated under Subsections 106.02 and 106.03. Submit a production certification for wire ropes and anchor tendons.

Construction and erection of midslope rockfall attenuator will be evaluated under Subsections 106.02 and 106.04.

Drain holes in rock will be evaluated under Section 267.

Minor concrete will be evaluated under Section 601.

Rock bolts and dowels will be evaluated under Section 260.

Slope scaling and safety scaling will be evaluated under Section 262.

Treating exposed steel surfaces, treating galvanized steel field cuts, and repairing damaged galvanizing will be evaluated under Section 563.

Measurement

264.08 Measure the Section 264 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure the midslope rockfall attenuator by the square yard of covered area of the installed cable net panel with wire mesh backing portion of the system on the slope, excluding overlaps and areas trimmed off.

Payment

264.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 264 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 264-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Non-shrink grout (701.04(b)(2))	Measured & tested for conformance (106.04)	Flow	–	ASTM C939	1 per mix design	Source of Material	Yes, if requested	Within 24 hours after completion of test	
		Compressive strength (3-day & 7-day)	–	ASTM C109	1 set from each batch of grout	Source of Material	Yes, if requested	Within 24 hours after completion of test	
Proof test for anchors	Measured & tested for conformance (106.04)	Deformation	–	Subsection 264.06	Subsection 264.06	Installation	No	Within 24 hours after completion of test	

Section 265. — ROADSIDE ROCKFALL PROTECTION

Description

265.01 This work consists of installing roadside rockfall protection.

Construction Requirements

265.02 Qualifications. Provide an on-site supervisor with experience installing gabion barriers and flexible rockfall barrier systems, and drill operators with experience installing ground anchors. At least 30 days before starting rockfall protection work, submit the following for approval:

(a) On-site supervisor. A résumé describing experience on at least five projects installing gabion barriers and flexible rockfall barrier fence systems within the past 5 years. Include project names, locations, and contact information for project owners;

(b) Drill operators. A résumé describing experience installing at least 1000 linear feet of ground anchors for flexible rockfall barrier systems within the past 3 years. Include project names, locations, and contact information for project owners; and

(c) Manufacturer of the flexible rockfall barrier systems. Include written evidence demonstrating the manufacturer has at least 5 years' experience with manufacturing and supplying systems used in a similar application and capacity.

265.03 Submittals. At least 30 days before starting roadside rockfall protection work, submit a work plan according to Subsection 104.06. Include the following:

(a) Evidence of certification for the flexible rockfall barrier systems according to European Assessment Document (EAD 340059-00-0106), including performance values for energy level classification, maximum energy level (MEL), service energy level (SEL), classification for residual height for MEL, and elongation at the MEL. Include evidence no more than 1 year old from the manufacturer that the flexible rockfall barrier system supplied has been tested and verified to equal or exceed the flexible rockfall barrier system requirements as shown in the plans;

(b) A list with brochures and data sheets for system appurtenances to be used. Include the welded or twisted wire mesh for gabion barriers, and the following for flexible rockfall barrier system; mesh fabrics, anchors, support system, lacing wire rope, wire mesh fasteners, anchor bars, wire rope anchors, grout, wire rope, clips, thimbles, ferrules, steel rings, and other fastening hardware;

(c) Manufacturer's design and detail drawings showing full, detailed dimensions of component parts and layout of posts, post anchorage systems, post foundations, anchors and support ropes, system and material specifications, and assembly plan for the flexible rockfall barrier system. Include post foundation dimensions and offset relative to centerline;

(d) Methods, equipment, and materials for preparing the alignment for the gabion barriers and flexible rockfall barrier systems;

(e) Methods, equipment, and materials for designing and installing the post anchorage systems and foundations for the flexible rockfall barrier system as required by the manufacturer. Include the construction sequence including the required curing time for foundations and anchors before installing other system components or applying external loads;

(f) A manual detailing the required flexible rockfall barrier system maintenance procedures, as specified by the manufacturer; and

(g) Methods, materials, and equipment for drilling, installing, grouting, and testing anchors for flexible rockfall barrier system. Include the following:

(1) Mix design for grouting operations;

(2) Manufacturer's recommendations for anchor test loads;

(3) Working drawings for the temporary yoke or load frame to be used for the anchor proof testing; and

(4) Calibration data performed by an independent testing laboratory within 90 days of the submittal for each load cell, test jack pressure gauge, and master pressure gauge to be used.

265.04 General. Install roadside rockfall protection at the locations and with the requirements shown in the plans.

Construct roadside rockfall protection consisting of gabion barriers and flexible rockfall barrier systems as shown in the plans.

Perform safety scaling that the Contractor deems necessary according to Section 262.

Repair galvanized finishes according to Section 563. If applicable, treat exposed steel surfaces according to Section 563.

Recalibrate each load cell, test jack pressure gauge, and master pressure gauge every 90 days from the originally submitted calibration date.

265.05 Gabion Barriers. Conform to Section 253.

265.06 Flexible Rockfall Barrier Systems. Design, provide, and install roadside rockfall protection fences according to the manufacturer's recommendations and as shown in the plans. Include all applicable posts, post anchorage systems and foundations, anchors, support wire ropes, braking elements, and mesh panels.

Provide barrier panels made of interlocking nominal 7- to 12-inch diameter openings backed by a finer mesh placed on the roadside of the fence to prevent smaller rock from moving past the barrier as shown in the plans.

(a) Equipment. List equipment to be used for roadside rockfall protection fence work. Include equipment capacities and intended uses.

(b) Design. Complete required design according to the manufacturer's recommendations for all component parts including, but not limited to, the layout of posts, post anchorage systems, post foundations, braking elements, anchors, and support ropes. Design a system that meet or exceeds the requirements shown in the plans, including system height, energy level classification, MEL, SEL, classification for residual height for MEL, and elongation at the MEL.

(c) Installation. Locate the barrier panel at the centerline offset shown in the plans.

Prepare the alignment of the flexible rockfall barrier system by clearing debris that is accumulated in the roadside ditch. Dispose of the material according to Subsection 203.07.

Erect the post anchorage systems, anchors, and posts according to the approved drawings, the construction sequence, and the manufacturer's recommendations. Install posts within the required manufacturer's tolerances for alignment and orientation.

Install and fasten top and bottom support wire ropes according to the manufacturer's recommendations. Fasten wire ropes only after the tested anchors have been accepted in writing.

Install and connect the rockfall mesh according to the manufacturer's recommendations.

(d) Post anchorage systems. Locate, anchor, and install posts according to the manufacturer's recommendations and the approved drawings. Do not exceed the manufacturer's spacing recommendations for the posts, center to center. Perform excavation and foundation preparation work according to Section 209.

Perform foundation work for the posts and anchors according to approved drawings, construction sequence, and the manufacturer's recommendations. Foundations may be either precast or cast-in-place. If cast-in-place systems are used, do not disturb or apply any load to any of the post anchorage systems until the concrete has cured at least 5 days or as recommended by the manufacturer, whichever is greater.

(e) Anchors. Locate, orient, and install anchors according to the manufacturer's recommendations and approved drawings for support of system appurtenances. Include posts, top and bottom support wire ropes, and other elements as specified by the manufacturer.

(f) Anchor testing. Verify anchor capacities by conducting axial pullout proof tests on all the end post base anchors, lateral anchors for support and lateral ropes, and upslope anchors; and 25 percent of the intermediate post base anchors, as selected by the CO. Provide test loads as specified by the manufacturer.

Proof tests will be accepted when an anchor maintains the test load for 10 minutes without loss of load. Conduct the test against a temporary yoke or load frame with no part of the yoke or load frame within 3 feet of the anchor. If more than two of the tested anchors fail, test all anchors. Replace failed anchors.

Collect samples of the grout from two batches of grout that is being used for grouting and submit grout cubes to an independent testing firm for breaking strength testing. Provide 3-day and 7-day unconfined compression test results to the CO. The CO may also request samples for testing.

Complete anchor testing before conducting additional work on the post anchorage systems or connecting any system components to any anchors.

(g) Wire ropes and mesh panels. Install and fasten support wire ropes according to the manufacturer's recommendations. Install and connect the mesh panels and backing material according to the manufacturer's recommendations.

(h) Manufacturer certification. Conduct an on-site review of the completed flexible barrier systems with a manufacturer's representative. Provide written certification from the manufacturer to the CO for approval that the flexible rockfall barrier systems have been installed according to the manufacturer's recommendations.

265.07 Flexible Rockfall Barrier System Test Results and Reporting. Submit test results. Maintain daily records of installation work. Include the following:

(a) Drawings depicting the location of each anchor, wire rope anchor, and post anchorage anchor. Note anchor designation, date drilled, the general drilling conditions, materials encountered, the location of significant drilling changes (such as geologic contacts, voids, or open fractures), dates of grouting operations, total anchor length, grout mix, grout volume, average grout pressure, hole diameter, and installation comments. Submit as-built drawings according to Subsection 104.06(c).

(b) Anchor proof test data forms. Include the anchor designation, date of testing operation, signature of testing operator or inspector, identification numbers of jacking equipment, and comments.

265.08 Acceptance. See Table 265-1 for sampling, testing, and acceptance requirements.

Design of flexible rockfall barrier systems will be evaluated under Subsection 106.02.

Material for flexible rockfall barrier systems will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of flexible rockfall barrier systems will be evaluated under Subsections 106.02 and 106.04.

Gabion barriers will be evaluated under Section 253.

Safety scaling will be evaluated under Section 262.

Treating exposed steel surfaces, treating galvanized steel field cuts, and repairing damaged galvanizing will be evaluated under Section 563.

Measurement

265.09 Measure the Section 265 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring roadside rockfall protection fence by the linear foot, measure along the alignment of the support posts between the terminal end posts.

When measuring roadside rockfall protection gabion barriers by the cubic yard, measure in the structure.

Payment

265.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 265 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 265-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Non-shrink grout (701.04(b)(2))	Measured & tested for conformance (106.04)	Flow	–	ASTM C939	1 per mix design	Source of Material	Yes, if requested	Within 24 hours after completion of test	–
		Compressive strength (3-day & 7-day)	–	ASTM C109	1 set from each batch of grout	Source of Material	Yes, if requested	Within 24 hours after completion of test	–
Proof test for flexible rockfall barrier anchors	Measured & tested for conformance (106.04)	Deformation	–	Subsection 265.06(f)	Subsection 265.06(f)	Installation	No	Within 24 hours after completion of test	–

Section 266. — ANCHORED WIRE MESH SYSTEM

Description

266.01 This work consists of providing and installing an anchored wire mesh system.

Material

266.02 Conform to the following Subsections:

Anchor nails	722.05
Anchor plates	717.01(h)
High tensile strength steel wire mesh	710.10(d)(2)
Non-shrink grout	701.04(b)(2)
Rockfall protection hardware	717.01(f)
Rockfall protection nuts and washers	717.01(g)
Turf reinforcement mat	713.18
Water for cementitious materials	725.01(a)
Wire mesh fastener	710.09(c)
Wire rope	709.03
Wire rope anchors	722.07(b)

Construction Requirements

266.03 Qualifications. Provide an on-site supervisor with experience installing anchored mesh systems, and drill operators with experience installing ground anchors. At least 21 days before starting rockfall protection work, submit the following for approval:

(a) On-site supervisor. A résumé describing experience on at least three projects installing anchored mesh systems within the past 3 years. Include project names, locations, and contact information for project owners;

(b) Drill operators. A résumé describing experience installing at least 1000 linear feet of anchor nails for anchored wire mesh systems within the past 3 years. Include project names, locations, and contact information for project owners;

(c) Rope supported laborers. A résumé for rope supported laborers conforming to Subsection 262.02; and

(d) High tensile strength steel wire mesh suppliers. Include the following:

(1) Evidence showing the manufacturer has at least 5 years' experience manufacturing the specified products used in similar system applications and capacities. Include details of the manufacturer's testing procedures and certification of a QA program; and

(2) Include summaries of at least 5 past projects with similar site conditions anchored wire systems were installed using the supplier's high tensile strength steel wire mesh. Include owner names and contact information.

266.04 Submittals. At least 21 days before starting anchored wire mesh installation work, submit the following according to Subsection 104.06:

(a) Materials. Identify the high tensile strength steel wire mesh suppliers, and submit the following:

(1) An inclusive list with brochures and data sheets for system appurtenances to be used. Include the high tensile strength steel wire mesh, anchor nails, anchor plates, grout, lacing wire rope, wire mesh fastener, wire rope thimbles, ferrules, and other fastening hardware; and

(2) At least two samples of each available color and texture for the turf reinforcement mat in a range of earth-tone colors representative of the adjacent landscape.

(b) Equipment.

(1) List of equipment to be used for anchored wire mesh installation, including equipment capacities and intended uses; and

(2) Calibration data, including a graph of torque versus tension for each torque wrench to be used. Include certifications showing calibration testing was conducted by an independent laboratory within 90 days of the date submitted.

(c) Work plan.

(1) A description of safety procedures minimizing exposure to hazardous and potentially hazardous conditions to the public, construction personnel, and equipment. Include temporary rockfall mitigation measures, special designs, and installation procedures deemed necessary to safely perform the rockfall protection work;

(2) A list of materials, devices, and equipment used, and the methods that will be incorporated to protect existing facilities (underground, on the ground surface, and above-ground) and minimize impacts to the environment according to Section 107;

(3) A list of equipment and methods for installing the high-tensile strength steel wire mesh system including temporary anchoring;

(4) Methods and equipment for installing and connecting adjacent wire mesh panels and attaching them to temporary supports. Explain how mesh panels will be placed on the slope in a top-down method. Detail how panels overlap on the slope to maintain direct contact with the slope to prevent bulges or loose areas in the finished mesh;

(5) Methods and equipment for drilling, grouting, and attaching anchoring boundary ropes and seam ropes;

(6) Methods and equipment for drilling, grouting, and installing anchor nails. Describe how anchor plates for the mesh system will be installed to obtain direct contact with the ground;

(7) Methods to ensure borehole stability during excavation and grout placement in holes. If open joints, seams, or loose material is encountered, the methods, equipment, and materials used to control excessive grout injection volumes; and

(8) Details for installing, stressing, and testing anchor nails.

266.05 Installation.

(a) General. Provide an anchored wire mesh system that utilizes rock and soil reinforcement with anchor plates and a homogenous high-tensile-strength steel wire mesh consisting of a single-component wire type installed into direct contact with the slope to be stabilized.

Perform safety scaling that the Contractor deems necessary according to Section 262.

Before installing anchor wire mesh systems, complete work required according to Sections 260, 262, and 267, and other on-slope rock stabilization work as applicable.

Repair galvanized finishes according to Section 563. If applicable, treat exposed steel surface according to Section 563.

Provide uniform high-tensile strength steel wire mesh to construct the anchored wire mesh system installation. Complete the portion of the roadway cut in overburden soils according to Section 204 before placing the anchored wire mesh system. Minimize bridging mesh over exposed gaps and protruding boulders between anchors if present and maximize the wire mesh fabric contact with the ground surface. Remove mesh bulges or loose mesh that is not in contact with the surface by removing and resetting the mesh. Do not twist, pinch, or fold mesh together to tighten loose mesh or bulged mesh. Do not pinch, crush, or damage mesh or turf reinforcement mat under the anchor plate or in the annulus space between the plate and anchor nail. Additional anchor nails may be required to remove areas of loose mesh.

If shown in the plans, place a permanent turf reinforcement mat, type 5.C between the natural slope and the steel wire mesh according to Section 629. Secure the turf reinforcement mat to the slope face according to Subsection 629.06(a)(1) or 629.06(a)(3). Provide a permanent turf reinforcement mat with an approved color and texture.

(b) Wire mesh installation. Install wire mesh panels at the locations shown in the plans. Construct the anchored wire mesh system from the top down following the manufacturer's installation guide. Extend the anchor nails and wire mesh at least three rows of mesh openings above the crest of the slope. The wire mesh should be temporarily secured at the top of the slope to facilitate the installation procedure. Construct required temporary anchoring according to the approved submittal plan.

No equipment operation is allowed on slope areas after wire mesh has been placed.

Overlap adjacent wire mesh panels at least 3 inches to provide at least one mesh opening of overlap between panels. Increase the wire mesh overlap as necessary to fully cover the required slope area shown in the plans. Lace mesh panel side seams to an adjacent panel using a ¼-inch diameter lacing wire rope or connect panels with wire mesh fasteners meeting the mesh manufacturer's recommendations. If the overlap between panels is too great to fully secure panel edges with a single lacing wire rope, use additional lacing wire ropes to secure panel edges or multiple rows of wire mesh fasteners. Secure both ends of lacing wire rope installations by looping the end of the rope back onto itself and fastening it with wire rope clips according to the manufacturer's specifications. Anchor wire mesh installations so they conform to the slope surface as much as practical.

Place a ½-inch diameter boundary rope along edges of the anchored wire mesh. Anchor the boundary rope at the end of each boundary rope with additional anchor nails as needed and connect the ends of boundary rope to the anchor nails according to the manufacturer's recommendations. More than 4 boundary ropes may be required depending on the final shape of the anchored mesh area and arrangement of the anchor nails. Attach boundary ropes to the wire mesh and anchor plates according to the manufacturer's recommendations.

Diagonal cutting of the high tensile strength mesh is not allowed.

Remove required temporary anchoring according to the approved submittal plan.

(c) Anchor nail installation. Anchor nail installations are required for the mesh system. The areas that will receive anchor nails are shown in the plans along with the general pattern for the anchors. The pattern shown in the plans indicates the estimated number of anchors for the anchored wire mesh system. The actual pattern constructed will be adjusted to fit the slope shape and stabilization requirements as directed. Schedule a test installation to demonstrate procedure for anchor nail installation and testing.

Requirements for the anchor nail installation are as follows:

(1) For each anchor nail, drill a minimum 3-inch diameter hole perpendicular to the slope surface. Over-drill each hole at least 6 inches beyond the required anchor length. Refer to plans for the minimum depth of anchor nails.

(2) Install anchor nails and grout according to the manufacturer's recommendations. Use positive displacement grout pumps according to Subsection 256.07(b)(1). Control grout pressures to avoid ground heaving or fracturing, and fill grout tube with grout if it remains in the hole. Flush surplus water and diluted grout from lines before injection and replace leaky fittings before continuing grouting operations. Clean excess grout off rock surfaces, anchor nails, and bearing plates. Perform QC of the grout by performing minimum compressive strength. Record the quantity of injected grout and the grout pressure for each installation. Notify the CO of grout quantity overruns including the reason for the overrun and proposed actions to minimize future overruns. Obtain approval for alternative grouting methods.

(3) Excavate as shown in the plans around each nail head to ensure optimal load transfer from the anchor nail to the anchor plate to the wire mesh fabric. Install anchor plates, washers, nuts, and associated hardware according to the manufacturer's recommendations and the plans.

(4) Tension each anchor nail no more than one week after completing grouting. Tension in the anchor nail with a calibrated torque wrench to loads shown in the plans. If the tension load cannot be achieved, replace the anchor nail with an additional nail installed in a separate hole. Additional anchors may be needed to supplement the anchor nail spacing patterns shown in the plans to accommodate slope geometry. Obtain approval for all anchor locations.

(5) Lock off each anchor to the specified design load capacity as shown in the plans.

266.06 Acceptance. See Table 266-1 for sampling, testing, and acceptance requirements.

Material for the anchored wire mesh system installations will be evaluated under Subsections 106.02 and 106.03.

Construction and erection of anchored wire mesh installations will be evaluated under Subsections 106.02 and 106.04.

Submit a production certification for wire ropes and anchor nails.

Drain holes in rock will be evaluated under Section 267.

Rock bolts and dowels will be evaluated under Section 260.

Safety scaling will be evaluated under Section 262.

Treating exposed steel surfaces, treating galvanized steel field cuts, and repairing damaged galvanizing will be evaluated under Section 563.

Measurement

266.07 Measure the Section 266 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring anchored wire mesh system pay items by the square yard, measure the completed in place work performed on the ground surface, excluding overlaps and areas trimmed off.

Do not measure anchor nails required for the anchored wire mesh.

Measure additional anchors as described under Subsection 266.05(a) per each additional anchor installed.

Payment

266.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 266 pay items listed in the bid schedule. Payment will be full compensation for the work described in this Section. See Subsection 109.05.

Table 266-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Non-shrink grout (701.04(b)(2))	Measured & tested for conformance (106.04)	Flow	–	ASTM C939	1 per mix design	Source of Material	Yes, if requested	Within 24 hours after completion of test	–
		Compressive strength (3-day & 7-day)	–	ASTM C109	1 set from each batch of grout	Source of Material	Yes, if requested	Within 24 hours after completion of test	–
Proof test for anchor nails	Measured & tested for conformance (106.04)	Deformation	–	Subsection 266.05(c)(4)	Each nail	Installation	No	Within 24 hours after completion of test	–

Section 267. — DRAIN HOLES IN ROCK

Description

267.01 This work consists of constructing unlined and lined drain holes in rock.

Material

267.02 Conform to the following Subsections:

Lined drain holes in rock	708.06(e)
Packaged repair mortar	701.05(b)
Water for cementitious materials	725.01(a)

Construction Requirements

267.03 Qualifications. At least 30 days before starting drain hole in rock work, submit the following for approval:

(a) On-site supervisor. A résumé for each on-site supervisor describing at least 2 years' experience in supervising construction of drain holes in rock of similar lengths and scope to those shown in the plans and in similar geotechnical conditions;

(b) Drill operator. A résumé for each drill operator describing at least 1 year's experience in the construction of drain holes; and

(c) Rope supported laborers. A résumé for rope supported laborers conforming to Subsection 262.02.

267.04 Submittals. At least 30 days before starting drain hole in rock work, submit the following according to Subsection 104.06:

(a) Proposed construction sequence and schedule;

(b) Drain hole access and drilling plan. Include details on the method for constructing the drain holes and measures proposed to contend with excessive drain flow during construction. Include narratives and drawings to describe the access, and the horizontal drilling and installation plan;

(c) List of materials with brochures and data sheets;

(d) List of equipment to be used. Include equipment capacities and intended uses, and;

(e) Examples of drilling logs for documenting the drain diameter, drain length, advancement rates, materials encountered, and the presence of water and estimated flows for each drilled hole.

267.05 General. Verify location, elevation, spacing, and orientation of the drain hole installations. The exact locations of the drain holes will be determined by the CO.

Perform safety scaling that the Contractor deems necessary according to Section 262.

Construct drain holes in rock that do not intersect or affect existing rock bolts and rock dowels. Complete work according to Sections 260 and 262 before constructing drain holes in rock.

Dispose of removed vegetation according to Subsection 203.07.

267.06 Drilling Holes. Schedule a meeting between the drilling foreperson, the drill operator, and the CO to review the drilling plan before starting drilling work.

Provide equipment that can drill straight, uniform-diameter holes with the diameter and length as shown in the plans. Install unlined horizontal drain holes inclined upwards as shown in the plans.

Maintain a log of material types, production rates, and estimated water flows encountered during drilling. Once the planned length of each drain is achieved, flush each hole until water is observed to be relatively clear.

Dispose of drilling water and drill flushing according to Federal, state, and local rules and regulations.

267.07 Lined Drain Holes. Install slotted PVC pipe from the terminus of the drilled hole to 5 feet from the face of the rock face. Install solid PVC pipe for the remaining 5 feet and to the outlet drain. Join the slotted PVC pipe to the solid PVC pipe with approved couplings.

Provide a 6-inch minimum thickness of mortar at the rock face. Add water for workability and molding.

267.08 Acceptance. Material for drain holes in rock will be evaluated under Subsections 106.02 and 106.03.

Construction of drain holes in rock will be evaluated under Subsections 106.02 and 106.04.

Rock bolts and dowels will be evaluated under Section 260.

Slope scaling and safety scaling will be evaluated under Section 262.

Measurement

267.09 Measure the Section 267 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring drain holes in rock by the linear foot, measure the length of the drilled hole from the termination of the hole to the rock slope face.

Payment

267.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 267 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 268. — HORIZONTAL DRAINS

Description

268.01 This work consists of constructing horizontal drains, including collector systems.

Material

268.02 Conform to the following Subsection:

Horizontal drains	708.06(d)

Construction Requirements

268.03 Qualifications. Provide an on-site supervisor and installation personnel with experience installing and testing horizontal drains. At least 30 days before starting horizontal drain work, submit a résumé for each individual describing their experience on at least five horizontal drain projects of similar complexity within the past 5 years for approval. Include project names, locations, and contact information for project owners.

268.04 General. Verify location, elevation, spacing, and orientation of the horizontal drains' installation.

Provide pipe and fittings with an outside diameter of at least 1½ inches or as specified. Provide slotted pipe with three rows of slots cut circumferentially in the pipe 120 degrees apart. Make the width of the slots 0.01 inch, with the total slot opening area equal to 0.46 square inch per foot of pipe. Provide couplings, cleanouts, elbows, and other fixtures required for collection of water made of material that are compatible with the installed drain pipe.

The locations for installing horizontal drains shown in the plans are approximate. The exact locations will be determined by the CO. Pipe drains that start more than 12 inches or end more than 3.5 feet per 100-foot installed pipe from their planned locations, are damaged in construction, or are improperly installed will be rejected.

268.05 Drilling Holes. Drill holes with rotary equipment that can drill 3- to 6-inch diameter holes up to 600 feet to designated lines and grades through soil and rock formations. Keep a log of material types, production rates, and estimated water flows encountered during drilling. Install horizontal drains as shown in the plans. During drilling operations, determine the elevation of the drilled hole at 100-foot intervals and at the upper end of the completed horizontal drain hole by inserting tubes or pipes and measuring liquid levels or by other approved means.

Dispose of drilling water and water encountered during drilling according to Federal, state, and local rules and regulations.

268.06 Installing Horizontal Drain. Tightly plug the entrance end of the slotted pipe with a rounded or pointed extension that does not extend more than 6 inches beyond the end of the pipe. Insert the pipe inside the drill rod and then retract the drill rod so the drilled hole is cased with the slotted pipe from the back of the hole to within 20 feet of the outlet. Connect additional pipe as necessary to form a continuous tube. Use unslotted pipe for the last 20 feet at the outlet end.

Seal the space between the drilled hole and the un-slotted pipe for at least 10 feet at the outlet end with an approved impermeable material. Do not seal the space between the drilled hole and the slotted pipe.

268.07 Installing Outlet Drains and Collector Systems. Attach outlet drain pipe to the ends of horizontal drains by a tee or street ell. Install a collector system of the type, kind, and size as shown in the plans.

For pipe drain installations draining directly to daylight, cover the outlet end of the pipe with a removable screen made of 0.055-inch diameter galvanized wires with approximately ½- by ½-inch mesh openings.

268.08 Acceptance. Material for horizontal drains will be evaluated under Subsections 106.02 and 106.03.

Construction of horizontal drains will be evaluated under Subsections 106.02 and 106.04.

Measurement

268.09 Measure the Section 268 pay items listed in the bid schedule according to Subsection 109.02.

Payment

268.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 268 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 300
AGGREGATE AND BASE COURSES

Section 301. — UNTREATED AGGREGATE COURSES

Description

301.01 This work consists of constructing aggregate courses on a prepared surface.

Material

301.02 Conform to the following Subsections:

Subbase, base, and surface course aggregate	703.05
Water for construction	725.01(c)

Construction Requirements

301.03 General. Prepare the surface according to Section 204 or 303 as applicable.

After a representative quantity of aggregate is produced, submit target values within the required gradation range along with a representative 300-pound sample at least 14 days before incorporating the aggregate into the work.

301.04 Mixing and Spreading. Determine the optimum moisture content according to AASHTO T 180, Method D. Mix the aggregate and adjust the moisture content to obtain a uniform mixture with a moisture content within 2 percent of the optimum moisture content. Spread and shape the mixture on the prepared surface in a uniform lift.

Place mixture in a lift no more than 6 inches in compacted thickness. If more than one lift is necessary, compact each lift according to Subsection 301.05 before placing the next lift. Route hauling equipment uniformly over the full width of the surface to minimize rutting or uneven compaction.

301.05 Compacting. Determine the maximum density of the mixture according to AASHTO T 180, Method D.

Compact the full width of each lift. Roll from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

Compact each lift to at least 95.0 percent of maximum density. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

301.06 Surface Tolerance. If grade finishing stakes are required, finish the surface to within ±0.05 feet from staked line and grade elevation.

If AMG methods are used, finish the surface to within ±0.05 feet from the design line and grade elevation.

If grade finishing stakes are not required and AMG methods are not used, shape the surface to the required template and check the surface with a 10-foot metal straightedge. Defective areas are surface deviations more than ½ inch in 10 feet between two contacts of the straightedge with the surface.

Correct defective areas by loosening the material, adding or removing material, reshaping, and compacting.

301.07 Maintenance. Maintain the aggregate course to the correct line, grade, and cross-section by blading, watering, rolling, or combination thereof until placement of the next course. Correct defects according to Subsection 301.06.

301.08 Acceptance. See Table 301-1 for sampling, testing, and acceptance requirements.

Aggregate gradation and surface course plasticity index will be evaluated under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

(a) Aggregate gradation. The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Tables 703-1 and 703-2, except as follows:

(1) If the calculated mean value for a tested sieve exceeds the maximum gradation range value shown in Table 703-1, then the upper specification is equal to the maximum gradation value in Table 703-1 plus or minus the allowable deviation in Table 703-2.

(2) If the calculated mean value for a tested sieve is less than the minimum gradation range value shown in Table 703-1, then the lower specification is equal to the minimum gradation value in Table 703-1 plus or minus the allowable deviation in Table 703-2.

(b) Plasticity index. The upper and lower specification limits for surface courses are shown in Subsection 703.05(c)(3).

Construction of untreated aggregate courses will be evaluated under Subsections 106.02 and 106.04.

Measurement

301.09 Measure the Section 301 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring aggregate by the cubic yard, measure in place.

When measuring aggregate by the square yard, measure the length horizontally along the centerline of the roadway. Measure the width horizontally to include the top of aggregate width, including designed widenings.

Payment

301.10 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the Section 301 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 301-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (703.05(a), (b), & (c))	Measured & tested for conformance (106.04 & 105)	LA abrasion (coarse)	–	AASHTO T 96	1 per type & source of material	Source of material	Yes	Before using in work	Not required if using Government -furnished sources
		Soundness using sodium sulfate (coarse & fine)	–	AASHTO T 104	"	"	"	"	"
		Fractured faces	–	AASHTO T 335	"	"	"	"	"
		Liquid limit	–	AASHTO R58 & T 89, Method A	"	"	"	"	"
Surface course aggregate (703.05(c))	Measured & tested for conformance (106.04 & 105)	Plasticity index	–	AASHTO R 58, T 89, & T 90	1 per type & source of material	Crusher belt or after processing	Yes	Before using in work	Not required if using Government -furnished sources

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source (continued)									
Subbase, base, or surface course aggregate (703.05(b) & (c))	Process control (153.03)	Gradation	–	AASHTO T 11 & T 27	2 per day per stockpile minimum	Crusher belt	No	24 hours	Not required if using a pre-crushed commercial source
		Fractured faces	–	AASHTO T 335	"	"	"	"	"
Surface course aggregate (703.05(c))	"	Plasticity index	–	AASHTO R 58, T 89, & T 90	2 per day per stockpile minimum	Crusher belt or after processing	No	24 hours	Not required if using a pre-crushed commercial source
Production									
Subbase course Grading A & B	Statistical (106.05)	Gradation		AASHTO T 27 & T 11	1 per 1000 tons	From windrow or roadbed after processing	Yes	4 hours	–
		No. 4	I						
		No. 200	I						
		Other specified sieves	II						

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Base course Grading C, D, & E	Statistical (106.05)	Gradation		AASHTO T 27 & T 11	1 per 1000 tons	From windrow or roadbed after processing	Yes	4 hours	–
		⅜ in	I						
		No. 4	I						
		No. 200	I						
		Other specified sieves	II						
Subbase & base course Grading A, B, C, D, & E	Measured & tested for conformance (106.04)	Liquid limit	–	AASHTO R 58 & T 89, Method A	1 per 1000 tons	From windrow or roadbed after processing	Yes	4 hours	–
		Moisture-density (maximum density)	–	AASHTO T 180, Method D(1)	1 per type & source of material	Stockpile or production output	"	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place after compaction	No	End of shift	–
		Moisture content (in-place)	–	"	"	"	"	"	–

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Surface course aggregate	Statistical (106.05)	Gradation		AASHTO T 27 & T 11	1 per 1000 tons	From windrow or roadbed after processing	Yes	4 hours	–
		No. 4	I						
		No. 40	I						
		No. 200	I						
		Other specified sieves	II						
		Plasticity index	I	AASHTO R 58, T 89, & T 90	"	"	"	"	–
	Measured & tested for conformance (106.04)	Moisture-density (maximum density)	–	AASHTO T 180, Method D(1)	1 per type & source of material	Stockpile or production output	Yes	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place after compaction	No	End of shift	–
		Moisture content (in-place)	–	"	"	"	"	"	–
		Fractured faces	–	AASHTO T 335	1 per 1000 tons	From windrow on roadbed after processing	Yes	4 hours	–

Table 301-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Subbase, base, & surface course	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	As directed	Surface of final course	No	Before placement of next lift or as requested	–

(1) At least 5 points per proctor.

Section 302. — CRUSHED AGGREGATE

Description

302.01 This work consists of providing and placing crushed aggregate.

Material

302.02 Conform to the following Subsections:

Crushed aggregate	703.06
Water for construction	725.01(c)

Construction Requirements

302.03 Preparing Surface.

(a) Roadway aggregate. Prepare the surface according to Section 204 or 303 as applicable.

(b) Bedding and backfill aggregate. Shape, compact, and finish the surface to the required line, grade, elevation, and cross-section according to Section 209.

(c) Shoulder finishing aggregate. Remove slide material, vegetation, and other debris from existing shoulders including shoulders in parking areas, turnouts, and other widened areas. Repair soft and unstable areas according to Subsection 204.07. Reshape shoulders to the widths and slopes shown in the plans. Dispose of waste at designated sites or according to Subsection 204.14.

302.04 Mixing and Spreading.

(a) Roadway aggregate. Mix the aggregate and adjust the moisture content to obtain a uniform mixture. Adjust the moisture content to obtain proper compaction. Spread and shape in uniform lifts no more than 6 inches compacted thickness. If more than one lift is necessary, compact each lift according to Subsection 302.05(a) before placing the next lift.

(b) Bedding and backfill aggregate. Spread and shape in uniform lifts no more than 6 inches compacted thickness. If more than one lift is necessary, compact each lift according to Subsection 302.05(b) before placing the next lift.

(c) Shoulder finishing aggregate. Mix the aggregate and adjust the moisture content to obtain a uniform mixture. Adjust the moisture content to obtain proper compaction. Spread and shape in uniform lifts no more than 6 inches compacted thickness.

302.05 Compacting and Finishing Crushed Aggregate.

(a) Roadway aggregate. If no compaction method is specified, use either method. Finish the surface according to Subsection 301.06.

(1) Method 1. Compact each lift according to Subsection 204.11(a). Roll from the sides to the center, parallel to the centerline of the road. Compact the material along curbs, headers, walls, and places not accessible to a roller with approved tampers or compactors.

Compactive effort may be decreased if in-place densities show that less compactive effort is required under Method 2.

(2) Method 2. Compact each lift according to Subsection 301.05.

(b) Bedding and backfill aggregate. Compact each lift according to Subsection 209.10.

(c) Shoulder finishing aggregate. Uniformly compact each lift to ensure it does not exhibit heaving, pumping, rutting, or shearing. Finish surface according to Subsection 301.06.

302.06 Acceptance. See Table 302-1 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsections 106.02 and 106.03. Submit a production certification including gradation and quality properties for each source.

Construction of crushed aggregate will be evaluated under Subsections 106.02 and 106.04.

Measurement

302.07 Measure the Section 302 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring crushed aggregate by the cubic yard, measure in place.

When measuring crushed aggregate by the square yard, measure the length horizontally along the centerline of the roadway. Measure the width horizontally to include the top of aggregate width, including designed widenings.

Payment

302.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 302 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 302-1
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Crushed aggregate	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D[1]	1 per aggregate supplied	Production output or stockpile	Yes	4 hours	Not required for shoulder finishing
		Gradation[2]	–	AASHTO T 11 & T 27	1 per 500 tons	From the windrow or roadbed after processing.	"	Before placing next lift	For Method 2 compactio n only
		Density	–	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place after compaction	No	End of shift	"
Crushed aggregate	Process control (153.03)	Moisture content (in-place)	–	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place after compaction	No	End of shift	Not required for shoulder finishing
Finished Product									
Crushed aggregate	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	As directed	Surface of final course	No	Before placement of next lift or as requested	–

(1) At least 5 points per proctor.
(2) Sampling and testing only required for roadway aggregate. Conform to the approved certification.

Section 303. — ROAD RECONDITIONING

Description

303.01 This work consists of reconditioning ditches, shoulders, roadbeds, aggregate surfaces, and roadways.

Material

303.02 Conform to the following Subsection:

Water for construction	725.01(c)

Construction Requirements

303.03 General. Dispose of waste at designated sites or according to Subsection 204.14.

303.04 Ditch Reconditioning. Remove slide material, sediment, vegetation, and other debris from existing ditches and culvert inlets and outlets. Reshape ditches and culvert inlets and outlets to achieve positive drainage and uniform ditch width, depth, and grade or as shown in the plans.

303.05 Shoulder Reconditioning. Remove slide material, vegetation, and other debris from existing shoulders including shoulders in parking areas, turnouts, and other widened areas. Repair soft and unstable areas according to Subsection 204.07. Reshape shoulders to the widths and slopes shown in the plans.

303.06 Roadbed Reconditioning. Remove organic, deleterious, and material larger than 6 inches from the top 6 inches of subgrade. Repair soft and unstable areas according to Subsection 204.07. Scarify surface to a 6-inch depth. Remove irregularities and shape to a uniform surface. Finish earth surfaces to within 0.05 feet and rock surfaces to within 0.10 feet of required line, grade, and cross-section. Compact according to Subsection 204.11.

303.07 Aggregate Surface Reconditioning. Repair soft and unstable areas to the full aggregate surface depth and according to Subsection 204.07. Scarify to the depth of aggregate surfacing shown in the plans. If no depth is indicated in the plans, scarify to a 6-inch depth. Remove irregularities and shape to a uniform surface. Compact and finish the surface according to Subsections 301.05 and 301.06.

303.08 Roadway Reconditioning. Perform applicable work described in Subsections 303.03 through 303.07. Maintain existing cross slope and crown or shape and grade as shown in the plans.

303.09 Acceptance. See Table 303-1 for sampling, testing, and acceptance requirements.

Road reconditioning work will be evaluated under Subsections 106.02 and 106.04.

Measurement

303.10 Measure the Section 303 pay items listed in the bid schedule according to Subsection 109.02.

Payment

303.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 303 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 303-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Existing roadbed material or aggregate surfacing	Measured & tested for conformance (106.04)	Classification	–	AASHTO M 145	1 per soil type	Roadbed	Yes	Before using in work	–
		Moisture-density	–	AASHTO T 180, Method D(1) or AASHTO T 99, Method C(1)	1 per mixture & change in material	Processed material	No	"	–
		Density	–	AASHTO T 310 or other approved procedures	1 per 2000 yd^2	In-place after compaction	"	End of shift	For Subsection 204.11(c) cases only
	Process control (153.03)	Moisture content (in-place)	–	AASHTO T 310 or other approved procedures	1 per 2000 yd^2	In-place after compaction	No	End of shift	–
Finished Product									
Aggregate surface reconditioning (303.07)	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	As directed	Surface of final course	No	Before placement of next lift or as requested	–

(1) At least 5 points per proctor.

Section 304. — FULL DEPTH RECLAMATION

Description

304.01 This work consists of pulverizing an existing pavement and base in-place, adding crushed aggregate if required, mixing this material with water, and shaping and compacting the mix to produce a base.

Material

304.02 Conform to the following Subsections:

Crushed aggregate	703.06
Water for construction	725.01(c)

Construction Requirements

304.03 General. Maintain the existing cross-section or construct to proposed cross-section.

Protect manholes, valve covers, and other buried facilities from damage.

304.04 Adding Crushed Aggregate. Add crushed aggregate as required to bring the finished surface to the established line, grade, and cross-section.

304.05 Pulverizing. Provide a road reclaimer that is:

(a) Self-propelled;

(b) Specifically manufactured for in-place reclamation;

(c) Capable of reducing the existing material to the required size;

(d) Equipped with at least an 8-foot cutting width;

(e) Equipped with standard automatic depth controls adjustable in increments of ½ inch; and

(f) Equipped with sufficient horsepower to constantly pulverize to the required depth in a single pass.

Pulverize the existing roadway material using the reclaimer until 100 percent passes the 1½-inch sieve. Reprocess or remove larger particles and dispose of them according to Subsection 203.07.

304.06 Mixing and Spreading. Add water as necessary to adjust the moisture content of the mixture to within 2 percent of the optimum for compaction. Mix to produce a homogenous full depth mixture. Spread the mixture uniformly to provide a final compacted shape according to the established line, grade, and cross-section.

304.07 Compacting and Finishing. If no compaction method is specified, use either method. Finish the surface according to Subsection 301.06.

(a) Method 1. Compact full depth reclamation (FDR) material full width according to Subsection 204.11(a).

(b) Method 2. Collect representative samples of the pavement and base from the project. Process and blend these materials to achieve a gradation representative of the in-place pulverized material. Compact FDR material according to Subsection 301.05.

304.08 Maintenance. Maintain the FDR material according to Subsection 301.07.

304.09 Acceptance. See Table 304-1 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsections 106.02 and 106.03.

Construction of full depth reclamation will be evaluated under Subsections 106.02 and 106.04.

Measurement

304.10 Measure the Section 304 pay items listed in the bid schedule according to Subsection 109.02.

Payment

304.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 304 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 304-1
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Pre-Production (reclaimed material)									
FDR material	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D(1)	1 sample at production start-up location	Production start-up location	Yes	Before production	For Method 2 compaction only
Production									
FDR material	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D(1)	1 per change in material	Behind reclaimer before compaction	Yes	Before using in work	–
		Density	–	AASHTO T 310	1 per 2000 yd^2	In-place after compaction	No	End of shift	For Method 2 compaction only
	Process control (153.03)	Moisture content (in-place)	–	AASHTO T 255 or other approved methods	1 per 3500 yd^2 minimum	FDR material after compaction	No	Upon completion of test	–
		Gradation	–	AASHTO T 27	"	Behind reclaimer before compaction	"	"	Minus 1½-in sieve requirement only
Finished Product									
Finished FDR material	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	As directed	Completed FDR surface	No	Before placement of next layer or as requested	–

(1) At least 5 points per proctor.

Section 305. — FULL DEPTH RECLAMATION WITH CEMENT

Description

305.01 This work consists of pulverizing an existing pavement and base in-place, adding crushed aggregate if required, mixing this material with cement and water, and shaping and compacting the mix to produce a stabilized base.

Material

305.02 Conform to the following Subsections:

Crushed aggregate	703.06
Hydraulic cement	701.01
Water for construction	725.01(c)

Construction Requirements

305.03 Proportioning. Collect representative samples of the pavement and base from the project. Process and blend these materials to achieve a gradation representative of the in-place pulverized material.

Estimate the median cement content by percent of total mix weight to meet the requirements shown in Table 305-1. At this median cement content and at cement contents 1 or 2 percent above and below this median, determine the optimum moisture content, maximum density, and the parameters shown in Table 305-1. Choose range of cement contents to properly bracket the strength requirements shown in Table 305-1.

Table 305-1
Soil-Aggregate-Cement Mix Design Parameters

Property	Requirement
Unconfined compressive strength, ASTM D1633, Method A(1)	
Average strength range (3 specimens)	200 to 400 psi
Maximum strength of a single specimen break	500 psi or less
Loss in mass, AASHTO T 135 & T 136, 12 cycles	14% maximum

(1) At 7-day cure at 70 °F according to ASTM D1632.

Submit a mix design for approval at least 14 days before production which includes the following:

(a) Optimum cement content conforming to the requirements shown in Table 305-1;

(b) Maximum density and moisture content at the optimum cement content according to AASHTO T 134, at least 5 points;

(c) Source of cement and imported crushed aggregate including certifications;

(d) Results of tests and applicable charts and graphs;

(e) Gradation and proportion of imported crushed aggregate;

(f) Proportion of base material to pavement and gradation of the mix;

(g) 200-pound sample of the pavement, base, and imported crushed aggregate, if requested; and

(h) 20-pound sample of portland cement, if requested.

Start production only after the mix design is approved. If the mix design is rejected, submit a new mix design for approval.

305.04 General. Establish existing pavement cross-section according to Subsection 152.05. Maintain the established cross-section or construct to proposed cross-section.

Protect manholes, valve covers, and other buried facilities from damage.

305.05 Production Start-Up Procedures. If an asphalt overlay is required, do not start FDR production until the asphalt overlay mix design has been approved.

(a) Preparatory phase meeting. Conduct a pre-stabilization preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of stabilizing operations.

Before the preparatory phase meeting, convert the approved mix design cement percentage to pounds per square yard and submit to the CO.

(b) Control strip. Provide 7 days' notice before starting production.

On the first day of production, stabilize a 1000-foot control strip, one-lane wide, at the designated lift thickness and mix design proportions. Construct the control strip on the project at an approved location.

Construct the control strip using construction procedures intended for the entire project. Take nuclear gauge density readings behind each roller pass to determine the roller pattern necessary to achieve the specification requirements in Subsection 305.10. Cease production after construction of the control strip until the stabilized base and the control strip are evaluated for acceptance.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed base. When a control strip is accepted, full production may start.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the starting of a new construction season.

305.06 Adding Crushed Aggregate. Conform to Subsection 304.04.

305.07 Pulverizing. Conform to Subsection 304.05.

305.08 Applying Cement. Do not add cement when the underlying surface is frozen, muddy, or when conditions allow for excessive loss to eroding or blowing. Start cement application when the air temperature is above 40 °F and is expected to stay above 40 °F for 48 hours. Apply cement by one of the following methods:

(a) Dry method. Use a metered mechanical spreader to uniformly apply the cement. Use canvas (or similar) skirts around the spreader box to minimize dust.

(b) Slurry method. Use approved equipment and dispersal processes to uniformly apply a cement and water slurry without pooling or run off. Equip slurry tanks with an agitator to keep the cement suspended in water. Apply the slurry to the pulverized material with 60 minutes from time water first contacts the cement. Make successive passes over the material if necessary to obtain the proper moisture and cement content for mixing and compacting.

305.09 Mixing. Start mixing within 30 minutes after cement application. Use a road reclaimer conforming to Subsection 304.05. Add water as necessary to adjust the moisture content of the mixture to within 2 percent of optimum as indicated in the approved mix design. Continue mixing until the cement is uniformly distributed within the in situ material creating a homogeneous full depth layer. Complete mixing within 1 hour of the cement application.

305.10 Compacting and Finishing. Compact the processed material uniformly to at least 95 percent of maximum density as determined from AASHTO T 134. Provide rollers sized and configured to achieve the required compaction and finishing. Operate rollers according to the manufacturer's recommendations. Compact the processed material full width by rolling from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

During compaction and final grading maintain the moisture content of the mixture to within 2 percent of optimum. Do not leave areas of stabilized material uncompacted or undisturbed for more than 30 minutes. Complete compaction within 1 hour after mixing.

Finish the compacted surface according to Subsection 301.06 to produce a surface that is smooth, dense, and free of compaction planes, ridges, or loose material. Clean the compacted surface of loose material, dirt, or other deleterious material by approved methods. Complete finishing operations within 4 hours from the start of mixing including corrections to irregularities in the surface.

305.11 Construction Joints. If cement application operations are delayed or stopped for more than 2 hours, make a transverse construction joint by cutting back into the completed work to form an approximately vertical face. Tie new work into the completed work by remixing approximately 36 inches of the completed course.

305.12 Micro-cracking. Micro-crack the finished compacted surface 48 to 72 hours after completion of compaction using a minimum 10-ton vibratory steel drum roller, set at maximum amplitude, advancing at approximately 3 feet per second, and make three full passes, or as approved.

305.13 Curing. Allow material to cure at least 24 hours before placing the next course. Cure by one of the methods below:

(a) Water method. Keep the surface continuously moist by applying water through a spray bar equipped with nozzles producing a fine, uniform spray. During the first 24 hours of curing, use a water truck with side spray to avoid driving on the newly stabilized layer. Prevent damage to the finished surface. Maintain a moist surface until next course is placed.

(b) Prime coat method. Seal the surface by placing an inverted prime coat according to Subsection 411.06(b). Provide and maintain a continuous film over the surface. Apply prime coat within 72 hours after compacting and finishing. Keep surface moist according to Subsection 305.13(a) until prime coat is placed.

Do not allow traffic and construction equipment on stabilized base until it is sufficiently stable to withstand marring and permanent deformation. Restrict traffic according to Section 156. Limit traffic speeds to 20 miles per hour.

305.14 Maintenance. Maintain the cement stabilized layer to the correct line, grade, and cross-section until placement of the next course. If the cement stabilized layer loses stability, density, or finish before placement of the next course, reprocess, recompact, and add cement as necessary to restore the strength of the damaged material.

Overlay the stabilized base within 14 days after completing finishing operations according to Subsection 305.10.

305.15 Acceptance. See Table 305-2 for sampling, testing, and acceptance requirements.

Crushed aggregate will be evaluated under Subsections 106.02 and 106.03.

Cement will be evaluated under Subsections 106.02 and 106.03.

Construction of full depth reclamation with cement will be evaluated under Subsections 106.02 and 106.04.

Prime coat will be evaluated under Section 411.

Measurement

305.16 Measure the Section 305 pay items listed in the bid schedule according to Subsection 109.02.

Payment

305.17 The accepted quantities will be paid at the contract price per unit of measurement for the Section 305 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 305-2
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Full depth reclamation (FDR) with cement mixture	Measured & tested for conformance (106.04)	All	–	Subsection 305.03	1 per submitted mix design	Existing roadway	Yes	14 days minimum before production	–
Production Start-up (control strip)									
FDR with cement material	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27	3 minimum	Behind reclaimer before compaction	No	Upon Completion of test	Minus 1½-in sieve requirement only
		Moisture-density (maximum density)	–	AASHTO T 134	1 minimum	"	Yes	"	5 points per proctor minimum
		Moisture content (in-place)	–	AASHTO T 255	3 minimum	In-place after compaction	No	"	–
		Density	–	AASHTO T 310 or other approved methods	Subsection 305.05(b)	"	"	"	–

Table 305-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
FDR with cement material	Measured & tested for conformance (106.04)	Moisture-density (maximum density)	–	AASHTO T 134	1 per change of material	Behind reclaimer before compaction	Yes	Before using in work	5 points per proctor minimum
		Density	–	AASHTO T 310 or other approved procedures	1 per 2000 yd^2	In-place after compaction	No	End of shift	–
	Process control (153.03)	Gradation	–	AASHTO T 27	1 per 3500 yd^2 minimum	Behind reclaimer before compaction	"	Upon completion of test	Monitor percent passing the 1½-in & No. 4 sieves
		Moisture content (in-place)	–	AASHTO T 255 or other approved methods	"	In-place after compaction	"	"	–
		Unconfined compression strength (7-day)	–	Table 305-1	1 per day minimum	Behind reclaimer before compaction	"	7 days	7-day cure
Finished Product									
FDR with cement material	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	As directed	Completed FDR surface	No	Before placement of next layer or as requested	–

Section 306. — FULL DEPTH RECLAMATION WITH ASPHALT

Description

306.01 This work consists of pulverizing an existing pavement and base in-place, adding crushed aggregate if required, mixing this material with emulsified asphalt or foamed asphalt, and shaping and compacting the mix to produce a stabilized base.

Material

306.02 Conform to the following Subsections:

Asphalt binder	702.01
Crushed aggregate	703.06
Emulsified asphalt	702.02
Fly ash	701.03(a)
Portland cement	701.01(a)
Water for construction	725.01(c)

Construction Requirements

306.03 Proportioning. Collect representative samples of the pavement and aggregate base from the project. Replace removed pavement with asphalt concrete conforming to Section 403, Type II or approved cold patch material.

Design a mix according to FLH T 522. Conform to the requirements shown in Table 306-1. If using foamed asphalt, provide a binder conforming to the requirements shown in Table 306-2. Submit the mix design and the following for approval 30 days before production:

(a) Optimum emulsified or foamed asphalt binder content based on total mass of mixture;

(b) Source and grade of emulsified or foamed asphalt binder;

(c) Optimum moisture content for compaction based on total mass of mixture;

(d) Recommended cement or fly ash content;

(e) Maximum wet and dry density for the mixture at the recommended proportions of binder, water, and cement or fly ash according to AASHTO T 180, Method D;

(f) Gradation and proportion of imported crushed aggregate;

(g) Results of tests and applicable graphs;

(h) A representative 350-pound sample of pavement, base, and imported crushed aggregate, if requested;

(i) Three 1-gallon samples of emulsified or asphalt binder, if requested;

(j) 15-pound sample of portland cement or fly ash, if requested; and

(k) Optimum percent of injection water for foaming based on total mass of asphalt binder (if using foamed asphalt for the binder).

Start production only after the mix design is approved. Submit a new mix design if there is a change in a material source.

Table 306-1
Asphalt Stabilized Base Course Mix Design Requirements

Binder type	Material or Property	Requirement
Emulsified asphalt and foamed asphalt	Indirect tensile strength, AASHTO T 283(1)	
	Tensile strength wet	25 psi minimum
	Tensile strength ratio	60% minimum

(1) Follow the modified AASHTO T 283 procedures as indicated in FLH T 522.

Table 306-2
Foamed Asphalt Binder Property Requirements

Property	Requirement
Foamed asphalt expansion characteristics at 320, 338, & 356 °F(1)	
Asphalt expansion ratio	10 minimum
Half-life of foamed expansion	6 seconds minimum

(1) See FLH T 522 for test procedures.

306.04 General. Establish existing pavement cross-section according to Subsection 152.05. Maintain the established cross-section or construct to proposed cross-section.

Protect manholes, valve covers, and other buried facilities from damage.

306.05 Production Start-Up Procedures. If an asphalt overlay is required, do not start FDR production until the asphalt overlay mix design has been approved.

(a) Preparatory phase meeting. Conduct a pre-stabilization preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of stabilizing operations.

(b) Control strip. Provide 7 days’ notice before starting production.

On the first day of production, stabilize a 1000-foot-long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using the construction procedures intended for the entire project. Cease production after construction of the control strip until the stabilized base and the control strip are evaluated and verified for acceptance.

After the reclaimer has pulverized and mixed one reclaimer width for 100 feet of the control strip and before compaction, dig a test pit to evaluate the mixing and distribution of the asphalt. If homogeneous mixing is not occurring, modify the process and pulverize, mix, and verify another 100 feet. Continue until acceptable mixing and distribution of asphalt is obtained.

Take three random loose mix samples within the control strip and verify that 100 percent passes the 2-inch sieve.

Take nuclear gauge density readings behind each roller pass according to AASHTO T 310 to determine the roller pattern necessary to achieve at least 97 percent of the maximum wet density. Determine the maximum wet density by sampling processed material from behind the reclaimer (before compaction) and testing the material according to AASHTO T 180, Method D.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed base.

(c) Control strip verification. The control strip is verified when the specified density, gradation, and moisture content are obtained. Full production may start once the control strip is verified. Provide the CO with the reclaimer speed, emulsified or foamed asphalt application temperature, and asphalt and water line pressures used on the verified control strip.

Use these start-up procedures when changing construction procedures, when resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the starting of a new construction season.

306.06 Adding Crushed Aggregate. Conform to Subsection 304.04.

306.07 Pulverizing and Mixing.

(a) If using emulsified or foamed asphalt, provide a road reclaimer that is:

(1) Self-propelled;

(2) Specifically manufactured for in-place reclamation;

(3) Capable of reducing the existing material to the required size;

(4) Equipped with at least an 8-foot cutting width;

(5) Equipped with standard automatic depth controls adjustable in increments of ½ inch;

(6) Equipped with independent asphalt application nozzles that can be turned off individually and verified open and working from within the operator cabin; and

(7) Equipped with an asphalt and water application control system including full width spray bars and positive displacement pumps automatically interlocked to the machine speed.

(b) In addition to the above, if using foamed asphalt, provide a road reclaimer that is:

(1) Equipped with an exterior test nozzle to verify proper foaming action;

(2) Equipped with individual expansion chambers for each nozzle where asphalt binder and water are injected under pressure through individual orifices for atomization and foam expansion;

(3) Equipped with an internal electric heat cleaning system to self-clean foaming nozzles;

(4) Equipped with maximum nozzle spacing of 6 inches; and

(5) Equipped with a compressor that can provide at least 45 pounds per square inch of pressure.

Use the reclaimer to pulverize the existing roadway material in-place until 100 percent passes the 1½-inch sieve. Reprocess or remove larger particles and dispose of them according to Subsection 203.07.

306.08 Applying Cement or Fly Ash. Do not apply cement or fly ash when conditions allow for excessive loss to blowing. Use a metered mechanical spreader to uniformly apply cement or fly ash on the roadway surface. Use skirts around the spreader box to minimize dust.

306.09 Applying Asphalt.

(a) Requirements for emulsified and foamed asphalt. Apply emulsified or foamed asphalt when the surface and air temperatures in the shade are at least 50 ºF. Do not start applying emulsified asphalt when fog, precipitation, or temperatures below 35 ºF are anticipated within 48 hours.

Automatically adjust the asphalt and water flow based on the reclaimer speed and recycled material mass for the approved mix design. Maintain the asphalt temperature within the range recommended by the supplier.

If the lane width exceeds the width of the reclaimer, complete pulverizing and mixing operations in continuous one lane-width segments up to ½ mile in length. Mix the pulverized roadway material with emulsified asphalt binder, other additives, and the necessary mixing water for optimum dispersion. If two passes are used, shape and compact the reclaimed material with a steel drum roller after the first pass to provide depth control for the second pass of the reclaimer. Add the required quantity of emulsified or foamed asphalt during the final pass of the reclaimer.

Verify that the emulsified or foamed asphalt is evenly dispersed and coating the pulverized material. Dig test pits within the mix at least every ¼ mile and observe the distribution of the emulsified or foamed asphalt in each pit.

(b) Additional requirements for foamed asphalt. Do not use foamed asphalt with an application temperature below 320 °F.

Do not apply foamed asphalt on previously treated foamed asphalt areas.

306.10 Compacting and Finishing. Compact and finish each segment before starting mixing operations on the next segment. Maintain the moisture content of the mixture within 2 percent of optimum.

Compact the processed material uniformly to at least 97 percent of the maximum wet density as determined from the control strip. If the material changes, reestablish the maximum wet density according to Subsection 306.05(b). Determine the in-place density according to AASHTO T 310.

Use at least three rollers: primary, secondary, and finish rollers sized and configured to achieve the required compaction and finish. Operate rollers according to the manufacturer's recommendations. Compact the processed material full width by rolling the material between the reclaimer wheel paths first then from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

Shape and grade the mixture to the correct lines, grades, and cross-section. Finish the compacted surface according to Subsection 301.06 to produce a surface that is smooth, dense, and free of compaction planes, ridges, or loose material. Clean the compacted surface of loose material, dirt, and other deleterious material by approved methods. Do not leave uncompleted segments at the end of the workday.

306.11 Construction Joints.

(a) Longitudinal joints. Make longitudinal joints coincide with each change in cross slope, regardless of the overlap width. Provide a minimum longitudinal overlap of 6 inches.

(b) Transverse joints. After full depth reclamation operations stop, ensure continuity across transverse joints by cutting back into the completed work for a distance recommended by the manufacturer of the reclaimer.

306.12 Curing and Maintenance.

(a) Emulsified asphalt. Keep traffic and equipment off the stabilized base for at least 1 hour after completing compaction. Do not allow traffic and construction equipment on the stabilized base until it is sufficiently stable to withstand marring and permanent deformation.

(b) Foamed asphalt. After completing compaction, moisten the surface and roll with a pneumatic-tire roller to create a tight and closed surface. Do not allow traffic and construction equipment on the stabilized base until compaction and surface moistening is complete. Continue to keep the surface moist until placement of the next course or final surface.

If shown in the plans, place a fog seal on the surface of the stabilized base after final compaction according to Section 406.

Route hauling and other construction equipment uniformly over the full width of the recycled surface to minimize non-uniform compaction.

Maintain the stabilized base to the correct line, grade, and cross-section until placement of the next course or final riding surface. If the stabilized base loses stability, density, or finish before placement of the next course, reprocess and recompact as necessary to restore the strength of the damaged material.

Overlay the stabilized base material within 14 days after completing finishing operations according to Subsection 306.10.

306.13 Acceptance. See Table 306-3 for sampling, testing, and acceptance requirements.

Cement or fly ash will be evaluated under Subsections 106.02 and 106.03.

Crushed aggregate will be evaluated under Subsections 106.02 and 106.03.

Emulsified and foamed asphalt will be evaluated under Subsections 106.03 and 106.04.

Construction of full depth reclamation with asphalt will be evaluated under Subsections 106.02 and 106.04.

Measurement

306.14 Measure the Section 306 pay items listed in the bid schedule according to Subsection 109.02.

Payment

306.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 306 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 306-3
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Emulsified asphalt	Measured & tested for conformance (106.04)	Quality	–	Subsection 702.02	1 per type & source of material	Asphalt supplier	Yes	30 days minimum before production	–
Asphalt binder (foamed)	"	"	–	Subsection 702.01 & Table 306-2	"	"	"	"	–
Mix Design									
Full depth reclamation (FDR) with asphalt mixture	Measured & tested for conformance (106.04)	All	–	Subsection 306.03 & FLH T 522	1 per submitted mix design	Existing roadway	Yes	30 days minimum before production	–

Table 306-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt binder (foamed)	Measured & tested for conformance (106.04)	Binder temperature	–	Subsection 306.09	1 minimum	Temperature gauge(3)	No	Upon completing test	–
		Half-life & expansion ratio	–	Table 306-2 & FLH T 522	"	Test nozzle on reclaimer	"	"	–
FDR with asphalt material	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27	3 minimum	Behind reclaimer before compaction	No	Upon completing test	Minus 1½-in sieve requirement only
		Moisture-density (wet density)(1)	–	AASHTO T 180, Method D	1 minimum	"	"	"	–
		Moisture content (in-place)	–	AASHTO T 255	3 minimum	In-place after compaction	"	"	–
		Density	–	AASHTO T 310	"	In-place after compaction	"	"	Report wet density
	Visual inspection (106.02)	Homogeneous mixing	–	Subsection 306.05(b)	Subsection 306.05(b)	Behind reclaimer before compaction	No	Upon completing test	–

Table 306-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
FDR asphalt material	Measured & tested for conformance (106.04)	Moisture-density (wet density)(1)	–	AASHTO T 180, Method D	1 per change in material	Behind reclaimer before compaction	No	Before using in work	–
		Density	–	AASHTO T 310	1 per 2000 yd^2	In-place after compaction	"	End of shift	Report wet density
	Process control (153.03)	Gradation	–	AASHTO T 27	1 per 3500 yd^2 minimum	Behind reclaimer before compaction	No	Upon completion of test	–
		Moisture content	–	AASHTO T 255	1 per lane mile	"	"	"	–
		Homogeneous mixing	–	Subsection 306.05(b)	1 per 3500 yd^2 minimum	"	"	"	–
		Binder content of mix	–	Calculation (yield rate)	1 per tank load minimum	–	"	"	–
		Indirect tensile strength(2)	–	AASHTO T 283 (as modified by FLH T 522)	1 per 15,000 yd^2	"	"	4 days	–

Table 306-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt binder (foamed)	Process control (153.03)	Binder temperature	–	Subsection 306.09	1 per tank load	Temperature gauge(3)	No	Upon completing test	–
		Half-life & expansion ratio	–	Table 306-2 & FLH T 522	"	Test nozzle on reclaimer	"	"	–
Finished Product									
FDR with asphalt material	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	As directed	Completed FDR surface	No	Before placement of next layer or as requested	–

(1) At least 5 points per proctor.
(2) Immediately after collecting sample, transport to a field material laboratory and compact for indirect tensile strength testing. Keep sample in moisture proof container.
(3) Measure asphalt binder temperature with a calibrated thermometer.

Section 307. — RESERVED

Section 308. — EMULSIFIED ASPHALT-TREATED BASE COURSE

Description

308.01 This work consists of constructing a course of emulsified asphalt-treated base on a prepared surface.

Material

308.02 Conform to the following Subsections:

Emulsified asphalt	702.02
Subbase or base course aggregate	703.05(b)
Water for construction	725.01(c)

Construction Requirements

308.03 General. Prepare the surface according to Section 204 or 303 as applicable.

After a representative quantity of aggregate is produced and at least 14 days before incorporating the aggregate into the work, submit the following:

(a) Proposed target values for base aggregate within the gradation ranges shown in Table 703-1 for the required grading; and

(b) A representative 400-pound aggregate sample.

Stop placement and resubmit new target values if the calculated mean value for a tested sieve differs from the target value by more than the allowable deviation for that sieve.

308.04 Mixing and Spreading. Use a stationary pugmill with weighing, volumetric, or other gauging equipment that can control the material entering the mixer. Interlock the controls for the aggregate feed with the emulsified asphalt and water controls to ensure uniform introduction of material into the mixer.

Determine the optimum moisture content of the mixture according to AASHTO T 180, Method D. Add aggregate and water to the mixer before the emulsified asphalt. Add 1 percent emulsified asphalt by mass of aggregate. Adjust the total liquid content (emulsified asphalt and water) to within 1 percent of the optimum moisture content at the time of compaction. Mix until particles are uniformly coated. Haul and place the treated aggregate immediately after mixing. Do not store emulsified asphalt-treated aggregates in stockpiles.

Spread the mixture on the prepared surface in a uniform lift. Shape the mixture to the required line, grade, and cross-section. Route hauling equipment uniformly over the full width of the surface to minimize non-uniform compaction.

308.05 Compacting. Compact the mixture according to Subsection 301.05.

308.06 Surface Tolerance. Finish the surface according to Subsection 301.06.

308.07 Maintenance. Maintain the emulsified asphalt-treated aggregate base course according to Subsection 301.07.

308.08 Acceptance. See Table 308-1 for sampling, testing, and acceptance requirements.

Emulsified asphalt will be evaluated under Subsections 106.02 and 106.03.

Aggregate gradation, $\frac{SE}{P_{200}}$Index (SEP), and fractured faces will be evaluated under Subsection 106.05.

(a) Aggregate gradation. The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Tables 703-1 and 703-2, except as follows:

(1) If the calculated mean value for a tested sieve exceeds the maximum gradation range value shown in Table 703-1, then the upper specification is equal to the maximum gradation value in Table 703-1 plus or minus the allowable deviation in Table 703-2.

(2) If the calculated mean value for a tested sieve is less than the minimum gradation range value shown in Table 703-1, then the lower specification is equal to the minimum gradation value in Table 703-1 plus or minus the allowable deviation in Table 703-2.

(b) SEP. See Table 308-1, Note (2). The lower specification limit is 1.000.

(c) Fractured faces. The lower specification limit is 50 percent.

Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Construction of emulsified asphalt-treated base course will be evaluated under Subsections 106.02 and 106.04.

Measurement

308.09 Measure the Section 308 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring emulsified asphalt-treated aggregate base by the cubic yard, measure in place.

When measuring emulsified asphalt-treated aggregate base by the square yard, measure the length horizontally along the centerline of the roadway. Measure the width horizontally to include the top of emulsified asphalt-treated aggregate base width and allowable widening.

Payment

308.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 308 pay items listed in the bid schedule, except the emulsified asphalt-treated aggregate base course contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 308-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (703.05)	Measured & tested for conformance (106.04 & 105)	LA abrasion (coarse)	–	AASHTO T 96	1 per rock type but not less than 5 per material source(1)	Source of material	Yes	Before using in work	Not required if using Government-furnished sources
		Durability index	–	AASHTO T 210	"	"	"	"	"
		Soundness using sodium sulfate	–	AASHTO T 104	"	"	"	"	"
Aggregate base, Grading C, D, & E (703.05)	Process control (153.03)	Gradation	–	AASHTO T 11 & T 27	2 per day per stockpile minimum	Crusher belt	No	24 hours	Not required if using Government-furnished sources
		Fractured faces	–	AASHTO T 335	"	"	"	"	"

Table 308-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Aggregate base, Grading C, D, & E	Measured & tested for conformance (106.04)	Moisture-density (maximum density)	–	AASHTO T 180, Method D(3)	1 per type & source of material	Stockpile or Production output	Yes	Before using in work	–
Emulsified asphalt-treated aggregate base, Grading C, D, & E (703.05)	Statistical (106.05)	Gradation	–	AASHTO T 30	1 per 1000 tons	In-place, after compaction	Yes	4 hours	–
		⅜ in	I						
		No. 4	I						
		Other specified sieves	II						
		Fractured faces	I	ASSHTO T 335	"	"	"	"	–
		Sand equivalent	–	AASHTO T 176, Alternate Method No. 2, Reference Method	"	Belt feed before adding emulsified asphalt	"	"	–
		SEP	I	(2)	"	–	No	–	–
Emulsified asphalt-treated aggregate base, Grading C, D, & E	Measured & tested for conformance (106.04)	Density	–	AASHTO T 310 or other approved procedures	1 per 500 tons but not less than 1 per lift	In-place, after compaction	No	Before placing next lift	–

Table 308-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Emulsified asphalt-treated aggregate base	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	As directed	Completed base surface	No	Before placing next lift or as requested	–

(1) Submit at least five reports, but at least one report per rock type for each source. Submit reports dated within 1 year of intended use and include rock type and sample location. Obtain samples representative of aggregates being provided.

(2) SEP is a measure of a material's ability to perform based on the quality and quantity of fines present. Quality is represented by the sand equivalent (SE) and quantity is represented by the percent passing the No. 200 sieve (P_{200}). SEP is computed as follows:

For SE ≥ 29, $SEP = \frac{SE}{P_{200} + 25}$ and for SE < 29, $SEP = \frac{SE + 4}{SE + P_{200}}$.

Where: SE = Plastic fines in graded aggregates and soils by using the sand equivalent test. See AASHTO T 176, Alternate Method No.2, Reference Method.

P_{200} = Material finer than the No. 200 sieve in mineral aggregates by washing. See AASHTO T 11.

(3) At least 5 points per proctor.

Section 309. — COLD CENTRAL PLANT RECYCLED ASPHALT BASE COURSE

Description

309.01 This work consists of constructing one or more courses of cold central plant recycled asphalt base using milled asphalt material.

Material

309.02 Conform to the following Subsections:

Engineered emulsion	702.02(d)
Hydraulic cement	701.01
Lime for asphalt mixtures	725.03(c)
Water for construction	725.01(c)

Construction Requirements

309.03 Composition of Mix (Job-Mix Formula). Collect representative samples of the recycled asphalt pavement to be used. Reduce oversize particles to no more than 1½ inches. Replace removed pavement with asphalt concrete conforming to Section 403, Type II.

Design a mix according to Table 309-1. Submit the JMF and the following for approval 30 days before production:

(a) Optimum engineered emulsion content based on total mass of mixture;

(b) Source of engineered emulsion;

(c) Optimum moisture content for dispersion and compaction based on total mass of mixture;

(d) Lime or cement content, if required;

(e) Results of tests and applicable charts and graphs;

(f) A representative 300-pound sample of pavement, if requested;

(g) Three 1-gallon samples of engineered emulsion, if requested; and

(h) A 2-pound sample of lime or cement, if requested.

Start production only after the mix design is approved. Submit a new mix design if there is a change in a material source.

Table 309-1
Cold Central Plant Asphalt Base Course Mix Design Parameters

Property	Requirement
Indirect tensile strength, AASHTO T 283(1)	
Tensile strength dry	70 psi minimum
Tensile strength ratio	70% minimum
Raveling test, ASTM D7196, 4-hour cure at 50 °F, 50% humidity	
Average mass loss	5% maximum

(1) Follow Section 7 for laboratory-mixed, laboratory-compacted specimens. Compact the mixture to the design air voids. Instead of Subsection 7.5, cure samples for at least 16 hours and no more than 48 hours at 140°F until constant weight is attained. Instead of the Subsection 10.4 saturation range, use a target range from 55 to 75 percent saturation. Do not use the conditioning cycles in Sections 10.4.9 and 10.4.10. Instead, condition the sample in a water bath at 77°F for 24 hours.

309.04 Equipment.

(a) Pugmill and proportioning equipment. Provide the following:

(1) Capable of continuously mixing the milled material with emulsified asphalt, water, lime, and other additives to produce a uniform and homogenous mixture;

(2) Belt scale for continuous weighing of milled and sized material with an interlocked computer controlled liquid metering device that can automatically adjust the flow of asphalt emulsion to the mass of milled material coming into the mixer;

(3) Proportioning equipment that can apply emulsified asphalt and water to within ±0.2 percent of the required quantity by mass of milled material; and

(4) Proportioning equipment with a digital meter for monitoring the flow rate and total milled material, emulsified asphalt, and water applied.

(b) Paver. Provide a paver conforming to Subsection 401.05 that can pick up the entire windrow and feeding it into the paver hopper. Do not heat the screed.

(c) Rollers. Provide double-drum steel-wheel and pneumatic-tire rollers in sufficient quantity and size to obtain the required density. Provide pneumatic-tire rollers weighing at least 30 tons.

309.05 Weather Limitations. Do not start work when fog, precipitation, frost, or temperatures below 35 ºF are anticipated within 24 hours.

Place cold central plant recycled asphalt base on a dry, unfrozen surface when the air temperature in the shade is 50 ºF and rising and the pavement surface temperature is 40 ºF and rising.

309.06 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-recycling preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of recycling operations.

(b) Control strip. Provide 7 days' notice before starting production of a cold central plant recycled asphalt base.

On the first day of production, produce sufficient cold central plant recycled asphalt base to construct a 1500-foot-long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using the production, lay-down, and compaction procedures intended for the entire mix. Document roller pattern and if roller was operated in vibratory or static mode. Provide frequency and amplitude settings if operated in vibratory mode. Provide this documentation to the CO after completion of the control strip.

Stop production after construction of the control strip until the cold central plant recycled asphalt base and the control strip are accepted.

Repeat the control strip process until an accepted control strip is produced. See Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed pavement. When a control strip is accepted, full production may start.

Use these start-up procedures when changing construction procedures, resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or starting a new construction season.

309.07 Mixing. Obtain milled material under Section 413. Reduce oversize particles to no more than 1½ inches.

Combine milled material with emulsified asphalt, water, and lime or cement at the approved application rates to produce a homogenous and uniformly coated mixture. Maintain the emulsified asphalt temperature within the range recommended by the supplier.

Adjust application rates in coordination with the CO based upon material variations.

309.08 Spreading, Compacting, and Finishing. Transport material according to Subsection 401.11.

(a) Spreading. Spread and finish the recycled asphalt base to the required line, grade, and cross-section.

(b) Compacting. Start compaction within 60 minutes of spreading. Use pneumatic-tire rollers until no displacement is observed. Use steel-wheel rollers, in static or low-amplitude vibratory mode, to achieve final density and eliminate pneumatic-tire roller marks. Do not park or idle rollers on uncompacted material. Compact the recycled mix using the following equipment, sequence, and number of roller passes:

(1) Six to twelve roller passes with a self-propelled pneumatic-tired roller having smooth pneumatic tires staggered in position to provide overlap between the front and rear tires, with a weight of at least 2000 pounds per wheel and a contact pressure of 80 pounds per square inch;

(2) Four to eight roller passes with a double-drum, vibratory roller having a minimum mass of 5.5 tons and equipped with frequency and amplitude controls; and

(3) Four to six roller passes with a static steel-wheel roller with a pressure of at least 250 pounds per square inch.

Compact the material with approved tampers or compactors along curbs, headers, walls, and places not accessible to the roller.

(c) Finishing. Produce a surface that is smooth, dense, and free of ruts, ridges, and loose material. Measure the surface using a 10-foot metal straightedge at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge more than ⅜ inch measured between two contacts of the straightedge or deviations more than ⅜ inch measured at the end of the straightedge.

309.09 Construction Joints.

(a) Longitudinal joints. Make longitudinal joints coincide with each change in cross slope. Provide a longitudinal overlap of at least 4 inches.

(b) Transverse joints. At the start of each day's recycling operations or after a 2-hour work stoppage, cut back into the completed work to ensure uniform material and depth across transverse joints.

309.10 Curing and Maintenance. Keep traffic and construction equipment off the recycled asphalt base for initial curing at least 2 hours after completing compaction and until it is sufficiently stable to withstand raveling, marring, and permanent deformation. Route hauling and other construction equipment uniformly over the full width of the recycled asphalt base to minimize non-uniform compaction.

After initial curing, place a fog seal according to Section 406 on the surface of the recycled asphalt base at a rate of 0.05 to 0.10 gallon per square yard.

Maintain the recycled asphalt base to the correct line, grade, and cross-section. Provide additional rolling with a steel-wheel roller to recompact and maintain a dense surface. Use a power broom to remove loose particles. If the recycled asphalt base ravels or loses stability, density, or finish, reprocess, recompact and finish according to Subsection 309.08 as necessary to restore the strength of the damaged material.

Overlay the recycled asphalt base when the moisture content is less than 2.5 percent according to AASHTO T 255, but within 14 days after completing finishing operations regardless of moisture content.

309.11 Acceptance. See Table 309-2 for sampling, testing, and acceptance requirements.

Cement and lime will be evaluated under Subsections 106.02 and 106.03.

Engineered emulsion will be evaluated under Subsections 106.02 and 106.03.

Milled material will be evaluated under Subsections 106.02 and 106.04.

Construction of the cold central plant recycled asphalt base course will be evaluated under Subsections 106.02 and 106.04.

Fog seal will be evaluated under Section 406.

Measurement

309.12 Measure the Section 309 pay items listed in the bid schedule according to Subsection 109.02.

Payment

309.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 309 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 309-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Engineered emulsion (702.02(d))	Process control (153.03)	Application rates	–	Calculation of yield rate	1 per tank load minimum	–	"	"	–
Finished Product									
Cold recycled asphalt base	Measured & tested for conformance (106.04)	Surface tolerance	–	Straightedge measurement, Subsection 309.08(c)	Continuously, after compaction	Finished recycled base surface	No	24 hours	–

Section 310. — COLD IN-PLACE RECYCLED ASPHALT BASE COURSE

Description

310.01 This work consists of constructing cold in-place recycled asphalt base course with a self-propelled recycling train.

Material

310.02 Conform to the following Subsections:

Crushed aggregate	703.06
Engineered emulsion	702.02(d)
Hydraulic cement	701.01
Lime for asphalt mixtures	725.03(c)
Water for construction	725.01(c)

Construction Requirements

310.03 Composition of Mix (Job-Mix Formula). Collect representative samples of the existing pavement to be milled. Replace removed pavement with asphalt concrete conforming to Section 403, Type II or approved cold patch material.

Design a mix according to FLH T 524 and Table 310-1. Submit the JMF and the following for approval 30 days before production:

(a) Optimum emulsified asphalt binder content based on total mass of mixture;

(b) Source and grade of emulsified asphalt binder;

(c) Optimum moisture content for dispersion and compaction based on total mass of mixture;

(d) Cement or lime content, if needed;

(e) Maximum density for the mixture;

(f) Bulk specific gravity for the mixture;

(g) Results of tests and applicable charts and graphs;

(h) A representative 300-pound sample of pavement, if requested;

(i) Three, 1-gallon samples of emulsified asphalt binder, if requested; and

(j) A 15-pound sample of cement or lime, if requested.

Start production only after the mix design is approved. Submit a new mix design if there is a change in a material source.

Table 310-1
Cold In-Place Recycled Asphalt Base Course Mix Design Parameters

Property	Requirement
Indirect tensile strength, AASHTO T 283(1)	
Tensile strength dry	70 psi minimum
Tensile strength ratio	70% minimum
Raveling test, ASTM D7196, 4-hour cure at 50 °F, 50% humidity(2)	
Average mass loss	5% maximum

(1) Follow the modified AASHTO T 283 procedures as indicated in FLH T 524.
(2) Use the listed testing conditions for the raveling test, unless otherwise directed.

310.04 General. Establish existing pavement cross-section according to Subsection 152.05. Maintain the established cross-section or construct to proposed cross-section.

Protect manholes, valve covers, and other buried facilities from damage.

Clear, grub, and remove vegetation and debris within the area to be disturbed according to Section 201. Clean the pavement and edge of pavement of loose material, dirt, vegetation, and other deleterious material.

310.05 Equipment. Provide a self-propelled recycling train with the following major units:

(a) Pavement milling machine. Provide the following:

(1) Automatic depth controls to maintain the cutting depth to within ±¼ inch;

(2) Automatic system to maintain cross slope;

(3) Capable of milling the existing asphalt pavement material to the required depth in a single pass; and

(4) 12.5 feet minimum cutter width.

(b) Crushing unit. Capable of screening and crushing material to the required size before mixing with emulsified asphalt.

(c) Pugmill and proportioning equipment. Provide the following:

(1) Capable of continuously mixing the milled material with emulsified asphalt, water, lime, and other additives to produce a uniform and homogenous mixture;

(2) Belt scale for continuous weighing of milled and sized material with an interlocked computer controlled liquid metering device that can automatically adjust the flow of asphalt emulsion to the mass of milled material coming into the mixer;

(3) Proportioning equipment that can apply emulsified asphalt and water to within ±0.2 percent of the required quantity by mass of milled material;

(4) Proportioning equipment with a digital meter for monitoring the flow rate and total milled material, emulsified asphalt, and water applied; and

(5) Capable of placing the mixture in a windrow without segregation.

(d) Paver. Provide a paver conforming to Subsection 401.05 that can pick up the entire windrow and feeding it into the paver hopper. Do not heat the screed.

(e) Rollers. Provide double-drum steel-wheel and pneumatic-tire rollers in sufficient quantity and size to obtain the required density. Provide pneumatic-tire rollers weighing at least 30 tons.

310.06 Weather Limitations. Do not start work when fog, precipitation, frost, or temperatures below 35 ºF are anticipated within 24 hours.

Place cold in-place recycled asphalt base on a dry, unfrozen surface when the air temperature in the shade and the road surface temperature are 50 ºF and rising.

310.07 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-recycling preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of recycling operations.

(b) Control strip. Provide 7 days' notice before starting production.

Construct a control strip on the project at an approved location. Recycle a control strip that is one lane wide, 1500 feet long, and the designated lift thickness. Use the construction procedures intended for the entire project. Stop production after construction of the control strip until the recycled base and the control strip are evaluated and accepted.

Acquire three random samples of milled material from the control strip after the material has passed through the crushing unit, but before emulsified asphalt is added for Type A compaction. Verify that 100 percent passes the 1½-inch sieve. Take density readings behind each roller pass to determine the roller pattern necessary to achieve the maximum in-place density (break point of compaction curve) according to ASTM D2950. Use the bulk specific gravity value from the mix design as a benchmark for evaluating the maximum in-place density achieved.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be measured as a part of the completed base course.

Full production may start when a control strip is verified. Provide the CO with the maximum in-place density achieved (Type A compaction), and application rates of the emulsified asphalt, water, and other additives used on the accepted control strip.

Use these start-up procedures when changing construction procedures, resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or starting of a new construction season.

310.08 Pavement Recycling and Mixing. Mill the existing pavement to the required depth and width. Reduce oversize particles to a maximum size of 1½ inches.

If cement or lime is required at the milling head or in the pugmill, incorporate cement or hydrated lime slurry to within ±10 percent of the approved application rate. Produce the cement or lime slurry using water in a slurry production unit equipped with scales and meters accurate to within 0.5 percent by mass. Agitate the transport and feed tanks to provide a consistent and pumpable lime slurry.

Combine milled material with emulsified asphalt, water, and cement or lime at the approved application rates to produce a homogenous and uniformly coated mixture. Maintain the emulsified asphalt temperature within the range recommended by the supplier.

Do not disturb underlying material. Synchronize the recycling rate to allow for continuous operation of recycling train equipment.

Continuously monitor and evaluate the milling, mixing, and placing operations to ensure optimum quality of the recycled asphalt base course. Adjust application rates in coordination with the CO based upon material variations.

310.09 Spreading, Compacting, and Finishing.

(a) Spreading. Spread and finish the recycled mix to the required cross-section.

(b) Compacting. Start compaction within 60 minutes of spreading. Use pneumatic-tire rollers until no displacement is observed. Use steel-wheel rollers, in static or low-amplitude vibratory mode, to achieve final density and eliminate pneumatic-tire roller marks. Do not park or idle rollers on uncompacted material. Compact using the designated type:

(1) Type A compaction. Use roller patterns established during the control strip. Compact the recycled mix to obtain a minimum density of 97 percent of the control strip density. Measure in-place density according to ASTM D2950. If an area fails to meet required density, rework and recompact the area.

If application rates of the emulsified asphalt from the approved mix design are changed by more than ±0.2 percent by mass of milled material, or if other material conditions distinctly change, reestablish roller pattern according to Subsection 310.07.

(2) Type B compaction. Compact the recycled mix using the following equipment, sequence, and number of roller passes:

(a) Four to six roller passes with a double drum, vibratory roller having a mass of at least 5.5 tons and equipped with frequency and amplitude controls.

(b) Four to six roller passes with a pneumatic-tire roller having a mass of at least 2000 pounds per wheel and a contact pressure of at least 80 pounds per square inch.

(c) Two to four roller passes with a static steel-wheel roller with a pressure of at least 250 pounds per square inch.

Compact the material with approved tampers or compactors along curbs, headers, walls, and places not accessible to the roller.

(c) Finishing. Produce a surface that is smooth, dense, and free of ruts, ridges, and loose material. Measure the pavement surface using a 10-foot metal straightedge at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge more than ⅜ inch measured between two contacts of the straightedge or deviations more than ⅜ inch measured at the end of the straightedge.

(d) Fog seal. Place a fog seal according to Section 406 on the surface of the recycled asphalt base. Use emulsified asphalt diluted to 50 percent by volume with water and apply it at a rate of 0.05 to 0.15 gallon per square yard. If necessary, place blotter according to Section 406.

310.10 Construction Joints.

(a) Longitudinal joints. Make longitudinal joints coincide with each change in cross slope. Provide a minimum longitudinal overlap of 6 inches.

(b) Transverse joints. At the starting of each day's recycling operations or after extended work stoppages, cut back into the completed work to ensure uniform material and depth across transverse joints.

310.11 Curing and Maintenance. Keep traffic and construction equipment off the recycled asphalt base for at least 2 hours after completing compaction and until it is sufficiently stable to withstand raveling, marring, and permanent deformation. Route hauling and other construction equipment uniformly over the full width of the recycled asphalt base to minimize non-uniform compaction.

Maintain the recycled asphalt base to the correct cross-section. Provide additional rolling with a steel-wheel roller to recompact and maintain a dense surface. Use a power broom to remove loose particles. If the recycled asphalt base ravels or loses stability, density, or finish, reprocess and recompact as necessary to restore the strength of the damaged material.

Overlay the recycled asphalt base when the moisture content of the recycled asphalt base is less than 2.5 percent according to AASHTO T 255, but within 14 days after completing finishing operations regardless of moisture content.

310.12 Acceptance. See Table 310-2 for sampling, testing, and acceptance requirements.

Blotter material will be evaluated under Subsection 106.03.

Cement and lime will be evaluated under Subsections 106.02 and 106.03.

Emulsified asphalt binder will be evaluated under Subsections 106.03 and 106.04.

Construction of the cold in-place recycled asphalt base course will be evaluated under Subsections 106.02 and 106.04. Type A compaction will be evaluated under Subsection 106.04.

Pavement smoothness will be evaluated under Subsections 106.02 and 106.04.

Measurement

310.13 Measure the Section 310 pay items listed in the bid schedule according to Subsection 109.02.

Payment

310.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 310 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 310-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Emulsified asphalt (702.02)	Measured & tested for conformance (106.04)	Quality	–	Subsection 702.02	1 per type & source of material	Asphalt supplier	Yes	30 days minimum before production	–
Design									
Emulsified asphalt mix design	Measured & tested for conformance (106.04)	All	–	Subsection 310.03 & FLH T 524	1 per submitted mix design	Existing roadway	Yes	30 days minimum before production	For Type A compaction only
Production Start-up (control strip)									
Emulsified asphalt mixture	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27	3 minimum	Before emulsion addition	No	Upon completing test	–
		Bulk specific gravity (density)	–	FLH T 524	1 minimum	Loose mix in windrow	"	"	For Type A compaction only
		Density	–	ASTM D2950 & Subsection 310.07	Subsection 310.07	In-place after compaction	"	"	"
		Depth of cut	–	–	3 minimum	Both ends of milling drum	"	"	–

Table 310-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Emulsified asphalt (702.02)	Measured & tested for conformance (106.04)	Bulk specific gravity (density)	–	FLH T 524	1 per change in material	Loose mix in windrow	No	Upon completion of test	For Type A compaction only
		Density	–	ASTM D2950 & Subsection 310.07	1 per 2000 yd^2	In-place after compaction	"	End of shift	"
		Depth of cut	–	–	1 per 500 ft	Both ends of milling drum	"	"	–
	Process control (153.03)	Gradation	–	AASHTO T 27	1 per 3500 yd^2 minimum	Before emulsion addition	No	Upon completion of test	–
		Indirect tensile strength[(1)]	–	FLH T 524	1 per 3500 yd^2	"	"	4 days	"
Emulsified asphalt (702.02)	"	Application rates	–	Calculation of yield rate, Subsection 310.08	1 per tank load minimum	–	"	"	–

Table 310-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Cold recycled asphalt base	Measured & tested for conformance (106.04)	Surface tolerance	–	Straightedge measurement, Subsection 310.09(c)	Continuously, after compaction	Finished recycled base surface	No	24 hours	–

(1) Transport samples immediately to a field material laboratory for indirect tensile strength compaction. Compact within 1 hour of sampling.

Section 311. — STABILIZED AGGREGATE SURFACE COURSE

Description

311.01 This work consists of constructing a stabilized aggregate surface course.

Material

311.02 Conform to the following Subsections:

Calcium chloride, magnesium chloride, and lignosulfonate	725.02
Surface course aggregate	703.05(c)
Water for construction	725.01(c)

Construction Requirements

311.03 Proportioning. Determine the maximum density and optimum moisture content according to AASHTO T 180, Method D for the surface course aggregate with and without calcium chloride at the target percentage. Use the proctor with calcium chloride to monitor yield and final compaction of the mixture.

The target calcium chloride content is 1.85 percent by dry mass of aggregate. The target water content is from 2 percent below the optimum moisture content to optimum moisture content.

311.04 General. Set target values within the gradation ranges shown in Table 703-1, grading G. Store calcium chloride in closed, weatherproof containers.

Conduct a pre-stabilization preparatory phase meeting at least 7 days before the start of stabilization operations according to Subsection 153.06(a).

Prepare the surface on which the stabilized aggregate surface course is placed according to Section 204 or 303, as applicable. Start the placement of surface course aggregate within 5 days of completing roadway reconditioning, unless otherwise approved.

(a) Weather requirements. Start application or mixing operations when the following conditions are met:

(1) The mean daily temperature is not expected to fall below 40 °F for a 7-day cure period after the calcium chloride is incorporated;

(2) The ambient air temperature is 40 °F or above, and is not expected to fall below 40°F within 48 hours;

(3) No precipitation is occurring or forecast to occur within 24 hours; and

(4) The underlying surface is not frozen or muddy.

(b) Control of mixture. Continuously monitor calcium chloride content, moisture content, and aggregate yield according to Section 153 during production and placement. Stop production and provide immediate corrective action if yield calculations, moisture content measurement, or other observations indicate specifications are not being met. Report moisture content and calcium chloride yield twice daily. Adjust operations as approved to ensure an accurate yield is maintained.

Maintain the accuracy of the quantities of calcium chloride, aggregate, and water content within the following tolerances during pugmill or in-place mixing and placement:

(1) Calcium chloride. 1.85 percent ±0.15 percent by dry mass of aggregate. Use an independent measuring device with display, accurate to ±0.05 percent of the mass of calcium chloride.

(2) Water. ±1.0 percent by mass (maintain moisture content from 2 percent below optimum to optimum).

(3) Aggregate. ±2.0 percent by mass.

Calculate the calcium chloride yield according to the following formulas:

$$Tons/_{ft} = \frac{(T \times 0.95 \times \gamma \times W \times D)}{2000}$$

$$Pounds/_{SQYD} = (T \times 0.95 \times \gamma \times D) \times 9$$

Where:

T = Target calcium chloride content in decimal percent

γ = Maximum dry density of aggregate, lb/ft^3

W = Width of calcium chloride application, ft

D = Depth of mixing calcium chloride, ft

Incorporate calcium chloride using pugmill mixing as described in Subsection 311.05 or in-place mixing as described in Subsection 311.06.

311.05 Pugmill Mixing.

(a) Calcium chloride mixing. Use a stationary pugmill with weighing or metering equipment that can accurately control the material entering the mixer. Interlock the metering controls for the aggregate feed with those of the calcium chloride and water to ensure uniform introduction of material into the mixer.

Take calcium chloride yield samples using an approved method at least twice daily during production. If yield test results indicate a rate outside the contract tolerances, correct the rate and perform additional yield testing.

Do not produce more treated aggregate than can be placed within 7 days, unless approved. Do not produce treated aggregate when precipitation is anticipated before the treated aggregate can be placed. Do not use treated aggregate that has been exposed to precipitation before placement without approval.

(b) Placement. Follow the requirements of Subsection 311.06(a).

311.06 In-Place Mixing.

(a) Surface course aggregate placement. Transport and place the surface course aggregate after preparation of the surface and approval of the surface. Process the aggregate to full depth and width with a motor grader into a uniform windrow within one hour of delivery on the roadway, adjusting the moisture content to obtain a homogenous mixture with a moisture content within 2 percent below the optimum moisture content to optimum moisture content. Spread the material on the prepared surface in a uniform lift. Shape the road to the required cross-section. Compact according to Subsection 311.07 by the end of the shift. Do not allow hauling vehicles to drive on the placed aggregate before windrow processing except where required to allow traffic to pass or to dump subsequent loads.

(b) Calcium chloride mixing. Incorporate calcium chloride within 14 days of placement of surface course aggregate, unless otherwise approved. Apply calcium chloride in a uniform layer across the full width of the surface to be mixed. Use distributor equipment that can meter the application rate from the operator's cab accurate to ±0.05 percent of the mass of calcium chloride.

As an alternative, rotary mixing machines that can closely meter calcium chloride and additional mixing water into the mixing process may be used if the required application rates are met and the application rates can be continuously controlled from the operator's cab accurate to ±0.05 percent of the mass of calcium chloride.

Verify the application rate by performing calcium chloride weight yield tests twice daily for each distributor. If yield test results indicate a rate outside the contract tolerances, then correct the application rate and perform additional yield testing. The CO may increase the test frequency. Do not spread more calcium chloride than can be incorporated within one hour.

Use rotary mixing equipment to uniformly incorporate the calcium chloride and additional mixing water into the surface course aggregate or surface course aggregate and existing aggregate to a compacted depth of 4 inches +0.0 inch/-0.5 inch. Mix the material one-lane at a time.

(c) Processing. After mixing is complete, ensure a uniform product free of segregation, streaking, and inconsistent moisture content by processing the treated material with a motor grader to full depth and width. Shape the road to the required cross-section. To the extent practical prevent hauling equipment from traveling on recently placed calcium chloride treated aggregate. If not practical route hauling equipment uniformly over the full width of the surface to minimize rutting or uneven compaction.

311.07 Compacting and Finishing. Maintain the moisture content from 2 percent below optimum to optimum. Compact each lift full width. Roll from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and places not accessible to the roller, compact the material with approved tampers or compactors.

Provide pneumatic tired rollers for initial compaction that have a minimum ballasted weight of 15 tons and have a minimum tire overlap of 1.5 inches. Provide single smooth drum rollers for final compaction to provide a smooth and uniform finished surface.

(a) Pugmill mixed. Compact each lift of treated surface course aggregate to at least 95 percent of maximum dry density according to the proctor performed with calcium chloride. Meet compaction requirements for sections of roadway before the end of the work shift. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

(b) In-place mixed. Compact the untreated surface course aggregate placed each shift to at least 95 percent of maximum dry density of the respective proctor by the end of shift. The CO may approve alternative test procedures if requested and if calcium chloride is to be incorporated within 2 days of aggregate placement.

After calcium chloride incorporation, compact each layer to at least 95 percent of maximum dry density as determined in Subsection 311.03 for aggregate combined with calcium chloride. Meet compaction requirements before the end of the work shift. Determine the in-place density and moisture content according to AASHTO T 310 or other approved test procedures.

(c) Finishing. Finish the mixture to produce a surface that is smooth, dense, and free of compaction planes, ridges, or loose material. Compact the aggregate foreslopes to ensure they are dense and recoverable. Shape the surface to the required template and check the surface with a 10-foot metal straightedge. Defective areas are surface deviations more than ½ inch in 10 feet between two contacts of the straightedge with the surface, or noticeable dips, bumps or other undulations identified through visual inspection or vehicle ride inspection.

Correct defective areas by loosening the material full depth, adding or removing material as required, adjusting moisture content, reshaping, and compacting. Submit alternative methods of correction, including patching or filling of potholes for approval.

311.08 Acceptance. See Table 311-1 for sampling, testing, and acceptance requirements.

Calcium chloride will be evaluated under Subsections 106.02 and 106.03.

Aggregate gradation, plasticity index, fractured faces, and liquid limit will be evaluated under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

(a) Aggregate gradation. The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Tables 703-1 and 703-2, except as follows:

(1) If the calculated mean value for a tested sieve exceeds the maximum gradation range value shown in Table 703-1, then the upper specification is equal to the maximum gradation value in Table 703-1 plus or minus the allowable deviation in Table 703-2.

(2) If the calculated mean value for a tested sieve is less than the minimum gradation range value shown in Table 703-1, then the lower specification is equal to the minimum gradation value in Table 703-1 plus or minus the allowable deviation in Table 703-2.

(b) Fractured faces. If aggregate is produced from a gravel source, use the specification limit shown in Subsection 703.05.

(c) Liquid limit. The specification limit is shown in Subsection 703.05.

(d) Plasticity index. The specification limit is shown in Subsection 703.05.

Aggregate stabilization construction will be evaluated under Subsections 106.02 and 106.04.

Compaction of surface course aggregate will be evaluated under Subsection 106.04.

Preparation of the surface for placement of surface course aggregate will be evaluated under Section 204 or 303, as applicable**.**

Measurement

311.09 Measure the Section 311 pay items listed in the bid schedule according to Subsection 109.02.

Payment

311.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 311 pay items listed in the bid schedule, except the stabilized aggregate surface course contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 311-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Surface course aggregate quality (703.05)	Measured & tested for conformance (106.04 & 105)	LA abrasion (coarse)	–	AASHTO T 96	1 per Type but not less than 5 per source of material(2)	Source of material	Yes	Before using in work	Not required if using Government -furnished sources
		Soundness using sodium sulfate (coarse & fine)	–	AASHTO T 104	"	"	"	"	"
		Durability Index (coarse & fine)	–	AASHTO T 210	"	"	"	"	"
		Accelerated weathering	–	WFL W DMSO	"	"	"	"	"
Surface course aggregate (703.05)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	1 per 6 hours of production but not less than 2 per day per stockpile	Flowing aggregate stream (bin or belt discharge) or conveyor belt	Yes	End of shift	"
		Fractured faces	–	ASSHTO T 335	"	"	"	"	"
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–
		Plasticity index	–	AASHTO R 58 & T 90	"	"	"	"	"

Table 311-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Proportioning									
Proportioning (311.03)	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D(1)	1 per mixture & change in material	Processed material before incorporating in work	Yes, if requested	Before using in work	Report proportion of aggregate, calcium chloride, & water
Production									
Surface course aggregate (703.05)	Statistical (106.05)	Gradation	–	AASHTO T 27 & T 11	1 per 1000 tons but not less than 3	In-place mixing: from windrow immediately after processing Pugmill mixing: flowing aggregate stream (bin or belt discharge) or conveyor belt before adding stabilizer	Yes, if requested	4 hours	–
		No. 4	I						
		No. 40	I						
		No. 200	I						
		Other	II						

Table 311-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Surface course aggregate (703.05)	Statistical (106.05)	Liquid limit	II	AASHTO R 58 & T 89, Method A	1 per 1000 tons but not less than 3	In-place mixing: from windrow immediately after processing Pugmill mixing: flowing aggregate stream	Yes, if requested	4 hours	–
		Fractured faces	I	ASSHTO T 335	"	"	"	"	–
		Plasticity index	I	AASHTO R 58 & T 90	"	"	"	"	–
Mixture (311.03)	Process control (153.03)	Moisture content of aggregates	–	AASHTO T 255	2 per day minimum	"	No	"	
	Measured & tested for conformance (106.04)	In-place density & moisture content	–	AASHTO T 310 or other approved procedures	1 per 500 tons or 3000 yd^2	In-place after compaction	No	4 hours	–

(1) At least 5 points per proctor.
(2) Submit at least five reports, but at least one report per rock type for each source. Submit reports dated within 1 year of intended use. Obtain samples representative of aggregates being provided. Include rock type and sample location on test reports.

Section 312. — DUST PALLIATIVE

Description

312.01 This work consists of providing and applying one or more applications of dust palliative on a prepared surface.

Material

312.02 Conform to the following Subsections:

Calcium chloride, magnesium chloride, and lignosulfonate	725.02
Water for construction	725.01(c)

Construction Requirements

312.03 General. Provide equipment for applying, spreading, and processing dust palliative. Make the equipment available for inspection and approval before use. Do not apply dust palliative when precipitation is anticipated within 24 hours of application, or when the ground is frozen. Apply when the ambient air temperature is 40 °F or above.

Protect structures, trees, and other objects identified by the CO from splatter or marring. Use multiple applications at a reduced rate if necessary to prevent runoff.

312.04 Surface Preparation and Application.

(a) Single application. Blade and shape the roadbed. Leave 1 to 2 inches of loose material on the surface. Water the loose material so it is visibly moist. Thoroughly mix the moist, loose material.

Apply water, calcium chloride, magnesium chloride, or lignosulfonate liquid at an approved rate from 0.25 to 0.50 gallons per square yard. Process the dust palliative uniformly throughout the loose material. Moisten the mixture as necessary and compact by operating rollers over the full width of each layer until visual displacement ceases.

Double application of calcium chloride or magnesium chloride liquid.

(1) First application. Scarify, blade, and shape the roadbed. Leave 3 inches of loose material on the surface. Water the loose material so it is visibly moist. Thoroughly mix the moist, loose material.

Apply calcium chloride or magnesium chloride liquid solutions using distributor equipment at an approved rate from 0.50 to 1.0 gallons per square yard. Use a tractor rotary tiller, or other approved mixing device, immediately behind the distributor to incorporate the liquid solution into the full width of loose material. Shape the surface to the required line and grade and compact according to Subsection 204.11(a).

Allow at least one week of curing time between the first and second applications.

(2) Second application. Apply calcium chloride or magnesium chloride liquid to the finished surface at an approved rate no more than 0.20 gallons per square yard.

312.05 Opening to Traffic. Keep traffic off the treated surface until the dust palliative has penetrated and cured to prevent excessive pickup under traffic.

312.06 Acceptance. Dust palliative material (calcium chloride liquid, magnesium chloride liquid, and lignosulfonate liquid) will be evaluated under Subsection 106.03. Provide a commercial certification that includes the date, identification number (truck or trailer), net mass, and brand name with each shipment. For liquid dust palliatives provide the net volume and specific gravity at 60 °F, percent solids by mass, and pH.

Construction of dust palliative treatments will be evaluated under Subsections 106.02 and 106.04.

Measurement

312.07 Measure the Section 312 pay items listed in the bid schedule according to Subsection 109.02.

Payment

312.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 312 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 313. — AGGREGATE-TOPSOIL COURSE

Description

313.01 This work consists of providing and placing an aggregate, topsoil, and seed mixture on a prepared shoulder or other surface.

Material

313.02 Conform to the following Subsections:

Aggregate for aggregate-topsoil course	703.13
Seed	713.04
Topsoil	713.01
Water for construction	725.01(c)

Construction Requirements

313.03 Preparing Surface. Complete the adjoining pavement before placing an aggregate-topsoil course on the shoulder. Scarify the area where the mixture is to be placed to a depth of 3 inches. Reduce clods and sod to a maximum size of 4 inches.

313.04 Mixing, Placing, and Compacting. Provide a mixture of 50±10 percent aggregate and 50±10 percent topsoil by volume with sufficient water for compaction.

Mix the components into a uniform mixture. Spread the mixture on the prepared surface in a uniform lift. Shape the mixture to the required line, grade, and cross-section. Remove clods and stones greater than 2 inches in diameter. Before compaction, dry seed the mixture surface at a rate of 75 pounds per acre according to Section 625.

Uniformly compact the mixture to ensure it does not exhibit heaving, pumping, rutting, or shearing. After compaction, dry seed the surface again at a rate of 75 pounds per acre.

Before opening the roadway to traffic, clean the roadway surface of excess aggregate, topsoil, and seed material.

313.05 Acceptance. Aggregate for aggregate-topsoil will be evaluated under Subsections 106.02 and 106.03.

Seed and topsoil will be evaluated under Subsections 106.02 and 106.03.

Construction of aggregate-topsoil course will be evaluated under Subsection 106.02.

Measurement

313.06 Measure the Section 313 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring aggregate-topsoil course by the cubic yard, measure in the hauling vehicle.

Payment

313.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 313 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 314. — STOCKPILED AGGREGATES

Description

314.01 This work consists of providing and placing aggregate in a stockpile for future use by the Government.

Material

314.02 Conform to the following Section:

Aggregate	703

Construction Requirements

314.03 General. Conform to the gradation and quality requirements specified in the Section identified for the material.

After a representative quantity of aggregate is produced, submit proposed target values for the appropriate sieve sizes along with a representative sample size as specified in the Section identified for the material.

Set target values within the gradation ranges shown in the applicable table for the required grading.

314.04 Stockpile Site. Prepare a plan of operation. Perform work within a Government-furnished source only after a plan of operation for the development of the source is approved.

Obtain CO approval before preparing sites. Prepare sites to prevent contamination of the stockpiles.

Prepare sites as follows:

(a) For new sites, clear and grub according to Section 201;

(b) Grade, shape, and compact the site to a uniform cross-section that drains; and

(c) Place, compact, and maintain at least a 6-inch lift of crushed aggregate over the stockpile site and access roads for stabilization.

Obtain CO approval before stockpiling aggregates.

314.05 Stockpile. Build aggregate stockpiles in layers no more than 36 inches in thickness. Make the side slopes of each layer no flatter than 1V:1.5H. Spread aggregates with trucks or other approved pneumatic-tire equipment. Complete each layer before depositing aggregates on the next layer. Do not allow aggregates from the layer being built to run down over lower layers. Do not drop aggregates from a bucket or spout in one location to form a cone-shaped pile. Do not push aggregates into piles. Make the stockpiles neat and regular in shape.

Do not track dirt or other foreign matter onto the stockpile material.

Space stockpiles far enough apart or install partitions to prevent the mixing of aggregate gradations.

Protect stockpiles with an approved cover.

314.06 Acceptance. Aggregate for stockpiling will be evaluated under the Section identified for the material. See the table for sampling, testing, and acceptance requirements in the applicable Section, except the point of sampling for aggregate is from the stockpile.

Subbase, base, surface course, and chip seal aggregate gradation, and surface course plasticity index will be evaluated under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Construction of stockpiles will be evaluated under Subsections 106.02 and 106.04.

Clearing and grubbing will be evaluated under Section 201.

Measurement

314.07 Measure the Section 314 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring aggregate by the cubic yard, measure in place.

Payment

314.08 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the Section 314 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 315. — RECYCLED AGGREGATE

Description

315.01 This work consists of providing and placing recycled aggregate using asphalt concrete pavement millings and existing aggregate.

Material

315.02 Conform to the following Subsection:

Water for construction	725.01(c)

Construction Requirements

315.03 General. Prepare the surface according to Section 204 or 303, as applicable. Provide recycled aggregate obtained under Section 304 or 413 with 100 percent passing the 1½-inch sieve.

315.04 Mixing and Spreading. Place recycled aggregate to the limits shown in the plans. Place enough material to bring the final surface to established line, grade, and cross-section.

Mix the recycled aggregate to its full depth. During mixing add water to provide the optimum moisture content for compaction. After mixing, spread to the thickness and cross-section shown in the plans.

315.05 Compacting. If no compaction method is specified, use either method.

(a) Method 1. Compact each lift according to Subsection 204.11(a). Roll from the sides to the center, parallel to the centerline of the road. Compact the material along curbs, headers, walls, and places not accessible to a roller with approved tampers or compactors.

Compactive effort may be decreased if in-place densities show that less compactive effort is required under Method 2.

(b) Method 2. Compact each lift according to Subsection 301.05.

Produce a surface that is smooth, dense, and without ruts, ridges, and loose material.

315.06 Surface Tolerance. Finish the surface according to Subsection 301.06.

315.07 Maintenance. Maintain the recycled aggregate according to Subsection 301.07.

315.08 Acceptance. See Table 315-1 for sampling, testing, and acceptance requirements.

Recycled aggregate will be evaluated under Subsections 106.02 and 106.04.

Construction of recycled aggregate will be evaluated under Subsections 106.02 and 106.04.

Preparation of the surface for placement of recycled aggregate will be evaluated under Section 204 or 303, as applicable**.**

Measurement

315.09 Measure the Section 315 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring recycled aggregate by the cubic yard, measure in place.

Payment

315.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 315 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 315-1
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Crushed aggregate	Measured & tested for conformance (106.04)	Moisture-density	–	AASHTO T 180, Method D(1)	1 per aggregate supplied	Production output or stockpile	No	4 hours	For Method 2 compaction only
		Density	–	AASHTO T 310 or other approved procedures	1 per 1500 yd^2 per lift	In-place after compaction	"	End of shift	"
Crushed aggregate	Process control (153.03)	Moisture content (in-place)	–	AASHTO T 310 or other approved procedures	1 per 1500 yd^2 per lift	In-place after compaction	No	End of shift	For Method 2 compaction only
Finished Product									
Crushed aggregate	Measured & tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 315.06	As directed	Surface of final course	No	Before placement of next lift or as requested	–

(1) At least 5 points per proctor.

DIVISION 400
ASPHALT PAVEMENTS AND SURFACE TREATMENTS

Section 401. — ASPHALT CONCRETE PAVEMENT BY GYRATORY MIX DESIGN METHOD

Description

401.01 This work consists of constructing asphalt concrete pavement using HMA or WMA.

Material

401.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Asphalt concrete aggregate	703.07
Mineral filler	725.05

Construction Requirements

401.03 Composition of Mix (Job-Mix Formula). Provide asphalt concrete mixes of aggregate, asphalt binder, RAP, and additives that meet the applicable material requirements and the appropriate design parameters shown in Table 401-1 and can be placed and compacted as specified. Volumetric mix properties will be determined at N_{design} according to AASHTO T 312 and AASHTO R 35. Short-term condition samples according to AASHTO R 30 at the manufacturer's recommended compaction temperature. Include the material finer than the No. 200 sieve when determining the AASHTO T 84 fine aggregate specific gravity and absorption.

Apply asphalt concrete mix design requirements for HMA to the development of the WMA mix design. Provide modifications to the process required for WMA technology. Submit modifications to the asphalt concrete mix design process for WMA according to Appendix X.2 of AASHTO R 35 for approval.

(a) RAP. Limit the quantity of RAP by mass in the JMF to 20 percent.

(b) Baghouse fines. If used, document how baghouse fines are reintroduced and measured. Submit target values for the percent of baghouse fines reintroduced to the JMF if they are a separate stockpile.

Table 401-1
Gyratory Asphalt Concrete Mix Design Requirements, AASHTO R 35

<table>
<tr><th rowspan="3">Design ESAL (Million)</th><th colspan="3" rowspan="2">Gyratory Compaction Level (Percent Theoretical Maximum Specific Gravity, G_{mm}) AASHTO T 312</th><th colspan="5">Minimum Voids in the Mineral Aggregate (VMA), percent[(1)(4)]</th><th rowspan="3">Voids Filled with Asphalt (VFA), percent</th><th rowspan="3">Dust-to-Binder Ratio[(3)]</th><th rowspan="3">Minimum Tensile Strength Ratio (TSR) AASHTO T 283</th></tr>
<tr><th colspan="5">Nominal Maximum Size Aggregate[(2)]</th></tr>
<tr><th>$N_{initial}$</th><th>N_{design}</th><th>N_{max}</th><th>1 inch</th><th>¾ inch</th><th>½ inch</th><th>⅜ inch</th><th>No. 4 sieve</th></tr>
<tr><td>< 0.3</td><td>6
(≤91.5%)</td><td>50
(96.0%)</td><td>75
(≤98.0%)</td><td rowspan="3">12.0</td><td rowspan="3">13.0</td><td rowspan="3">14.0</td><td rowspan="3">15.0</td><td rowspan="3">–</td><td>70.0 to 80.0</td><td rowspan="3">0.8 to 1.6</td><td rowspan="4">0.80</td></tr>
<tr><td>0.3 to < 3</td><td>7
(≤90.5%)</td><td>75
(96.0%)</td><td>115
(≤98.0%)</td><td>65.0 to 78.0</td></tr>
<tr><td>3 to 30</td><td>8
(≤89.0%)</td><td>100
(96.0%)</td><td>160
(≤98.0%)</td><td>65.0 to 78.0</td></tr>
<tr><td>–</td><td>6
(≤91.5%)</td><td>50
(96.0%)</td><td>75
(≤98.0%)</td><td>–</td><td>–</td><td>–</td><td>–</td><td>16.0</td><td>76.0 to 80.0</td><td>0.6 to 2.0</td></tr>
</table>

(1) If mineral filler or hydrated lime is used, include in the calculation for compliance with the VMA.
(2) The NMSA is one size greater than the first sieve to retain more than 10 percent of the combined aggregate.
(3) Dust-to-binder ratio is the total percent of material passing the No. 200 sieve divided by the effective asphalt content. Dust includes lime, bag house fines, and other mineral matter.
(4) Provide historical reference of satisfactory construction of mixtures submitted with VMA exceeding the minimum value by more than 3 percent, for approval.

(c) Antistrip additive. Use at least 1 percent Type 3 (lime) of the total weight of aggregates including RAP. Type 1 (liquid) antistrip additive may be used instead of Type 3 (lime) antistrip additive if the requirements shown in Table 401-2 are met.

Table 401-2
Antistrip Requirements Using Hamburg Wheel-Track Testing, AASHTO T 324(1),(2)

PG Binder Grade	Testing Temperature	Maximum Allowable Rut Depth	Number of Passes	Stripping Inflection Point
PG 58 & lower	45 °C	12.5 mm	20,000	None
Greater than PG 58 & less than PG 76	50 °C			
PG 76 & higher	55 °C			

(1) Report the plot of the rut depth versus number of passes for each test for each deformation location. Report the number of passes at maximum rut depth, the maximum rut depth, creep and strip slopes, the stripping inflection point, testing temperature, compaction method (slab or Superpave gyratory compactor cylindrical specimen), and air voids of the specimens.
(2) Perform two tests at each additive rate and perform one set of control specimens with no additive.

(d) Submittals. Submit written JMFs and associated material with Form FHWA 1641, *Worksheet for Superpave Asphalt Concrete Mix Design*, for verification at least 30 days before the control strip. Include a signed statement prepared by the testing laboratory that certifies the proposed JMF meets requirements and can be compacted in the field during production. For each proposed JMF, submit the following:

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each specified sieve size for the aggregate blend; and

(2) Designate target values within the gradation band specified for the NMSA grading shown in Table 703-3. Allowable deviations are shown in Table 703-2;

(b) Source and percentage of each stockpile to be used;

(c) Average gradation of each stockpile;

(d) Representative samples from each stockpile. Use split samples of material taken at the same time samples are taken for testing by the Contractor's laboratory.

(1) 600 pounds of aggregates proportioned by each stockpile according to the JMF;

(2) 2 pounds of mineral filler, if proposed for the JMF; and

(e) Results of aggregate quality tests performed within 1 year of use.

(2) Asphalt binder.

(a) Target asphalt binder content;

(b) Five 1-gallon samples of the asphalt binder;

(c) Test results from the manufacturer according to AASHTO M 320 for the asphalt binder including a temperature-viscosity curve;

(d) Mixing temperature range and minimum compaction temperature for the asphalt binder; and

(e) Laboratory mixing and compaction temperatures used for mix design.

(3) Antistrip additives. If part of the JMF:

(a) Type 1 (liquid) antistrip additive:

(1) Target liquid antistrip additive dosage rate by weight of total binder;

(2) Test results according to AASHTO T 324 and Table 401-2;

(3) 1 pint of liquid antistrip additive;

(4) Name of product;

(5) Manufacturer; and

(6) Manufacturer's SDS and product data sheets.

(b) Type 3 (lime) antistrip additive:

(1) 1 pound of lime additive;

(2) Name of product;

(3) Manufacturer;

(4) Manufacturer's SDS and product data sheets; and

(5) Dosage rate.

(4) RAP. If part of the JMF:

(a) Source and percentage of RAP;

(b) Gradation of the RAP;

(c) Effective specific gravities of each stockpile;

(d) Percent asphalt binder in RAP by total mass according to AASHTO T 308;

(e) 100-pound representative sample of each RAP stockpile; and

(f) RAP data sheet of Form FHWA 1641.

(5) WMA technology and additive information.

(a) 1-gallon WMA additive sample with method for incorporating it in the asphalt concrete mix design process;

(b) WMA manufacturer's usage recommendations including additive target rates;

(c) Documentation of past WMA technology field applications including project type, project owner, tonnage placed, asphalt concrete mix design, mixture volumetrics, and performance;

(d) Laboratory mixing and compacting temperature;

(e) Asphalt binder performance grade test data over the range of WMA additive percentages proposed for use if applicable;

(f) Compatibility of WMA additive with asphalt binder and antistrip additive; and

(g) Temperature range for field asphalt concrete mix production, delivery, lay-down and compaction.

(e) Verification. The verification process starts when required documentation and material are received. After the JMF is verified, start asphalt concrete mix production for the control strip.

(1) Aggregate gradations. The Contractor's aggregate gradation is verified if the CO's gradation on the JMF design aggregate structure using the Contractor's aggregate and RAP stockpile percentage recommendations is within the Contractor's target value gradation plus or minus the tolerance shown in Table 401-3.

Table 401-3
Aggregate Gradation Verification Tolerances

Sieve Size	Tolerance, percent (±)
1 in	3.0
¾ in	3.0
½ in	3.0
⅜ in	3.0
No. 4	3.0
No. 8	3.0
No. 16	2.0
No. 30	2.0
No. 50	2.0
No. 200	1.0

(2) RAP asphalt binder content and gradation. The RAP asphalt binder content results are verified if the CO's result for each stockpile is within ±0.75 percent by total mass using AASHTO T 308. Submit the RAP dry gradation, burned gradation, asphalt content, and specific gravity information as shown on the RAP data sheet of Form FHWA 1641.

(3) Bulk specific gravity of aggregate (G_{sb}). The coarse and fine G_{sb} are verified if the CO's results are within 0.013 for AASHTO T 85 and 0.030 for AASHTO T 84.

(4) VMA. The VMA result is verified if the CO's result is above the specification limit in Table 401-1. Do not exceed 3 percent above the minimum VMA requirement without approval.

(5) VFA. The VFA result is verified if the CO's result is within the specification limit in Table 401-1.

(6) Air voids (V_a). The V_a result is verified if the CO's result at the same design asphalt binder content is between 3.0 and 5.0 percent.

(7) TSR. The TSR result is verified if the CO's result meets the requirements shown in Table 401-1.

(f) Changes and resubmissions. If a JMF is rejected or the source of material is changed, submit a new JMF for verification. Allow up to 30 days for the CO to evaluate a change after receipt of required documentation and material. Approved changes in target values will not be applied retroactively for payment.

The CO will deduct JMF evaluation costs resulting from the following:

(1) Contractor-requested changes to the approved JMF;

(2) Contractor requests for more than one JMF evaluation; and

(3) Additional testing necessary due to the failure of a submitted JMF.

401.04 Mixing Plant. Use mixing plants conforming to AASHTO M 156.

(a) Drum dryer-mixer plants.

(1) Bins. Provide a separate bin in the cold aggregate feeder for each individual aggregate stockpile in the asphalt concrete mix. Use bins of sufficient size to keep the plant in continuous operation and of proper design to prevent overflow of material from one bin to another.

(2) Stockpiling procedures. Separate aggregate into at least three stockpiles with different gradations.

(b) Batch plants.

(1) Hot aggregate bin. Provide a bin with three or more separate compartments for storage of the screened aggregate fractions to be combined for the asphalt concrete mix. Make the partitions between the compartments tight and of sufficient height to prevent spillage of aggregate from one compartment into another.

(2) Load cells. Calibrated load cells may be used in batch plants instead of scales.

(3) RAP. Modify batch plants so RAP is introduced into the asphalt concrete mix after bypassing the dryer. Design the cold feed bin, conveyor system, and special bin adjacent to the weigh hopper, if used, to avoid segregation and sticking of the recycled asphalt pavement material. Heat aggregate to a temperature that will transfer sufficient heat to the recycled asphalt pavement material to produce an asphalt concrete mix of uniform temperature within the range specified in the approved JMF.

(c) WMA plant modifications.

(1) Modify the mixing plant as required by the manufacturer to introduce the WMA technology. Interlock the WMA additive delivery system with the automated proportioning system.

(2) Incorporate additives and WMA technologies into the asphalt concrete mix according to the manufacturer's recommendations. Deliver and store of additives according to the manufacturer's recommendations.

(3) Modify the plant burner and drum flights to operate at lower production temperatures.

401.05 Equipment.

(a) Pavers. Provide pavers that are:

(1) Self-contained, power-propelled units with adjustable vibratory screeds with full-width screw augers;

(2) Heated for the full width of the screed;

(3) Capable of spreading and finishing courses of asphalt concrete mix in widths at least 12 inches more than the width of one lane;

(4) Equipped with a receiving hopper having sufficient capacity to ensure a uniform spreading operation;

(5) Equipped with automatic feed controls, which are properly adjusted to maintain a uniform depth of material ahead of the screed;

(6) Operable at forward speeds consistent with satisfactory asphalt concrete mix lay down;

(7) Capable of producing a smooth-finished surface without segregating, tearing, shoving, or gouging;

(8) Equipped with automatic screed controls with sensors that can sense grade from an outside reference line, sensing the transverse slope of the screed, and providing the automatic signals that operate the screed to maintain grade and transverse slope; and

(9) If required, provide a screed mounted safety edge device that can:

(a) Maintain contact with the road shoulder surface;

(b) Allow automatic transition to intersections and obstructions; and

(c) Constrain and reduce the volume of the asphalt concrete material head to increase the density of the extruded profile.

Do not use conventional single plate strike-off.

(b) Material transfer vehicle (MTV). If required, provide an MTV with the following:

(1) Independently operated with its own operator;

(2) Independent from the paver;

(3) A loading system with the ability to receive mixtures from the hauling equipment;

(4) A minimum storage capacity of 13 tons with a remixing system in the MTV storage bin;

(5) A discharge conveyor to deliver the mixture to the paver hopper; and

(6) A mass no more than the maximum legal loadings on structures.

Pick-up machines, hopper inserts, and material transfer devices are not considered MTVs.

401.06 Surface Preparation. Clean the existing surface of loose material, dirt, or other deleterious material by approved methods. Apply an asphalt tack coat to contact surfaces of pavements, curbs, gutters, manholes, and other structures according to Section 412.

401.07 Weather Limitations. Place asphalt concrete mix on a dry, unfrozen surface when the air temperature in the shade is above 35 °F and rising. For HMA, conform to Table 401-4. For WMA, adjust Table 401-4 minimum lay-down temperatures according to the manufacturer's recommendations.

Table 401-4
Asphalt Concrete Mix Placement Temperature

Compacted Lift Thickness	< 2 Inches	2 to 3 Inches	> 3 Inches
Road Surface Temperature, °F	**Minimum Lay-Down Temperature, °F(1)**		
< 35	(2)	(2)	(2)
35 to 39.9	(2)	(2)	280
40 to 49.9	(2)	285	275
50 to 59.9	295	280	270
60 to 69.9	285	275	265
70 to 79.9	280	270	265
80 to 89.9	270	265	260
≥ 90	265	260	255

(1) Do not heat the asphalt concrete mix above the temperature specified in the approved asphalt concrete mix design.
(2) Do not pave.

401.08 Asphalt Preparation. Uniformly heat the asphalt binder to provide a continuous supply of heated asphalt binder from storage to the mixer. Do not heat asphalt binder above 365 °F.

If a liquid heat stable antistrip additive is used, meter it into the asphalt binder transfer lines at a bulk terminal or mixing plant. Inject the additive for at least 80 percent of the transfer or mixing time to obtain uniformity.

401.09 Aggregate Preparation. If lime is used as an antistrip, adjust the aggregate moisture to at least 4 percent by mass of aggregate. Mix the lime uniformly with the aggregate before introducing the aggregate into the dryer or dryer drum. Use calibrated weighing or metering devices to measure the quantity of lime added to the aggregate.

For batch plants, heat, dry, and deliver aggregate for pugmill mixing at a temperature sufficient to produce an asphalt concrete mix temperature within the approved range. Adjust flames used for drying and heating to prevent damage to and contamination of the aggregate. Additional plant adjustments may be required to provide dry aggregate at the reduced mixing temperatures of WMA.

Control plant operations so the moisture content of the asphalt concrete mix behind the paver is no more than 0.5 percent according to AASHTO T 329.

Before starting asphalt concrete mix production, obtain approval of synchronized metering and weighing devices used to introduce a constant rate of lime and water.

Add lime to the aggregate by one of the following methods:

(a) Method A. Add lime to the combined cold feed aggregate using an enclosed in-line cold feed mechanical pugmill mixer. Use a twin-shaft, continuous mixing pugmill with adjustable mixing paddles. Adjust the retention time of the mixture in the pugmill so no unmixed lime is visible after the lime and aggregate exit the pugmill.

(b) Method B. Add lime to the produced aggregates during stockpiling using a pugmill. Distribute the lime according to the stockpile ratios stated in the asphalt concrete mix design.

A minimum moisture content of 2 percent by dry weight for coarse aggregate and 4 percent by dry weight for fine aggregate is required at the time the aggregates and lime are mixed. Marinate treated aggregate in stockpiles from 24 hours to 60 days before using in asphalt concrete mix. Do not use aggregate marinated longer than 60 days.

(c) Method C. Add lime to the combined cold feed aggregate as the aggregate flows from the cold feed bins. Mix the lime and aggregate on the conveyor belt by placing at least six paddles over the conveyor belt. Make the paddles protrude into the aggregate flow and direct the aggregate to fold over itself causing the material to migrate from one side of the conveyor belt to the other. Space the paddles to provide complete mixing. Provide a water spray over the conveyor belt as necessary to control dust and to maintain minimum moisture content.

401.10 Mixing. Measure the aggregate and asphalt into the mixer according to the JMF. Mix until particles are completely and uniformly coated with asphalt according to AASHTO M 156. Maintain the discharge temperature according to the JMF.

401.11 Hauling. Use vehicles with clean and smooth metal beds free of holes for hauling asphalt concrete mixes.

Coat the beds with an approved material to prevent the asphalt concrete mix from adhering to the beds. Do not use petroleum derivatives or other coating material that contaminates or alters the characteristics of the mix. Drain the bed before loading.

Equip each truck with a canvas cover or other suitable material of sufficient size to protect the asphalt concrete mix from the weather. If necessary to maintain temperature, use insulated truck beds and securely fastened covers. Provide access ports or holes for checking temperature of asphalt concrete mix in the truck.

401.12 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-paving preparatory phase meeting according to Subsection 153.06(a) at least 3 days before the start of paving operations. Be prepared to discuss and provide the following:

(1) Calibration certification for the gyratory compactor. If gyratory compactor is moved, recalibrate;

(2) Asphalt and aggregate correction factors according to AASHTO T 308 and AASHTO T 30 on Form FHWA 1640, *Worksheet for Ignition Furnace Binder Correction Factor AASHTO T 308*. If RAP is included as part of the JMF, provide the asphalt and aggregate correction factors according to AASHTO T 30 and the FLH Addendum to AASHTO T 308 on Form FHWA 1648, *Worksheet For Ignition Furnace Binder Correction Factor And Aggregate Gradation Correction Factor For Mixes Including RAP*; and

(3) Plant mixing temperature.

(b) Control strip. Provide at least 7 days' notice before starting production of an asphalt concrete mix.

Produce sufficient asphalt concrete mix to construct a 1000-foot-long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using asphalt concrete mix production, lay-down, and compaction procedures intended for the entire mix. Construct a control strip for each equipment combination and each plant from which production is intended.

Stop production after construction of the control strip until the asphalt concrete mix and the control strip are accepted. Acceptance will be based on the following:

(1) Mixture. Take at least three control strip asphalt concrete mix samples and test samples as shown in Table 401-10. The asphalt concrete mix is acceptable if all test results are within specification limits for asphalt content, VMA, and VFA; and the calculated pay factor for asphalt content, VMA, VFA, and gradation is 0.90 or greater.

(2) Compaction. Compact according to Subsection 401.14. Take nuclear gauge density readings behind each roller pass to determine the roller pattern necessary to achieve required density. Use Form FHWA 1646, *Asphalt Control Strip Worksheet*. Document if roller was operated in vibratory or static mode. Provide frequency and amplitude settings if operated in vibratory mode. Provide documentation after completion of the control strip.

Take nuclear gauge density readings and cut and test core samples as shown in Table 401-10. Density is acceptable if the core density pay factor is 0.90 or greater. Provide the CO with documented nuclear gauge readings correlated to core specific gravities.

(3) Control strip mat defects. Control strips that exhibit physical or visual defects may be rejected. Defects include tearing, cracking, rutting, shoving, segregation, bleeding, excessive pavement roughness, and poor joints.

Repeat the control strip process until an acceptable control strip is produced. Conform to Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed pavement. Tests used for the control strip will not be included in the evaluation for payment according to Subsection 106.05. Start full production only after the control strip is verified and accepted.

Use start-up procedures if resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.05.

401.13 Placing and Finishing. Do not use mixes produced from different plants unless the mixes are produced according to the same JMF, use material from the same sources, and are approved.

Place HMA and WMA at temperatures according to Subsection 401.07. Measure temperature of the asphalt concrete mix in the hauling vehicle immediately before dumping into the spreader or measure it in the windrow immediately before pickup.

Suspend paving if the MTV malfunctions during paving operations. Do not resume mix placement until the MTV is operational.

Do not use diesel fuel or products that cause stripping as a release agent on equipment used with the asphalt concrete mix.

Place the asphalt concrete mix as continuously as possible. Control horizontal alignment using a reference line. Automatically control the grade and slope from reference lines, a ski and slope control device, or dual skis. Use skis having a length of at least 20 feet.

In areas where mechanical spreading and finishing are impractical, place and finish the asphalt concrete mix with alternate equipment to produce a uniform surface closely matching the surface obtained when using a mechanical paver.

Offset the longitudinal joint of one lift at least 6 inches from the joint in the lift immediately below. Make the longitudinal joint in the top lift along the striped centerline of two-lane roadways or at the lane lines of roadways with more than two lanes.

401.14 Compacting. Provide at least three rollers, with at least one being a pneumatic-tire roller with rubber tires in the front and rear. Provide one roller each for breakdown, intermediate, and finish rolling. Size the rollers to achieve the required results. Operate rollers according to the manufacturer's recommendations.

Do not cause cracking, shoving, or undue displacement. Do not pass rollers over an unsupported edge of freshly laid asphalt concrete mix. Continue rolling until roller marks are eliminated, cracks are sealed, and the required density is obtained. For HMA, do not roll the mix after the surface cools below 175 °F.

Monitor the compaction process with nuclear density gauges calibrated to the control strip core density test results and evaluate according to Subsection 401.18(c).

Take nuclear gauge density readings and cut and test core samples as shown in Table 401-10.

Compact the asphalt concrete mix with alternate equipment to obtain the required compaction along forms, curbs, headers, walls, and other places inaccessible to rollers.

401.15 Joints, Trimming Edges, and Cleanup. Complete pavement construction of adjacent traffic lanes to the same elevation within 24 hours. If elevation differences more than 3 inches between adjacent lanes are left overnight, sign with "*Uneven Lanes*" warning signs and provide a 1V:3H fillet.

Make transverse joints vertical to the depth of the new pavement at connections to existing pavements and previously placed lifts. Form vertical and clean transverse joints by cutting back the previous run to expose the full-depth course. Protect saw cut edge from equipment and traffic. Repair damaged joints by sawcutting before placement of adjoining asphalt concrete pavement.

Apply an asphalt tack coat to the edge of both transverse and longitudinal joints according to Section 412.

Dispose of material trimmed from the edges and other discarded asphalt concrete mix according to Subsection 203.07.

401.16 Pavement Roughness. Measure the profile of the pavement surface according to the designated pavement roughness type. If no roughness type is designated, use Type IV. In addition, construct pavement surfaces to meet the requirements of Subsection 401.16(d).

Provide flaggers, pilot car operations, or other temporary traffic control during profile measurement according to Section 635.

(a) Profile measurement. The CO will use profile measurements to determine the Mean Roughness Index (MRI) values for the traveled way according to FLH T 401 and using the current version of Profile Viewer and Analysis (ProVAL) software. The CO will determine areas of localized roughness. The MRI and areas of localized roughness will be used to determine payment for the designated pavement roughness type and pavement areas requiring surface corrections.

The CO will identify the starting and ending points of the profile measurements. The CO will identify excluded areas. Cattle guards, bridges not being overlaid, and turning lanes, passing lanes, side roads, and ramps less than 1000 feet in length will be excluded from profile measurement, the calculation of MRI, and the determination of localized roughness. Measure excluded areas with a straightedge according to Subsection 401.16(d).

Areas for which the ProVAL continuous report exceeds the threshold MRI value for the specified roughness type will be considered a defective area requiring correction. If corrections are not allowed, a reduction in payment will be applied according to Subsection 401.20(b). No deduction will be made for areas of localized roughness identified within 12.5 feet of the starting or end of a profile section or within 12.5 feet of excluded areas. Measure these areas with a straightedge according to Subsection 401.16(d).

(b) Type I and II pavement roughness. Measure the profile of the initial pavement surface before construction activities disturb the existing pavement surface. The initial pavement surface is defined as the existing pavement surface before construction activities start.

Do not proceed with work that will disturb the initial pavement surface until the CO's analysis is complete.

Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving. The original overall surface MRI will be used in conjunction with the final overall MRI to determine an overall percent improvement for the entire traveled way.

(c) Type III pavement roughness. Measure the profile of the final pavement surface before placing a surface treatment and within 21 days of completing roadway paving.

(d) Type IV straightedge measurement. Measure the pavement surface using a 10-foot metal straightedge at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge more than ¼ inch measured between two contacts of the straightedge or deviations more than ¼ inch measured at the end of the straightedge.

401.17 Defective Area Correction. Obtain approval before starting corrective work. Allow 7 days for review and approval of correction method proposal.

Do not correct defective areas on the final pavement surface unless approved. Evaluate and correct defective areas, including localized roughness, on lower lifts by one of the following:

(a) Milling. Replace the defective area by milling at least one-half of the pavement depth and repaving with the approved asphalt concrete mix. Extend defective area corrections beyond the wheel path. Mill the defective area according to Section 413.

(b) Sawcutting. Replace the defective area by sawcutting and removing the defective area and repaving with the approved asphalt concrete mix. Saw cut and remove the defective area according to Section 203. Extend defective area corrections beyond the wheel path.

(c) Grinding. Use a diamond blade machine to grind off the defective surface area. Submit the manufacturer and model of the equipment to be used. Identify the starting and ending station of each grind location, the grinding depth, and lateral extent of grinding. Optimize the endpoints of the areas where a grinder is to be applied using ProVAL's Smoothness Assurance function in conjunction with the grinding simulation function. Submit the type of seal to be placed after grinding is completed for approval. Place seals according to Section 409 or 410. Limit the grinding depth to 12.5 percent of the design pavement thickness. If grinding more than this depth, provide a minimum 1-inch overlay.

(d) Other. Submit a proposal for approval for other correction methods not listed above.

After corrections are made, re-measure the pavement profile according to Subsection 401.16(a). Data from the re-measurement will be analyzed to determine the MRI or percent improvement, areas of localized roughness, and the final PF_{rough}. If correction and re-measurement of the surface is required, the maximum allowable pay factor under Subsection 401.20 is 1.00.

If corrections are not allowed, no adjustment will be made to the final PF_{rough} or localized roughness pay deductions.

401.18 Acceptance. See Table 401-10 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler, antistrip additives, and WMA additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt content, VMA, and core density will be evaluated under Subsection 106.05. Pavement roughness will be evaluated under Subsection 106.04. Asphalt binder will be evaluated under Subsections 106.03 and 106.04. Evaluations will consider the following:

(a) Asphalt content. The upper and lower specification limits are the approved JMF target value ±0.4 percent;

(b) VMA. The lower specification limits are shown in Table 401-1. Use the Contractor's combined coarse and fine bulk specific gravity of aggregate G_{sb} values to calculate VMA on field produced asphalt concrete mix samples;

(c) Density (core). The lower specification limit is 91.0 percent of the maximum specific gravity (density) determined according to AASHTO T 166 and AASHTO T 209.

The percent compaction will be determined using the average maximum specific gravity (AASHTO T 209) from all samples tested the day the core was obtained;

(d) Pavement roughness. The evaluation for payment will be made after defective areas are addressed. The pay factor is determined from Table 401-6, Table 401-7, Table 401-8, and Table 401-9; and

(e) Asphalt binder. The pay factor is determined from Table 401-5.

Construction of the HMA or WMA pavement course will be evaluated under Subsections 106.02 and 106.04.

Asphalt tack coat will be evaluated under Section 412.

Measurement

401.19 Measure the Section 401 pay items listed in the bid schedule according to Subsection 109.02.

Payment

401.20 The accepted quantities will be paid at the contract price per unit of measurement for the Section 401 pay items listed in the bid schedule, except the asphalt concrete pavement contract price will be adjusted according to Subsections 106.05, 401.18(d) and (e). Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be adjusted according to the following:

(a) Asphalt concrete pavement. Payment for asphalt concrete pavement will be made at a price determined by multiplying the contract price by the material pay factor for each lot. The material pay factor is calculated as follows:

$$PF_{material} = 1 + [(PF_{Volumetric} - 1) + (PF_{PG} - 1)]$$

where:

$PF_{material}$ = Material pay factor.

$PF_{Volumetric}$ = Pay factor for asphalt concrete pavement. $PF_{Volumetric}$ is the lowest single pay factor determined for asphalt binder content, VMA, and core density.

PF_{PG} = Pay factor for asphalt binder. The PF_{PG} formula is as follows:

$$PF_{PG} = \frac{(PF_1 + PF_2 + PF_3 + \ldots . PF_n)}{n}$$

where:

$PF_{\#}$ = For each sample, the lowest pay factor determined from any test in Table 401-5. If the lowest pay factor for a sample is in reject, the sample's pay factor is zero.

n = Number of samples tested.

If either the pay factor for the asphalt binder (PF_{PG}) or the pay factor for asphalt concrete pavement ($PF_{Volumetric}$) is below 0.75, the lot for asphalt concrete pavement is in reject.

(b) Pavement roughness. If the contract specifies a pavement roughness Type I, Type II, or Type III, a separate pay adjustment will be made for pavement roughness calculated as follows:

Type I, Type II, or Type III Pay Adjustment = (RF)(PF_{rough} - 1.00)(L) – (LRPR)

where:

PF_{rough} = Pay factor from Tables 401-6, 401-7, or 401-8.

L = Total project length in lane miles.

LRPR = Localized roughness pay reduction. Each area of localized roughness more than the localized roughness threshold MRI specified for the designated pavement roughness type will receive a reduction in payment according to Table 401-9.

RF = Roughness factor: 100,000.

For Type I and Type II pavement roughness, the localized roughness threshold computed to the nearest whole number is equal to the following:

Type I Localized Roughness Threshold = Initial Overall MRI + 1.881(S_{25})

Type II Localized Roughness Threshold = Initial Overall MRI + 1.282(S_{25})

where:

Initial Overall MRI = MRI obtained before construction activities start.

S_{25} = sample standard deviation of the 25-foot fixed interval MRI values.

The overall percent improvement in MRI will be determined to one decimal place for the traveled way according to the following formula:

$$Percent\ Improvement = \left[\frac{(Initial\ Overall\ MRI - Final\ Overall\ MRI)}{Initial\ Overall\ MRI}\right] \times 100$$

For Type I pavement roughness, Table 401-6 will be used to determine the final pay factor (PF_{rough}) for the traveled way to two decimal places. If the percent improvement is less than 25.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile, Type III-A from Table 401-8 will be used to determine the final PF_{rough}.

For Type II pavement roughness, Table 401-7 will be used to determine the final PF_{rough} for the traveled way to two decimal places. If the percent improvement is less than 49.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile, Type III-A from Table 401-8 will be used to determine the final PF_{rough}.

For Type III pavement roughness, pay factors from Table 401-8 will be used in conjunction with the long continuous histogram printout from ProVAL's Smoothness Assurance Analysis function and by utilizing a long continuous 528-foot segment length for analysis. The localized roughness threshold for Type III pavement roughness is 140 inches per mile. The final PF_{rough} is equal to the sum of the products of the individual pay factors shown in Table 401-8 multiplied by the ratio of individual lane miles to the overall project lane miles and by ProVAL's corresponding histogram percentages, divided by 100. The final PF_{rough} will be determined to three decimal places.

For Type IV pavement roughness, each defective area as determined by a 10-foot metal straightedge will receive a reduction in payment according to Table 401-9.

Table 401-5
Asphalt Binder Pay Factor Table

Property	Specifications(1)	Pay Factor					
		1.01	**1.00**	**0.95**	**0.90**	**0.75**	**Reject**
Tests on Original							
Dynamic shear rheometer, kPa	≥ 1.00	≥ 1.17	1.16 to 1.00	0.99 to 0.89	0.88 to 0.77	0.76 to 0.50	< 0.50
Tests after Rolling Thin Film Oven (RTFO)							
Dynamic shear rheometer, kPa	≥ 2.20	≥ 2.69	2.68 to 2.20	2.19 to 1.96	1.95 to 1.43	1.42 to 1.10	< 1.10
Tests on Pressure Aging Vessel (PAV)							
Dynamic shear rheometer, kPa(2)	< 5000	≤ 4711	4712 to 5000	5001 to 5289	5290 to 5578	5579 to 6000	> 6000
Bending beam rheometer, s, MPa	≤ 300	≤ 247	248 to 300	301 to 338	339 to 388	389 to 449	≥ 450
Bending beam rheometer, m-value	≥ 0.300	≥ 0.320	0.319 to 0.300	0.299 to 0.294	0.293 to 0.278	0.277 to 0.261	< 0.261

(1) Conform to Subsection 702.01.
(2) If dynamic shear rheometer (PAV) value is between 5000 kPa and 6000 kPa, and the phase angle is equal to or greater than 42 degrees, the pay factor is 1.00

Table 401-6
Type I Pavement Roughness Pay Factors

Type I-A	Type I-B	–
Percent Improvement (%)	**Percent Improvement (%)**	**Pay Factor (PFrough)**
Greater than 50.0	Greater than 45.0	1.05
47.6 to 50.0	44.0 to 45.0	1.04
45.1 to 47.5	43.0 to 43.9	1.03
43.6 to 45.0	41.6 to 42.9	1.02
42.1 to 43.5	40.1 to 41.5	1.01
25.0 to 42.0	20.0 to 40.0	1.00
24.0 to 24.9	19.0 to 19.9	0.99
23.0 to 23.9	18.0 to 18.9	0.98
22.0 to 22.9	17.0 to 17.9	0.97
21.0 to 21.9	16.0 to 16.9	0.96
20.0 to 20.9	15.0 to 15.9	0.95
19.0 to 19.9	14.0 to 14.9	0.94
18.0 to 18.9	13.0 to 13.9	0.93
17.0 to 17.9	12.0 to 12.9	0.92
16.0 to 16.9	11.0 to 11.9	0.91
15.0 to 15.9	10.0 to 10.9	0.90
14.0 to 14.9	9.0 to 9.9	0.89
13.0 to 13.9	8.0 to 8.9	0.88
12.0 to 12.9	7.0 to 7.9	0.87
11.0 to 11.9	6.0 to 6.9	0.86
10.0 to 10.9	5.0 to 5.9	0.85
5.0 to 9.9	4.0 to 4.9	0.80
0.0 to 4.9	0.0 to 3.9	0.70
Negative Improvement	Negative Improvement	Correct & overlay

Table 401-7
Type II Pavement Roughness Pay Factors

Type II-A	**Type II-B**	**–**
Percent Improvement (%)	**Percent Improvement (%)**	**Pay Factor (PFrough)**
Greater than 60.0	Greater than 50.0	1.05
58.6 to 60.0	49.0 to 50.0	1.04
57.6 to 58.5	48.0 to 48.9	1.03
56.6 to 57.5	47.0 to 47.9	1.02
55.1 to 56.5	45.0 to 46.9	1.01
49.0 to 55.0	35.0 to 44.9	1.00
48.0 to 48.9	34.0 to 34.9	0.99
47.0 to 47.9	33.0 to 33.9	0.98
46.0 to 46.9	32.0 to 32.9	0.97
45.0 to 45.9	31.0 to 31.9	0.96
44.0 to 44.9	30.0 to 30.9	0.95
43.0 to 43.9	29.0 to 29.9	0.94
42.0 to 42.9	28.0 to 28.9	0.93
41.0 to 41.9	27.0 to 27.9	0.92
40.0 to 40.9	26.0 to 26.9	0.91
38.0 to 39.9	25.0 to 25.9	0.90
36.0 to 37.9	24.0 to 24.9	0.89
35.0 to 35.9	23.0 to 23.9	0.88
34.0 to 34.9	22.0 to 22.9	0.87
33.0 to 33.9	21.0 to 21.9	0.86
31.0 to 32.9	20.0 to 20.9	0.85
25.0 to 30.9	16.0 to 19.9	0.80
10.0 to 24.9	7.5 to 15.9	0.70
Less than 10.0	Less than 7.5	Correct & overlay

Table 401-8
Type III Pavement Roughness Pay Factors

Type III-A, inch/mile	Type III-B, inch/mile	Pay Factor (PF_{rough})
Mean Roughness Index (MRI)	**Mean Roughness Index (MRI)**	
If MRI of entire roadway is greater than 125 in/mi	If MRI of entire roadway is greater than 135 in/mi	REJECT
Greater than 95.0	Greater than 110.0	0.700
95.0 to 90.0	110.0 to 105.0	0.800
90.0 to 85.0	105.0 to 100.0	0.850
85.0 to 80.0	100.0 to 95.0	0.900
80.0 to 75.0	95.0 to 90.0	0.960
75.0 to 70.0	90.0 to 85.0	0.980
70.0 to 65.0	85.0 to 80.0	1.000
65.0 to 60.0	80.0 to 75.0	1.010
60.0 to 55.0	75.0 to 70.0	1.020
55.0 to 50.0	70.0 to 65.0	1.025
50.0 to 45.0	65.0 to 60.0	1.030
45.0 to 40.0	60.0 to 55.0	1.035
40.0 to 35.0	55.0 to 50.0	1.040
35.0 to 30.0	50.0 to 45.0	1.045
Less than 30.0	Less than 45.0	1.050

Table 401-9
Localized Roughness and Straightedge Measurement Pay Reductions

Type I	Type II & IV	Localized Roughness Limit MRI	Type III	
Deduction per Occurrence	**Deduction per Occurrence**		**Localized Roughness Limit MRI, inch/mile**	**Deduction per Occurrence**
$200	$300	Computed MRI value according to Subsection: 401.16(b) for Type I 401.16(b) for Type II 401.16(c) for Type III	140.0 to 169.9	$300
			170.0 to 179.9	$450
			180.0 to 189.9	$600
			190.0 to 199.9	$750
			200.0 to 209.9	$900
			210.0 to 219.9	$1,200
			220.0 to 229.9	$1,500
			230.0 to 239.9	$2,000
			> 240.0	$4,000

Table 401-10
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Asphalt concrete aggregate (703.07)	Measured & tested for conformance (106.04 & 105)	Aggregate quality	–	Subsection 703.07	1 per type & source of material	Source of material	Yes	Before production	Not required if using Government-furnished source
Asphalt binder (702.01)	Measured & tested for conformance (106.04 & 105)	Quality	–	AASHTO M 320	1 per type & source of material	Asphalt supplier or mixing plant	Yes	Before production	–
Asphalt concrete aggregate (703.07)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required if using a pre-crushed commercial source

Table 401-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Asphalt concrete mixture	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	30 days before producing	–
		RAP asphalt binder content	–	AASHTO T 308	"	"	"	"	–
		Bulk specific gravity of aggregate (coarse & fine)	–	AASHTO T 84 & T 85	"	"	"	"	–
		VMA	–	AASHTO R 35	"	–	"	"	–
		VFA	–	"	"	–	"	"	–
		Air voids	–	"	"	–	"	"	–
		Tensile strength ratio	–	AASHTO T 283	"	–	"	"	–

Table 401-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt concrete pavement	Statistical (106.05)	Gradation		AASHTO T 30	3 minimum	Behind the paver before compaction	Yes	6 hours	–
		No. 4	I						
		No. 30	I						
		No. 200	I						
		Other specified sieves	II						
		Asphalt content[1]	I	AASHTO T 308	"	"	"	"	–
		VMA	I	AASHTO R 35	"	"	"	"	–
		VFA	II	"	"	"	"	"	–
		Density[2]	I	AASHTO T 166	5 minimum	In-place after compaction	"	24 hours	Deliver cores to CO after testing is completed

Table 401-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip) (continued)									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Mix temperature	–	–	First load & as directed thereafter	Hauling vehicle before dumping or windrow before pickup	No	Immediately upon completion of test	–
		Maximum specific gravity[(4)]	–	AASHTO T 209	3 minimum	Behind the paver before compaction	Yes	24 hours	–
	Process control (153.03)	Density	–	ASTM D2950	5 minimum	At core location before coring	No	24 hours	See Subsection 401.12

Table 401-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Asphalt concrete pavement	Statistical (106.05)	Asphalt content[1]	I	AASHTO T 308	1 per 700 tons	Behind the paver before compaction	Yes	6 hours	–
		VMA	I	AASHTO R 35	"	"	"	"	–
		Density[2]	I	AASHTO T 166	"	In-place after compacting	"	24 hours	Deliver cores to CO after testing is completed
	Measured & tested for conformance (106.04)	Placement temperature	–	–	First load & as determined by the CO thereafter	Hauling vehicle before dumping, or windrow before pickup	No	Immediately upon completion of measurement	–
		Maximum specific gravity[3],[4]	–	AASHTO T 209	1 per day minimum	Behind the paver before compaction	Yes	24 hours	–
Asphalt binder (702.01)	Measured & tested for conformance (106.04)	Quality	See Table 401-5	AASHTO M 320	1 per 2000 tons of mix	In line between tank and mixing plant	Yes, 2 1-quart samples	–	Tested by the Government

Table 401-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt concrete pavement	Process control (153.03)	Gradation at plant	–	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	No	24 hours	–
		Moisture content of aggregates	–	AASHTO T 255	Contractor determined	Stockpile	"	"	–
		Gradation at paver	–	AASHTO T 30	1 per 700 tons of mix	Behind the paver before compaction	"	"	–
		Air voids	–	AASHTO T 312 & T 166	"	"	"	"	–
		VFA	–	AASHTO R 35	"	"	"	"	–
		Density	–	ASTM D2950	1 per 500 ft	In-place after compacting	"	"	–

Table 401-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Type I & II roughness, before construction (Initial MRI)	–	FLH T 401	See Subsection 401.16	Left and right wheel paths	No	Within 21days before ground disturbing work	Original surface before construction
		Type I, II & III roughness, after construction (Final MRI)	–	"	"	"	"	Within 21 days after completing paving	–
	Process control (153.03)	Surface tolerance	–	Straightedge measurements Subsection 401.16(d)	Contractor determined	See Subsection 401.16(d)	"	24 hours	–

(1) Use AASHTO T 308, Method A. Calculate the asphalt binder content by weighing the sample before and after the burn using a calibrated external balance.
(2) Cut two 6-inch diameter side by side cores. Obtain cores according to AASHTO R 67 as soon as the pavement has cooled sufficiently to allow coring, but not later than 12 hours after final rolling. Remove them with a core retriever and fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling and temperature. Submit one core for verification testing. Dry the other core to constant mass at 125±5 °F or vacuum dry it according to ASTM D7227 before performing the core density and measuring the thickness according to ASTM D3549. Use 62.245 pounds per cubic foot to convert specific gravity to density.
(3) After production paving has begun, use the average maximum specific gravity value (AASHTO T 209) for each day to adjust the percent compaction for the cores that represent that day's paving.
(4) Do not use the supplemental procedure for mixtures containing porous aggregate (dry back method of AASHTO T 209).

Section 402. — ASPHALT CONCRETE PAVEMENT BY HVEEM OR MARSHALL MIX DESIGN METHOD

Description

402.01 This work consists of constructing asphalt concrete pavement using HMA or WMA.

Material

402.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Asphalt concrete aggregate	703.07
Mineral filler	725.05

Construction Requirements

402.03 Composition of Mix (Job-Mix Formula). Provide asphalt concrete mixes of aggregate, asphalt binder, RAP, and additives that meet the applicable aggregate gradation in Table 703-3 and design parameters (a), (c), and (d) or (b), (c), and (d) in Table 402-1 for the class of mix listed in the bid schedule.

Apply asphalt concrete mix design requirements for HMA to the development of the WMA mix design. Provide modifications to the process required for WMA technology. Submit modifications to the asphalt concrete mix design process according to Appendix X.2 of AASHTO R 35 for approval.

Table 402-1
Asphalt Concrete Mix Requirements

Design Parameters	Class of Mix		
	A	B	C
(a) Hveem (AASHTO T 246 and AASHTO T 247)			
Percent air voids(1)	3.0 to 5.0	3.0 to 5.0	3.0 to 5.0
Stabilometer, minimum	37	35	30
VMA, minimum, %	See Table 402-2		
(b) Marshall (AASHTO T 245)			
Percent air voids(1)	3.0 to 5.0	3.0 to 5.0	3.0 to 5.0
Compaction, number of blows each end of test specimen	75	50	50
Stability, pounds minimum	2000	1500	1000
Flow, 0.01 inch	8 to 14	8 to 16	8 to 20
VMA, minimum, %	See Table 402-2		
(c) Moisture Susceptibility (AASHTO T 283)(2)			
Tensile strength ratio, minimum	0.80	0.80	0.80
(d) Dust-to-binder ratio(3)	0.8 to 1.6	0.8 to 1.6	0.8 to 1.6

(1) The percent of air voids is based on AASHTO T 166, AASHTO T 209, and AASHTO T 269. Maximum specific gravity (density) is based on AASHTO T 209.
(2) Use 4-inch diameter specimens. AASHTO T 283 requires a freeze-thaw cycle.
(3) Dust-to-binder ratio is the percent of material including lime, bag-house fines, and other mineral matter added to the mixture. Calculate the ratio using the effective asphalt content calculated by mass of mix.

Table 402-2
Voids in Mineral Aggregate Hveem or Marshall Mix Design

Sieve Size(1)	VMA, Minimum, Percent(2),(3)	
	Hveem	Marshall
No. 4	16.0 to 19.0	18.0 to 21.0
⅜ in	14.0 to 17.0	16.0 to 19.0
½ in	13.0 to 16.0	15.0 to 18.0
¾ in	12.0 to 15.0	14.0 to 17.0
1 in	11.0 to 14.0	13.0 to 16.0

(1) The largest sieve size listed in the applicable specification upon which material is allowed to be retained.
(2) Determine VMA according to AASHTO R 35.
(3) If mineral filler or hydrated lime is used, include in the calculation for compliance with the VMA.

(a) RAP. Conform to Subsection 401.03(a).

(b) Baghouse fines. Conform to Subsection 401.03(b).

(c) Antistrip additive. Conform to Subsection 401.03(c).

(d) Submittals. Submit written JMFs and associated material with Form FHWA 1607, *Worksheet For A Hveem Mix Design AASHTO T 246* or Form FHWA 1622, *Worksheet For A Marshall Mix Design AASHTO T 245* for verification at least 30 days before the control strip. Include a signed statement prepared by the testing laboratory that certifies the proposed JMF meets the requirements and can be compacted in the field during production. For each proposed JMF, submit the following:

(1) Aggregate and mineral filler. Conform to Subsection 401.03(d)(1).

(2) Asphalt binder. Conform to Subsection 401.03(d)(2).

(3) Antistrip additives. Conform to Subsection 401.03(d)(3).

(4) RAP. Conform to Subsection 401.03(d)(4).

(5) WMA technology and additive information. Conform to Subsection 401.03(d)(5).

(e) Verification. The verification process starts when required documentation and material have been received. After the JMF is verified, start asphalt concrete mix production for the control strip.

(1) Aggregate gradations. Conform to Subsection 401.03(e)(1).

(2) RAP asphalt binder content and gradation. Conform to Subsection 401.03(e)(2).

(3) Bulk specific gravity of aggregate (G_{sb}). Conform to Subsection 401.03(e)(3).

(4) Hveem stabilometer value. The Hveem stabilometer value is verified if the CO’s result is above the minimum specification limit in Table 402-1.

(5) Marshall stability and flow value. The Marshall stability and flow values are verified if the CO’s results meet the requirements in Table 402-1.

(6) Air voids (V_a). Conform to Subsection 401.03(e)(6).

(7) TSR. Conform to Subsection 401.03(e)(7).

(8) VMA. The VMA result is verified if the CO’s result is within the specification limit in Table 402-2.

(f) Changes and resubmissions. Conform to Subsection 401.03(f).

402.04 Mixing Plant. Conform to Subsection 401.04.

402.05 Equipment. Conform to Subsection 401.05.

402.06 Surface Preparation. Conform to Subsection 401.06.

402.07 Weather Limitations. Conform to Subsection 401.07.

402.08 Asphalt Preparation. Conform to Subsection 401.08.

402.09 Aggregate Preparation. Conform to Subsection 401.09.

402.10 Mixing. Conform to Subsection 401.10.

402.11 Hauling. Conform to Subsection 401.11.

402.12 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-paving preparatory phase meeting according to Subsection 153.06(a) at least 3 days before the start of paving operations. Be prepared to discuss and provide the following:

(1) Calibration certification for the Hveem or Marshall compactor. If the Hveem or Marshall compactor is moved, recalibrate; and

(2) Asphalt and aggregate correction factors according to AASHTO T 308 and AASHTO T 30 on Form FHWA 1640, *Worksheet for Ignition Furnace Binder Correction Factor AASHTO T 308*. If RAP is included as part of the JMF, provide the asphalt and aggregate correction factors according to AASHTO T 30 and the FLH Addendum to AASHTO T 308 on Form FHWA 1648, *Worksheet For Ignition Furnace Binder Correction Factor And Aggregate Gradation Correction Factor For Mixes Including RAP*.

(b) Control strip. Provide at least 7 days' notice before starting production of an asphalt concrete mix.

On the first day of production, produce sufficient asphalt concrete mix to construct a 1000-foot-long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using asphalt concrete mix production, lay-down, and compaction procedures intended for the entire mix. Construct a control strip for each equipment combination and each plant from which production is intended.

Stop production after construction of the control strip until asphalt concrete mix and the control strip are accepted. Acceptance will be based on the following:

(1) Mixture. Take and test at least three control strip asphalt concrete mix samples and evaluate according to Subsection 402.17. The asphalt concrete mix is acceptable if all test results are within specification limits for gradation and asphalt content and the calculated pay factor for gradation and asphalt content is 0.90 or greater.

(2) Compaction. Compact according to Subsection 401.14. Take nuclear density gauge readings behind each roller pass to determine the roller pattern necessary to achieve required density. Use Form FHWA 1646, *Asphalt Control Strip Worksheet*. Document if roller was operated in vibratory or static mode. Provide frequency and amplitude settings if operated in vibratory mode. Submit documentation after completion of the control strip.

Take nuclear gauge density readings and cut core samples according to Table 402-3. Density is acceptable if the calculated pay factor is 0.90 or greater. Provide the CO with documented nuclear gauge readings correlated to core specific gravities.

(3) Control strip mat defects. Control strips that exhibit physical or visual defects may be rejected. Defects include tearing, cracking, rutting, shoving, segregation, bleeding, excessive pavement roughness, and poor joints.

Repeat the control strip process until an acceptable control strip is produced. Conform to Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed pavement. Tests used for the control strip will not be included in the evaluation for payment according to Subsection 106.05. After a control strip is verified and accepted, full production may start.

Use start-up procedures if resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.05.

402.13 Placing and Finishing. Conform to Subsection 401.13.

402.14 Compacting. Conform to Subsection 401.14.

402.15 Joints, Trimming Edges, and Cleanup. Conform to Subsection 401.15.

402.16 Pavement Roughness. Conform to Subsection 401.16.

402.17 Acceptance. See Table 402-3 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler, antistrip additives, and WMA additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt content, core density, and aggregate gradation will be evaluated under Subsection 106.05. Pavement roughness will be evaluated under Subsection 106.04. Asphalt binder will be evaluated under Subsections 106.03 and 106.04. Evaluations will consider the following:

(a) Asphalt content. The upper and lower specification limits are the approved JMF target value ±0.4 percent;

(b) Density (core). The lower specification limit is 91.0 percent of the maximum specific gravity (density) determined according to AASHTO T 166 and AASHTO T 209. The percent compaction will be determined using the average maximum specific gravity (AASHTO T 209) from all samples tested the day the core was obtained;

(c) Aggregate gradation. The upper and lower specification limits are the approved JMF target values plus or minus the allowable deviations shown in Table 703-2;

(d) Pavement roughness. The evaluation for payment will be made after defective areas are addressed. Conform to Subsection 401.18(d); and

(e) Asphalt binder. The pay factor is determined from Table 401-5.

Construction of HMA and WMA pavement courses will be evaluated under Subsections 106.02 and 106.04.

Measurement

402.18 Measure the Section 402 pay items listed in the bid schedule according to Subsection 109.02.

Payment

402.19 The accepted quantities will be paid at the contract price per unit of measurement for the Section 402 pay items listed in the bid schedule, except the asphalt concrete pavement contract price will be adjusted according to Subsections 106.05, 402.17(d) and (e). Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be adjusted according to the following:

(a) Asphalt concrete pavement. Payment for asphalt concrete pavement will be made at a price determined by multiplying the contract price by the material pay factor for each lot. The material pay factor is calculated as follows:

$PF_{material} = 1 + [(PF_{Volumetric} - 1) + (PF_{PG} - 1)]$

where:

$PF_{material}$ = Material pay factor.

$PF_{Volumetric}$ = Pay factor for asphalt concrete pavement. $PF_{Volumetric}$ is the lowest single pay factor determined for asphalt binder content, VMA, and core density.

PF_{PG} = Pay factor for asphalt binder. The PF_{PG} formula is as follows:

$$PF_{PG} = \frac{(PF_1 + PF_2 + PF_3 + \dots . PF_n)}{n}$$

where:

$PF_{\#}$ = For each sample, the lowest pay factor determined from any test in Table 401-5. If the lowest pay factor for a sample is in reject, the sample's pay factor is zero.

n = Number of samples tested.

If either the pay factor for the asphalt binder (PF_{PG}) or the pay factor for asphalt concrete pavement ($PF_{Volumetric}$) is below 0.75, the lot for asphalt concrete pavement is in reject.

(b) Pavement roughness. If the contract specifies a pavement roughness Type I, Type II, or Type III, a separate pay adjustment will be made for pavement roughness calculated as follows:

Type I, Type II, or Type III Pay Adjustment = $(RF)(PF_{rough} - 1.00)(L) - (LRPR)$

where:

PF_{rough} = Pay factor from Tables 401-6, 401-7, or 401-8.

L = Total project length in lane miles.

LRPR = Localized roughness pay reduction. Each area of localized roughness more than the localized roughness threshold MRI specified for the designated pavement roughness type will receive a reduction in payment according to Table 401-9.

RF = Roughness factor: 100,000.

For Type I and Type II pavement roughness, the localized roughness threshold computed to the nearest whole number is equal to the following:

Type I Localized Roughness Threshold = Initial Overall MRI + 1.881(S_{25})

Type II Localized Roughness Threshold = Initial Overall MRI + 1.282(S_{25})

where:

Initial Overall MRI = MRI obtained before construction activities start.

S_{25} = sample standard deviation of the 25-foot fixed interval MRI values.

The overall percent improvement in MRI will be determined to one decimal place for the traveled way according to the following formula:

$$Percent\ Improvement\ = \left[\frac{(Initial\ Overall\ MRI - Final\ Overall\ MRI)}{Initial\ Overall\ MRI}\right] \times 100$$

For Type I pavement roughness, Table 401-6 will be used to determine the final pay factor (PF_{rough}) for the traveled way to two decimal places. If the percent improvement is less than 25.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile, Type III-A from Table 401-8 will be used to determine the final PF_{rough}.

For Type II pavement roughness, Table 401-7 will be used to determine the final PF_{rough} for the traveled way to two decimal places. If the percent improvement is less than 49.0 percent and the final overall MRI value is less than or equal to 70.0 inches per mile, Type III-A from Table 401-8 will be used to determine the final PF_{rough}.

For Type III pavement roughness, pay factors from Table 401-8 will be used in conjunction with the long continuous histogram printout from ProVAL's Smoothness Assurance Analysis function and by utilizing a long continuous 528-foot segment length for analysis. The localized roughness threshold for Type III pavement roughness is 140 inches per mile. The final PF_{rough} is equal to the sum of the products of the individual pay factors shown in Table 401-8 multiplied by the ratio of individual lane miles to the overall project lane miles and by ProVAL's corresponding histogram percentages, divided by 100. The final PF_{rough} will be determined to three decimal places.

For Type IV pavement roughness, each defective area as determined by a 10-foot metal straightedge will receive a reduction in payment according to Table 401-9.

Table 402-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Asphalt concrete aggregate (703.07)	Measured & tested for conformance (106.04 & 105)	Aggregate quality	–	Subsection 703.07	1 per type & source of material	Source of material	Yes	Before producing	Not required if using Government-furnished source
Asphalt binder (702.01)	Measured & tested for conformance (106.04)	Quality	–	AASHTO M 320	1 per type & source of material	Asphalt supplier or mixing plant	Yes	Before producing	–
Asphalt concrete aggregate (703.07)	Process control (153.03)	Gradation	–	AASHTO T 27& T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required if using a pre-crushed commercial source

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Asphalt concrete mixture	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	30 days before paving	–
		RAP asphalt binder content	–	AASHTO T 308	"	"	"	"	–
		RAP asphalt gradation	–	AASHTO T 30	"	"	"	"	Dry gradation, no binder removed
		Bulk specific gravity of aggregate (coarse & fine)	–	AASHTO T 84 & T 85	"	"	"	"	–
		VMA	–	AASHTO R 35	"	–	"	"	–
		VFA	–	"	"	–	"	"	–
		Air voids	–	AASHTO T 269	"	–	"	"	–
		Hveem S-value	–	AASHTO T 246 & T 247	"	–	"	"	Required only for Hveem mix
		Marshall stability & flow	–	AASHTO T 245	"	–	"	"	Required only for Marshall mix
		Tensile strength ratio	–	AASHTO T 283	"	–	"	"	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt concrete pavement	Statistical (106.05)	Gradation:		AASHTO T 30	3 minimum	Behind the paver before compaction	Yes	6 hours	–
		½ in	I						
		No. 4	I						
		No. 30	I						
		No. 200	I						
		Other specified sieves	II						
		Asphalt content(1)	I	AASHTO T 308	"	"	"	"	–
		Density(2)	I	AASHTO T 166	5 minimum	In-place after compacting	"	24 hours	Deliver core to the CO

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Maximum specific gravity[4]	–	AASHTO T 209	3 minimum	Behind the paver before compaction	Yes	24 hours	–
		Mix temperature	–	–	First load & as directed thereafter	Hauling vehicle before dumping or windrow before pickup	No	Upon completion of test	–
	Process control (153.03)	Density	–	ASTM D2950	5 minimum	At core location before coring	No	24 hours	See Subsection 402.12

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Asphalt concrete pavement	Statistical (106.05)	Gradation:		AASHTO T 30	1 per 700 tons	Behind the paver before compaction	Yes	6 hours	–
		½ in	I						
		No. 4	I						
		No. 30	I						
		No. 200	I						
		Other specified sieves	II						
		Asphalt content[(1)]	I	AASHTO T 308	"	"	"	"	–
		Density[(2)]	I	AASHTO T 166	"	In-place after compacting	"	24 hours	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Maximum specific gravity(3),(4)	–	AASHTO T 209	1 per day minimum	Behind the paver before compaction	Yes	24 hours	–
		Placement temperature	–	–	First load & as directed thereafter	Hauling vehicle before dumping, or windrow before pickup	No	Upon completion of measurement	–
		Surface tolerance	–	Straightedge measurements Subsection 401.16(d)	As directed	See Subsection 401.16(d)	No	24 hours	–
Asphalt binder (702.01)	Measured & tested for conformance (106.04)	Quality	See Table 401-5	AASHTO M 320	1 per 2000 tons of mix	In line between tank & mixing plan	Yes, 2 1-quart samples	–	Tested by Government
Asphalt concrete pavement	Process control (153.03)	Gradation at plant	–	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	No	24 hours	–
		Moisture content of aggregates	–	AASHTO T 255	Contractor determined	Stockpile	"	"	–
		Density	–	ASTM D2950	1 per 500 ft	In-place after compacting	"	"	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Type I pavement roughness, before construction (Initial MRI)	–	AASHTO R 56 & R 57	See Subsection 402.16	Left and right wheel paths	No	Within 21 days before ground disturbing work	Original surface before construction
		Type I pavement roughness, after construction (Final MRI)	–	"	"	"	"	Within 21 days after completing paving	–
		Type II pavement roughness, before construction (Initial MRI)	–	"	"	"	"	Within 21 days before ground disturbing work	Original surface before construction
		Type II pavement roughness, after construction (Final MRI)	–	"	"	"	"	Within 21 days after completing paving	–

Table 402-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product (continued)									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Type III pavement roughness (Final MRI)	–	AASHTO R 56 & R 57	See Subsection 402.16	Left and right wheel paths	No	Within 21 days after completing paving	–
	Measured & tested for conformance (106.04)	Surface tolerance	–	Straightedge measurements Subsection 401.16(d)	As directed	See Subsection 401.16(d)	No	24 hours	–

(1) Use AASHTO T 308, Method A. Calculate the asphalt binder content by weighing the sample before and after the burn using a calibrated external balance.
(2) Cut two 6-inch diameter side by side cores. Obtain cores as soon as the pavement has cooled sufficiently to allow coring, but not later than 12 hours after final rolling. Remove them with a core retriever and fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling and temperature. Submit one core for verification testing. Dry the other core to constant mass at 125±5 °F or vacuum dry it according to ASTM D7227 before performing the core density and measuring the thickness. Use 62.245 pounds per cubic foot to convert specific gravity to density.
(3) After production paving has begun, use the average maximum specific gravity value (AASHTO T 209) for each day to adjust the percent compaction for the cores that represent that day's paving.
(4) Do not use the supplemental procedure for mixtures containing porous aggregate (dry back method of AASHTO T 209).

Section 403. — ASPHALT CONCRETE

Description

403.01 This work consists of constructing asphalt concrete facilities using HMA or WMA.

Construction Requirements

403.02 Composition of Mix (Job-Mix Formula). Conform to current state department of transportation material specifications for asphalt concrete.

Submit a state department of transportation JMF approved within the past 12 months for approval at least 30 days before production that meets the current state department of transportation requirements for the location and type of facility being constructed.

For each proposed JMF, submit a production certification conforming to state department of transportation specifications. Submit the strength, quality, and gradation specifications for the asphalt concrete mix. Include copies of laboratory test reports that demonstrate aggregate, asphalt binder, additive, and mix properties meet state department of transportation specifications. Submit the maximum specific gravity (density) of the mix as determined by AASHTO T 209.

If requested, submit a representative 100-pound loose mix sample 21 days before placement.

403.03 Production Start-Up Procedures. Conform to Subsection 153.03(b).

403.04 Equipment. Conform to Subsection 401.05.

403.05 Surface Preparation. Conform to Subsection 401.06.

403.06 Weather Limitations. Conform to Subsection 401.07.

403.07 Hauling. Conform to Subsection 401.11.

403.08 Placing and Finishing. Do not use mixes produced from different plants unless the mixes are produced according to the same JMF, use material from the same sources, and are approved.

Place HMA at temperatures shown in Table 401-4. Place WMA at temperatures according to Subsection 401.03(d)(5). Measure temperature of the asphalt concrete mix in the hauling vehicle immediately before dumping into the spreader or measure it in the windrow immediately before pickup.

Place the mix with a paver conforming to Subsection 401.05. Control horizontal alignment using a reference line. Automatically control the grade and slope from reference lines, a ski and slope control device, or dual skis. Use skis having a minimum length of 20 feet.

In areas where mechanical spreading and finishing are impractical, place and finish the asphalt concrete mix by other approved methods to produce a uniform finished surface.

Offset the longitudinal joint according to Subsection 401.13.

403.09 Compacting. Thoroughly and uniformly compact the asphalt surface by rolling. In places inaccessible to rollers, use approved alternate equipment. Do not cause cracking, shoving, or undue displacement.

Monitor the compaction process with nuclear density gauges calibrated according to ASTM D2950 within 6 months before use. Check the standard and reference on each day of use according to the ASTM D2950 standardization and reference check sections. Compact to at least 91.0 percent of the maximum specific gravity (density) determined in Subsection 403.02.

Do not pass rollers over an unsupported edge of freshly laid asphalt concrete mix. Continue rolling until roller marks are eliminated, cracks are sealed, and the required density is obtained. For HMA, do not roll the mix after the surface cools below 175 °F.

403.10 Joints, Trimming Edges, and Cleanup. Conform to Subsection 401.15.

403.11 Pavement Straightedge Measurement. Measure the pavement surface using a 10-foot metal straightedge at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge more than ¼ inch measured between two contacts of the straightedge or deviations more than ¼ inch measured at the end of the straightedge.

Correct defective areas according to Subsection 401.17. Obtain approval for the method of correction.

403.12 Acceptance. See Table 403-1 for sampling, testing, and acceptance requirements. If no asphalt concrete type is designated, evaluate according to Type I in Table 403-1.

Asphalt binder will be evaluated under Subsection 106.03.

Asphalt concrete mix properties will be evaluated under Subsections 106.03 and 106.04.

Construction of asphalt concrete facilities will be evaluated under Subsections 106.02 and 106.04.

Pavement straightedge measurement will be evaluated under Subsection 106.04.

Measurement

403.13 Measure the Section 403 pay items listed in the bid schedule according to Subsection 109.02.

Payment

403.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 403 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 403-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design								
Asphalt concrete, Type I	Measured & tested for conformance (106.04)	Job-mix formula	Subsection 403.02	If requested	Flowing mix stream (bin or belt discharge) or behind the paver before compaction	Yes	Before approval of job-mix formula	Tested by the Government
Production								
Asphalt concrete, Type I	Measured & tested for conformance (106.04)	Job-mix formula	Subsection 403.02	1 per 700 tons	Behind the paver before compaction	Yes	24 hours	–
		Density(1)	AASHTO T 166	"	In-place after compacting	"	"	Deliver cores to CO after testing is completed
		Maximum specific gravity(2),(3)	AASHTO T 209	"	Behind the paver before compaction	"	"	–
		Surface tolerance	Straightedge measurement, Subsection 403.11	Continuously, after compaction	Finished pavement surface	No	"	–
		Placement temperature	–	First load & as directed thereafter	Hauling vehicle before dumping, or windrow before pickup	"	Upon completion of measurement	–
	Process control (153.03)	Gradation at the plant	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	No	24 hours	–
		Moisture content of aggregates	AASHTO T 255	"	Stockpile	"	"	–
		Density	ASTM D2950	1 per 500 ft	In-place after compacting	"	"	–

Table 403-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Asphalt concrete, Type II	Measured & tested for conformance (106.04)	Density	ASTM D2950	1 per 500 ft	In-place after compacting	No	24 hours	–
		Surface tolerance	Straightedge measurement, Subsection 403.11	Continuously, after compaction	Finished pavement surface	"	"	–
		Placement temperature	–	First load & as directed thereafter	Hauling vehicle before dumping, or windrow before pickup	"	Upon completion of measurement	–

(1) For asphalt concrete Type I, cut two 6-inch diameter side by side cores. Obtain cores as soon as the pavement has cooled sufficiently to allow coring, but not later than 12 hours after final rolling. Remove them with a core retriever and fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling and temperature. Submit one core for verification testing. Dry the other core to constant mass at 125±5 °F or vacuum dry it according to ASTM D7227 before performing the core density and measuring the thickness. Use 62.245 pounds per cubic foot to convert specific gravity to density.
(2) After production paving has begun, use the average maximum specific gravity value (AASHTO T 209) for each day to adjust the percent compaction for the cores that represent that day's paving.
(3) Do not use the supplemental procedure for mixtures containing porous aggregate (dry back method of AASHTO T 209).

Section 404. — THIN LIFT ASPHALT CONCRETE PAVEMENT

Description

404.01 This work consists of constructing thin lift asphalt concrete pavement using HMA or WMA.

Material

404.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Asphalt concrete aggregate	703.07
Mineral filler	725.05

Construction Requirements

404.03 Composition of Mix (Job-Mix Formula).

(a) General. Provide a thin lift asphalt concrete pavement JMF that conforms to one of the following:

(1) Type I. At least 30 days before production, submit a state department of transportation thin lift asphalt concrete JMF that is used for a highway system and approved by the state department of transportation within the past 12 months.

For each proposed JMF, submit a current production certification conforming to state department of transportation specifications. Submit the strength, quality, and gradation specifications for the asphalt concrete mix. Include copies of laboratory test reports that demonstrate the aggregate, asphalt binder, additive, and mix properties meet state department of transportation specifications.

(2) Type II. Select JMF mix design procedure (a) or (b) from Table 404-1. For the selected design procedure, provide an asphalt concrete mixture of aggregate, asphalt binder, RAP, and additives that meets the applicable aggregate gradation shown in Table 703-3 for No. 4 gradation and conforms to the design parameters shown in Table 404-1 for the selected mix design procedure. In addition, conform to the requirements of (c) from Table 404-1.

Submit the strength, quality, and gradation specifications for the asphalt concrete mix. Include copies of laboratory test reports that demonstrate aggregate, asphalt binder, additive, and mix properties meet Federal or state department of transportation specifications.

Table 404-1
Asphalt Concrete Mix Requirements
Type II Thin Lift Asphalt Concrete Pavement

Design Parameters	Specification
(a) Asphalt Concrete Pavement by Gyratory Mix Design Method (AASHTO M 323, AASHTO R 35, and AASHTO T 312)	
Gyratory compaction level ($N_{initial}$, N_{design}, N_{max})	6, 50, 75
Gradation (No. 4)	Table 703-3
Air voids (Va), %	5
VMA, %	16 to 21(1)
VFA, %	66 to 82
Dust-to-binder ratio	0.6 to 2.0
(b) Asphalt Concrete Pavement by Marshall Mix Design Method (AASHTO T 245)	
Compaction, number of blows each end of test specimen	75
Gradation (No. 4)	Table 703-3
Air voids (Va), %	4
Stability, lb, minimum	2000
Flow, 0.01 in	8 to 14
VMA, %	16 to 21(1)
VFA, %	66 to 82
Dust-to-binder ratio	0.6 to 2.0
(c) Moisture Susceptibility (AASHTO T 283)	
Tensile strength ratio, minimum	0.80

(1) Minimum verification value of design VMA is 16.5 percent.

Submit the maximum specific gravity (density) of the mix as determined by AASHTO T 209.

Limit the natural sand content of the thin lift asphalt concrete pavement mixture to no more than 10 percent of the total weight of aggregate in the JMF.

If using WMA, apply asphalt concrete mix design requirements for HMA to the development of the WMA mix design. Provide modifications to the process required for WMA technology.

Submit modifications to the asphalt concrete mix design process according to AASHTO R 35, Appendix X.2, *Special Mix Design Considerations and Practices for Warm Mix Asphalt (WMA)* for approval.

(b) Submittals. Conform to Subsection 401.03(d).

(c) Verification. Allow at least 30 days for verification of each JMF. The verification process starts when required documentation and material are received. After the JMF is verified, start asphalt concrete mix production for the control strip.

(1) Type I.

(a) Aggregate gradations. The aggregate gradation is verified if the CO's gradation on a combined asphalt concrete mix using the aggregate and RAP stockpile percentage recommendations is within the target value gradation plus or minus the tolerance for each sieve shown in Table 404-2.

(b) RAP asphalt binder content and gradation. The RAP asphalt binder content results are verified if the CO's result for each stockpile is within ±0.75 percent by total mass using AASHTO T 308.

(c) Theoretical maximum specific gravity of mixture (G_{mm}). The G_{mm} is verified if the CO's results are within 0.024 for AASHTO T 209.

(d) Bulk specific gravity of compacted mixture (G_{mb}). The G_{mb} is verified if the CO's results are within 0.044 for AASHTO T 166.

(e) Bulk specific gravity of aggregate (G_{sb}). The coarse and fine G_{sb} is verified if the CO's results are within 0.038 for the combined AASHTO T 85 and AASHTO T 84.

(f) VMA. The VMA result is verified if the CO's result is 0.5 percent above the minimum specification limit.

(g) VFA. The VFA result is verified if the CO's result is within the specification limit.

(h) Air voids (V_a). The V_a result is verified if the CO's result at the same design asphalt binder content is within ±1.0 percent of the JMF design Va.

(i) TSR. The TSR result is verified if the CO's result is above the minimum specification limit.

(j) Stability (Marshall mix design method only). The stability result is verified if the CO's result is above the minimum specification limit.

(k) Flow (Marshall mix design method only). The flow result is verified if the CO's result is within the specification limits.

(2) Type II.

(a) Aggregate gradations. The aggregate gradation is verified if the CO's gradation on a combined asphalt concrete mix using the Contractor's aggregate and RAP stockpile percentage recommendations is within the Contractor's target value gradation plus or minus the tolerance for each sieve shown in Table 404-2.

(b) RAP asphalt binder content and gradation. The RAP asphalt binder content results are verified if the CO's result for each stockpile is within ±0.75 percent by total mass using AASHTO T 308.

(c) Theoretical maximum specific gravity of mixture (G_{mm}). The G_{mm} is verified if the CO's results are within 0.024 for AASHTO T 209.

(d) Bulk specific gravity of compacted mixture (G_{mb}). The G_{mb} is verified if the CO's results are within 0.044 for AASHTO T 166.

(e) Bulk specific gravity of aggregate (G_{sb}). The coarse and fine G_{sb} is verified if the CO's results are within 0.038 for the combined AASHTO T 85 and AASHTO T 84.

(f) VMA. The VMA result is verified if the CO's result is 0.5 percent above the minimum specification limit shown in Table 404-1 for the selected mix design procedure.

(g) VFA. The VFA result is verified if the CO's result is within the specification limits shown in Table 404-1 for the selected mix design procedure.

(h) Air voids (V_a). The V_a result is verified if the CO's result at the same design asphalt binder content is within ±1 percent of the target value shown in Table 404-1 for the selected mix design procedure.

(i) TSR. The TSR result is verified if the CO's result is above the minimum specification limit shown in Table 404-1 for the selected mix design procedure.

(j) Stability (Marshall mix design method only). The stability result is verified if the CO's result is above the minimum specification limit shown in Table 404-1 for the selected mix design procedure.

(k) Flow (Marshall mix design method only). The flow result is verified if the CO's result is within the specification limits shown in Table 404-1 for the selected mix design procedure.

Table 404-2
Aggregate Gradation Verification Tolerances

Sieve Size	Tolerance, Percent (±)
No. 4	3.0
No. 8	3.0
No. 16	3.0
No. 30	2.0
No. 50	2.0
No. 200	1.0
Other sieves	3.0

(d) Changes and resubmissions. If a JMF is rejected or the source of material is changed, submit a new JMF for verification. Up to 30 days may be required to evaluate a change after receipt of required documentation and material. Approved changes in target values will not be applied retroactively for payment.

The CO will deduct JMF evaluation costs resulting from the following:

(1) Contractor-requested changes to the approved JMF;

(2) Contractor requests for more than one JMF evaluation; and

(3) Additional testing necessary due to the failure of a submitted JMF.

404.04 Mixing Plant. Conform to Subsection 401.04.

404.05 Equipment. Conform to Subsection 401.05.

404.06 Surface Preparation. Conform to Subsection 401.06.

404.07 Weather Limitations. Place asphalt concrete mix on a dry, unfrozen surface when the air temperature in the shade is above 60 °F and rising. For HMA, conform to Table 404-3. For WMA, adjust Table 404-3 minimum lay-down temperatures according to the manufacturer's recommendations.

Table 404-3
Thin Lift Asphalt Concrete Pavement Placement Temperature

Road Surface Temperature, °F	Minimum Lay-Down Temperature, °F(1)
< 59.9	(2)
60 to 69.9	295
70 to 79.9	285
80 to 89.9	280
≥ 90	270

(1) Do not heat the asphalt concrete mix above the temperature specified in the approved asphalt concrete mix design.
(2) Do not pave.

404.08 Asphalt Preparation. Conform to Subsection 401.08.

404.09 Aggregate Preparation. Conform to Subsection 401.09.

404.10 Mixing. Conform to Subsection 401.10.

404.11 Hauling. Conform to Subsection 401.11.

404.12 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-paving preparatory phase meeting according to Subsection 153.06(a) at least 3 days before the start of paving operations. Be prepared to discuss the following:

(1) Calibration certification for the appropriate laboratory equipment based on the approved JMF mix design procedure.

(2) Asphalt and aggregate correction factors according to AASHTO T 308 and AASHTO T 30 on Form FHWA 1640, *Worksheet for Ignition Furnace Binder Correction Factor AASHTO T 308*. If RAP is included as part of the JMF, provide the asphalt and aggregate correction factors according to AASHTO T 30 and the FLH Addendum to AASHTO T 308 on Form FHWA 1648, *Worksheet for Ignition Furnace Binder Correction Factor and Aggregate Gradation Correction Factor for Mixes Including RAP*.

(b) Control strip. Provide 7 days' notice before starting production of an asphalt concrete mix.

On the first day of production, produce sufficient asphalt concrete mix to construct a 1000-foot-long control strip, one-lane wide, and at the designated lift thickness. Construct the control strip on the project at an approved location.

Construct the control strip using asphalt concrete mix production, lay-down, and compaction procedures intended for the entire mix. Stop production after construction of the control strip until the asphalt concrete mix and the control strip are evaluated for acceptance.

(1) Mixture. Take at least three control strip asphalt concrete mix samples from the paver hopper and test according to Subsection 404.17.

Asphalt concrete pavement mixtures will be evaluated based on the following:

(a) Gyratory mix design method (AASHTO M 323, AASHTO R 35, and AASHTO T 312). The asphalt concrete mix is acceptable if all test results are within specification limits for asphalt content and VMA, and the calculated pay factor for asphalt content, VMA, and gradation is 0.90 or greater.

(b) Marshall mix design method (AASHTO T 245). The asphalt concrete mix is acceptable if all test results are within specification limits for asphalt content and gradation, and the calculated pay factor for asphalt content and gradation is 0.90 or greater.

(2) Compaction. Compact according to Subsection 404.14. Provide thin-lift nuclear density gauges calibrated according to the ASTM D2950 calibration section and within 6 months before use. Check the standard and reference on each day of use according to the ASTM D2950 standardization and reference check sections.

Take nuclear gauge density readings behind each roller pass to determine the roller pattern necessary to achieve required density. Provide documentation of passes for each roller used in the control strip. Identify breakdown and finish roller in the documentation. Provide this documentation to the CO after completion of the control strip.

Take nuclear gauge density readings at 10 randomly selected locations as directed. Take 5 of the 10 readings at the location designated by the CO for asphalt pavement cores. Take reading over the core location before the core is taken from pavement. Take other 5 readings at random locations on the test strip mat at locations designated by the CO.

Cut and test 5 core samples at randomly selected locations as directed and as shown in Table 404-4 to verify nuclear density gauge readings. A correction factor will be applied to control strip and production density results as shown in Table 404-4, Footnote (4), if applicable. Provide the CO with documented nuclear gauge readings correlated to core densities. Density is acceptable if the nuclear gauge density pay factor of the 10 randomly selected locations is 0.90 or greater.

(3) Control strip mat defects. Control strips that exhibit physical or visual defects will be rejected. Defects include tearing, cracking, checking, rutting, shoving, segregation, bleeding, excessive pavement roughness, or poor joints.

Repeat the control strip process until an acceptable control strip is produced. Conform to Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed pavement. Tests used for the control strip will not be included with production paving results in the evaluation for payment according to Subsection 106.05. After a control strip is verified and accepted, full production may start.

Use start-up procedures if resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.05.

404.13 Placing and Finishing. Conform to Subsection 401.13.

404.14 Compacting. Provide one roller each for breakdown and finish rolling. Size the rollers to achieve the required results. Operate rollers in static mode according to the manufacturer's recommendations. Do not use diesel fuel as a release agent with rollers used to compact asphalt concrete mix.

Monitor the compaction process with nuclear density gauges calibrated to the control strip density test results. Compact to the requirements of Subsection 404.17(b).

Compact the asphalt concrete mix with alternate equipment to obtain the required compaction along forms, curbs, headers, walls, and other places inaccessible to rollers.

Do not cause cracking, shoving, or undue displacement. Continue compaction until surface marks are eliminated and cracks are sealed.

404.15 Joints, Trimming Edges, and Cleanup. Conform to Subsection 401.15.

404.16 Pavement Straightedge Measurement. Measure the pavement surface using a 10-foot metal straightedge at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge more than ¼ inch measured between two contacts of the straightedge or deviations more than ¼ inch measured at the end of the straightedge.

Correct defective areas according to Subsection 401.17. Obtain approval for the method of correction.

404.17 Acceptance. See Table 404-4 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler, antistrip additives, and WMA additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt content, density, VMA for asphalt concrete pavement by gyratory mix design method, and gradation for asphalt concrete pavement by Marshall mix design will be evaluated under Subsection 106.05. Pavement roughness will be evaluated under Subsection 106.04. Asphalt binder will be evaluated under Subsections 106.03 and 106.04.

(a) Asphalt content. The upper and lower specification limits are the approved JMF target value ±0.4 percent.

(b) Density. The lower specification limit is 90.0 percent of the maximum specific gravity (density) determined according to ASTM D2950 and AASHTO T 209. The percent compaction will be determined using the average maximum specific gravity (AASHTO T 209) from all samples tested each day.

(c) Pavement roughness. The evaluation for payment will be made after defective areas are addressed. Conform to Subsection 401.17.

(d) Asphalt binder. The pay factor is determined from Table 401-5.

(e) VMA for asphalt concrete pavement by gyratory mix design method.

(1) Type I. The lower specification limit is the minimum VMA as found in the state department of transportation specifications for the thin lift asphalt concrete pavement used for the approved JMF. After the JMF has been verified according to Subsection 404.03, use the Contractor's combined coarse and fine bulk specific gravity of aggregate G_{sb} value from the approved JMF to calculate VMA on field produced asphalt concrete mix samples.

(2) Type II. The lower specification limit is the value shown in Table 404-1. After the JMF has been verified according to Subsection 404.03, use the Contractor's combined coarse and fine bulk specific gravity of aggregate G_{sb} value from the approved JMF to calculate VMA on field produced asphalt concrete mix samples.

(f) Gradation for asphalt concrete pavement by Marshall mix design method. The upper and lower specification limits are the approved JMF target values plus or minus the allowable deviations shown in Table 703-2.

Construction of the HMA or WMA pavement course and the in-place mat condition will be evaluated under Subsections 106.02 and 106.04. Areas of the asphalt pavement course which exhibit physical or visual defects or distresses as described in Subsection 404.12(b)(3) may require removal and replacement.

Measurement

404.18 Measure the Section 404 pay items listed in the bid schedule according to Subsection 109.02.

Payment

404.19 The accepted quantities will be paid at the contract price per unit of measurement for the Section 404 pay items listed in the bid schedule, except the asphalt concrete pavement contract price will be adjusted according to Subsection 106.05 and Table 401-7. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for thin lift asphalt concrete pavement work will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is calculated as follows:

PF_{PG} = Pay factor for asphalt binder.

The PF_{PG} formula is as follows:

$$PF_{PG} = \frac{(PF_1 + PF_2 + PF_3 + \ldots . PF_n)}{n}$$

where:

$PF_{\#}$ = For each sample, the lowest pay factor determined from any test in Table 401-7. If the lowest pay factor for a sample is in reject, the sample's pay factor is zero.

n = Number of samples tested.

$PF_{material} = 1 + [(PF_{mix} - 1) + (PF_{PG} - 1)]$

where:

$PF_{material}$ = Material pay factor.

PF_{mix} = Pay factor for asphalt concrete pavement. PF_{mix} is the lowest single pay factor determined for:

(a) Gyratory mix design method Type I or II. Asphalt binder content, VMA, and density.

(b) Marshall mix design method Type I or II. Asphalt binder content, aggregate gradation, and density.

If either the pay factor for the asphalt binder (PF_{PG}) or the pay factor for asphalt concrete pavement (PF_{mix}) is below 0.75, the lot for asphalt concrete pavement is in reject.

Table 404-4
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Asphalt concrete aggregate (703.07)	Measured & tested for conformance (106.04 & 105)	Aggregate quality	–	Subsection 703.07	1 per type & source of material	Source of material	Yes	Before producing	Not required if using Government-furnished source
Asphalt binder (702.01)	Measured & tested for conformance (106.04)	Quality	–	AASHTO M 320	"	Asphalt supplier or mixing plant	"	"	–
Asphalt concrete aggregate (703.07)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required if using a pre-crushed commercial source

Table 404-4 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Asphalt concrete mixture	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	30 days before paving	–
		RAP asphalt binder content	–	AASHTO T 308	"	"	"	"	–
		RAP asphalt Gradation	–	AASHTO T 30	"	"	"	"	Dry gradation, no binder removed
		Bulk specific gravity of aggregate (coarse & fine)	–	AASHTO T 84 & T 85	"	"	"	"	–
		VMA	–	AASHTO R 35	"	–	"	"	–
		VFA	–	"	"	–	"	"	–
		Air voids	–	AASHTO T 269	"	–	"	"	–
		Marshall stability & flow	–	AASHTO T 245	"	–	"	"	Only required for mixtures designed by Marshall mix design method
		Tensile strength ratio	–	AASHTO T 283	"	–	"	"	–

Table 404-4 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
Asphalt concrete pavement	Statistical (106.05)	Gradation		AASHTO T 30	3 minimum	Paver hopper	Yes	6 hours	–
		No. 4	II						
		No. 8	II						
		No. 16	II						
		No. 30	II						
		No. 50	II						
		No. 200	II						
		Other specified sieves	II						
		Asphalt content(1)	II	AASHTO T 308	"	"	"	"	–
		VMA	II	AASHTO R 35	"	"	"	"	Only required for mixtures designed by Gyratory mix design method
		Density(2),(4),(5)	II	ASTM D2950	10 minimum	In-place after compacting	"	24 hours	Locations randomly selected and witnessed by CO
		Density(2),(6)	II	AASHTO T 166	5 minimum	In-place after compacting	"	24 hours	Locations randomly selected and witnessed by CO

Table 404-4 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip) (continued)									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Maximum specific gravity(3)	–	AASHTO T 209	3 minimum	Paver hopper	Yes	24 hours	–
		Mix temperature	–	–	First load & as directed thereafter	Hauling vehicle before dumping or windrow before pickup	No	Upon completion of test	–
	Process control (153.03)	Density	–	ASTM D2950	5 minimum	–	No	24 hours	–

Table 404-4 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Asphalt concrete pavement	Measured & tested for conformance (106.04)	Placement temperature	–	–	First load & as directed thereafter	Hauling vehicle before dumping, or windrow before pickup	"	Upon completion of measurement	–
		Maximum specific gravity(3)	–	AASHTO T 209	1 per 7000 yd^2 but not less than 1 per day	Paver hopper	Yes	24 hours	Part of sample taken from paver hopper for gradation and AC content
		Surface tolerance	–	Straightedge measurement, Subsection 404.16	Continuously, after compaction	Finished pavement surface	No	–	–
	Process control (153.03)	Gradation at the plant	–	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	"	24 hours	–
		Moisture content of aggregates	–	AASHTO T 255	"	Stockpile	"	"	–
		Density	–	ASTM D2950	1 per 500 ft	In-place after compacting	"	"	–

Table 404-4 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Asphalt concrete pavement	Statistical (106.05)	Gradation		AASHTO T 30	1 per 7000 yd^2 but not less than 1 per day	Paver hopper	Yes	6 hours	Only required for mixtures designed by Marshall mix design method
		No. 4	II						
		No. 8	II						
		No. 16	II						
		No. 30	II						
		No. 50	II						
		No. 200	II						
		Other specified sieves	II						
		Asphalt content(1)	II	AASHTO T 308	"	"	"	"	–
		VMA	II	AASHTO R 35	"	"	"	"	Only required for mixtures designed by Gyratory mix design method
		Density(7),(8)	II	ASTM D2950	10 per 7000 yd^2	In-place after compacting	"	Immediate	Testing witnessed by CO

Table 404-4 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Asphalt concrete mixture pavement surface	Measured & tested for conformance (106.04)	Type IV straightedge (surface tolerance)	–	Straightedge measurement, Subsection 404.16	–	Subsection 404.16	–	24 hours	–

(1) Use AASHTO T 308, Method A. Calculate the asphalt binder content by weighing the sample before and after the burn using a calibrated external balance.
(2) Take nuclear gauge density readings according to ASTM D2950. Set nuclear gauge readings to 1 minute and the layer thickness to 1 inch. Take 5 of the 10 readings at the location designated by CO for asphalt pavement cores. Take reading over the core location before the core is taken. Take other 5 readings at random locations on the test strip mat at locations designated by CO. For calculation of percent compaction (percent of maximum density), use the average of the three loose mix samples taken during the test strip.
(3) Cut two 6-inch diameter side by side cores. Remove them with a core retriever and fill and compact the core holes with the approved thin lift asphalt concrete mixture. Label the cores and protect them from damage due to handling and temperature. Submit one core for verification testing. Dry the other core to constant mass at 125±5 °F or vacuum dry it according to ASTM D7227 before performing the core density and measuring the thickness. Use 62.245 pounds per cubic foot to convert specific gravity to density. Use core results to verify control strip nuclear density gauge readings.
(4) Calculate theoretical maximum specific gravity according to AASHTO T 209. Use 62.245 pounds per cubic foot to convert specific gravity to density. Compare the core density to the corresponding nuclear gauge reading. Subtract corresponding nuclear density gauge reading from core density value. Do this for all 5 asphalt pavement core nuclear density gauge reading pairs. Determine the average correction factor by averaging the differences of the 5 pairs. This will be the correction factor applied to the nuclear density gauge readings for the test strip and during production.
(5) Use the developed correction factor and apply it to the 10 nuclear density readings taken for the test strip. Use the corrected density readings to determine the pay factor for density for the test strip.
(6) Do not use the supplemental procedure for mixtures containing porous aggregate (dry back method of AASHTO T 209).
(7) After production paving has begun, use the average maximum specific gravity value (AASHTO T 209) for each day to adjust the percent compaction for the in- place density readings taken by ASTM D2950 that represent that day’s paving
(8) The average in-place density of the 10 locations will be considered the in-place density of that 7000-square yard lot of thin lift asphalt concrete pavement and will be used for acceptance purposes. Report as percent compaction (percent of maximum density)

Section 405. — OPEN-GRADED ASPHALT FRICTION COURSE

Description

405.01 This work consists of constructing an open-graded asphalt friction course (OGFC).

Material

405.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Mineral filler	725.05
Open-graded asphalt friction course aggregate	703.08

Construction Requirements

405.03 Composition of Mix (Job-Mix Formula). Provide OGFC mixes of aggregate and asphalt binder designed according to ASTM D7064 or other approved methods that meet the applicable requirements shown in Table 405-1. Fabricate gyratory compacted specimens 6 inches in diameter and 4 inches nominal height. The Cantabro abrasion test is not required.

Table 405-1
OGFC Mix Requirements

Design Parameter	Requirement
Air voids, ASTM D3203 or D6752	18% minimum
Draindown, ASTM D6390	0.3% maximum, by mixture mass
Moisture susceptibility, AASHTO T 283, except as modified by ASTM D7064	80% minimum

(a) Submittals. Submit a written JMF, mix design reports, applicable charts, application temperature range, and design data for verification at least 30 days before production. Include a signed statement prepared by the testing laboratory that certifies the proposed JMF meets requirements. For the proposed JMF, submit the following:

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each specified sieve size for the aggregate blend and

(2) Set target values within the gradation ranges shown in Table 703-4 for the required grading. Allowable deviations are shown in Table 703-2.

(b) Source and percentage of each stockpile to be used;

(c) Average gradation of each stockpile;

(d) Representative samples from each stockpile. Use split samples of material taken at the same time samples are taken for testing by the Contractor's laboratory.

(1) 200 pounds of aggregates proportioned by each stockpile according to the JMF and

(2) 2 pounds of mineral filler, if proposed for the JMF.

(e) Results of aggregate quality tests performed within 1 year of use.

(2) Asphalt binder. Conform to Subsection 401.03(d)(2).

(3) Antistrip additives. Conform to Subsection 401.03(d)(3).

(b) Verification. The verification process starts after required documentation and material are received. Do not start OGFC production until the JMF is verified.

(1) Aggregate gradations. The Contractor's aggregate gradation is verified if the CO's gradation on a combined OGFC mix using the Contractor's aggregate stockpile percentage recommendations is within the Contractor's target value gradation plus or minus the tolerance shown in Table 405-2.

Table 405-2
Aggregate Gradation Verification Tolerances

Sieve Size	Tolerance, Percent (±)
No. 4	3.0
No. 8	3.0
No. 200	1.0

(2) Moisture susceptibility. The Contractor's retained tensile strength result determined by AASHTO T 283, except as modified by ASTM D7064, is verified if the CO's result is 80 percent minimum.

(c) Changes and resubmissions. If a JMF is rejected or the source of material is changed, submit a new JMF for verification. Up to 14 days may be required to evaluate a change after receipt of required documentation and material. Approved changes in target values will not be applied retroactively for payment.

The CO will deduct JMF evaluation costs resulting from the following:

(1) Contractor-requested changes to the approved JMF; and

(2) Additional testing necessary due to the failure of a submitted JMF.

405.04 Mixing Plant. Conform to Subsection 401.04.

405.05 Pavers. Conform to Subsection 401.05(a).

405.06 Surface Preparation. Conform to Subsection 401.06.

405.07 Weather Limitations. Place the OGFC mix on a dry asphalt surface when the air temperature in the shade is above 55 °F and the road surface temperature is above 60 °F. Stop placement if either temperature falls below these minimums.

405.08 Preparing and Mixing Material. Prepare, mix, and control material according to Subsections 401.08 through 401.10, except do not heat the aggregate introduced into the mixer above the optimum mixing temperature established in the JMF.

405.09 Hauling, Placing, and Finishing. Haul, place, and finish the mix according to Subsections 401.11 and 401.13. Place the mix within the approved temperature range. Minimize asphalt binder drainage by discharging the mix into the paver within 1½ hours of loading the truck. If surge bins are used, start this 1½-hour limit at the time the mix is deposited into the surge bin.

405.10 Compacting. Roll the OGFC mix before the mix temperature drops below 200 °F or the temperature recommended by the asphalt binder manufacturer. Use a steel-wheeled roller for compacting the mix. Do not shove, distort, or strip the mix beneath the roller. Roll the mix parallel to the centerline, commencing at the outside edge and progressing towards the center. On superelevated curves, start the rolling on the low side and progress to the high side. Limit rolling to that necessary to consolidate the OGFC and bond it to the underlying surface.

405.11 Joints and Cleanup. Use butt joints for longitudinal and transverse joints. Protect the completed OGFC from traffic until it has sufficiently hardened to resist abrasion, pickup, and raveling.

Dispose of material trimmed from the edges and other discarded asphalt concrete mix according to Subsection 203.07.

405.12 Straightedge Measurement. Conform to Subsection 403.11.

405.13 Acceptance. See Table 405-3 for sampling, testing, and acceptance requirements.

Aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

Mineral filler and antistrip additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt binder will be evaluated under Subsections 106.03 and 106.04.

Asphalt content and aggregate gradation will be evaluated under Subsection 106.05. Evaluations will consider the following:

> **(a) Asphalt content.** The upper and lower specification limits are the approved JMF target value ±0.4 percent.
>
> **(b) Aggregate gradation.** The upper and lower specification limits are the approved JMF target values plus or minus the allowable deviations shown in Table 703-2.

Construction of open-graded asphalt friction course will be evaluated under Subsections 106.02 and 106.04.

Measurement

405.14 Measure the Section 405 pay items listed in the bid schedule according to Subsection 109.02.

Payment

405.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 405 pay items listed in the bid schedule, except the OGFC contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for OGFC will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is the lowest single pay factor determined for asphalt content or any individual sieve of the aggregate gradation.

Table 405-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
OGFC aggregate (703.08)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 703.08	1 per type & source of material	Source of material	Yes	Before production	Not required if using Government-furnished source
Asphalt binder (702.01)	"	Quality	–	AASHTO M 320	"	Asphalt supplier or mixing plant	"	"	–
Mix Design									
OGFC asphalt concrete mixture	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	30 days before producing	–
		Air voids	–	ASTM D3203 or D6752	"	–	"	"	–
		Draindown	–	ASTM D6390	"	–	"	"	–
		Tensile strength ratio	–	AASHTO T 283	"	–	"	"	Complete AASHTO T 283, except as modified by ASTM D7064

Table 405-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
OGFC	Statistical (106.05)	Asphalt content	I	AASHTO T 308	1 per 300 tons	Point of discharge of the mixing unit	Yes	24 hours	–
		Gradation (at paver)		AASHTO T 30	"	"	"	"	–
		No. 4	I						
		No. 200	I						
		Other specified sieves	II						
	Measured & tested for conformance (106.04)	Placement & compaction temperature	–	–	First load & as directed thereafter	Hauling vehicle before dumping, or windrow before pickup and pavement surface during rolling	No	Upon completion of measurement	–
Asphalt binder (702.01)	"	Quality	–	Subsection 702.01	1 per 1000 tons of mix	In line between tank & mixing plant	Yes, 2 1-quart samples	–	Test by Government

Table 405-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
OGFC	Process control (153.03)	Gradation at plant	–	AASHTO T 27 & T 11	Contractor determined	Cold feed or hot bins as applicable	No	24 hours	–
		Moisture content of aggregates	–	AASHTO T 255	"	Stockpile	"	"	–
Finished Product									
OGFC	Measured & tested for conformance (106.04)	Surface tolerance	–	Straightedge measurements, Subsection 403.11	Continuously, after compaction	Finished pavement surface	No	24 hours	–

Section 406. — FOG SEAL

Description

406.01 This work consists of applying an emulsified asphalt fog seal.

Material

406.02 Conform to the following Subsections:

Blotter	703.12
Emulsified asphalt	702.02
Water for construction	725.01(c)

Construction Requirements

406.03 Equipment. Provide an asphalt distributor with the following:

(a) Heater for uniformly heating the asphalt;

(b) Full circulation spray bar adjustable to 15-foot width;

(c) Positive controls including tachometer, pressure gauge, volume measuring device, or calibrated tank to uniformly deposit asphalt over the full width within 0.02 gallons per square yard of the required rate; and

(d) Thermometer for measuring asphalt temperature in the tank.

406.04 Surface Preparation.

(a) Clean the existing surface of loose material, dirt, and other deleterious material before placing the fog seal. Remove or protect raised pavement markers, pavement markings, reflectorized tape, and other material that interferes with the work. Protect service entrances (such as manholes, valve boxes, and drop inlets). Protect concrete work, rock walls, and other objects adjacent to the work.

(b) Dry the surface before placing the fog seal.

406.05 Weather Limitations. Apply fog seals only when the following apply:

(a) Ambient air temperature is above 50 °F;

(b) Surface temperature is above 50 °F;

(c) Weather is not foggy;

(d) Precipitation or temperatures below 40 °F are not anticipated for at least 24 hours after application; and

(e) Sustained winds are less than or equal to 10 miles per hour.

406.06 Asphalt Application. Dilute the emulsion one part water to one part emulsified asphalt.

Apply the emulsion uniformly according to Subsection 407.09. Submit a proposed application rate for approval. Refer to AASHTO R 105 for guidance.

At locations where the fog seal cannot be applied with an asphalt distributor spray bar, apply the fog seal uniformly using a hand spray attachment or by another approved method.

Do not allow traffic on the fog seal until it is completely cured or substantially tack free.

Cover unabsorbed asphalt with blotter to protect traffic or minimize precipitation damage. Remove excess blotter after the asphalt is absorbed. Dispose of material according to Subsection 203.07.

406.07 Acceptance. See Table 406-1 for sampling, testing, and acceptance requirements.

Blotter will be evaluated under Subsection 106.03.

Emulsified asphalt will be evaluated under Subsections 106.02 and 106.03. Provide a production certification with each load of emulsified asphalt.

Construction of fog seals will be evaluated under Subsections 106.02 and 106.04.

Measurement

406.08 Measure the Section 406 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure fog seal including water added for dilution. Show a breakdown of total emulsion and water added on the load invoices provided to the CO.

Do not measure fog seal placed on newly patched areas during chip seal work.

Payment

406.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 406 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 406-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Emulsified asphalt (702.02)	Process control (153.03)	Placement temperature	–	–	1 per distributor truck minimum	Distributor truck	No	Before incorporating into work	–

Section 407. — CHIP SEAL

Description

407.01 This work consists of applying a single or double course chip seal.

Material

407.02 Conform to the following Subsections:

Asphalt binder	702.01
Blotter	703.12
Chip seal aggregate	703.09
Emulsified asphalt	702.02

Construction Requirements

407.03 Qualifications. At least 14 days before starting chip seal work, submit a résumé for the foreperson describing experience on at least five chip seal projects of similar complexity for approval.

407.04 Composition. Submit the following for approval at least 30 days before placement:

(a) Aggregate samples. 80 pounds from the material produced for the project, the gradation range represented, and the proposed target value for each sieve size;

(b) Asphalt sample. 1-gallon sample with test results from the manufacturer according to AASHTO M 316;

(c) Spread rates. The proposed spread rate for the asphalt and aggregate; and

(d) Density. The density of the aggregate according to AASHTO T 19, shoveling procedure.

407.05 Equipment. Provide equipment conforming to the following:

(a) Asphalt distributor. Conform to Subsection 406.03. Maintain two-way radio communication with the aggregate spreader.

(b) Sweeper. Provide two sweepers conforming to Subsection 409.05(d).

(c) Pneumatic-tire rollers.

(1) Three rollers each with a minimum compacting width of 5 feet or two rollers each with a minimum compacting width of 6.5 feet; and

(2) Gross mass adjustable within the range of 200 to 360 pounds per inch of compaction width.

(d) Aggregate spreader. Controls to uniformly deposit aggregate over the full asphalt width.

407.06 Surface Preparation. Conform to Subsection 406.04(a). Prepare the surface as follows:

(a) Newly asphalt patched areas. Fog seal according to Section 406.

(b) Existing asphalt surfaces including recycled asphalt pavements. Dry the surface.

(c) Aggregate base course surfaces.

(1) If using an emulsified asphalt, make the surface damp.

(2) If using an asphalt binder, dry the surface.

407.07 Weather Limitations. Apply chip seals only when the following apply:

(a) Ambient air temperature is above 65 °F;

(b) Surface temperature in the shade is above 60 °F;

(c) Surface temperature in the sun is below 150 °F;

(d) Weather is not foggy;

(e) Precipitation or temperatures below 40 °F are not anticipated for at least 24 hours after application;

(f) Sustained winds are less than or equal to 10 miles per hour; and

(g) Application is completed at least 2 hours before sunset.

407.08 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-chip seal preparatory phase meeting according to Subsection 153.06(a) at least 3 days before the start of chip seal operations.

(b) Control strip. On the first day of each chip seal layer placement, construct up to three 200- to 500-foot control strips that are one-lane wide according to Subsections 407.09 and 407.10. Coordinate the control strip locations with the CO. Start the first control strip at the proposed application rates. Vary the asphalt material or surface aggregate application rate for each control strip. Construct the control strip using the material, lay-down procedures, and compaction procedures intended for the entire project.

Repeat the control strip process until an acceptable control strip is produced. Cease production until the material and the control strip are evaluated and accepted. The CO will indicate which strip will serve as the accepted project control strip.

Accepted control strips may remain in place and will be accepted as a part of the completed project. Correct rejected control strips.

Use these start-up procedures if changing construction procedures, if resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the starting of a new construction season.

407.09 Asphalt Application. Calibrate asphalt distributors before the start of the project and if directed. Calibrate the spray bar height, check nozzle angle, and verify longitudinal and transverse application rates according to ASTM D2995.

Spread building paper on the pavement surface at the start and end of each asphalt application so distributor flow is started and stopped on the paper.

Apply asphalt uniformly at the optimum application rate determined from the control strip. Do not apply more asphalt than can immediately be covered with aggregate. Correct skipped areas or deficiencies.

Submit documentation of calibrations and application rates at the end of each day's production.

Remove and dispose of material spills and associated debris at the end of each shift according to Subsections 203.05 and 203.07.

407.10 Aggregate Application. If emulsified asphalt is used, verify the aggregate stockpile moisture daily and use moist surfaced aggregate.

If asphalt binder is used, dry the aggregate. Precoat the aggregate uniformly with 2 to 3 percent of residual asphalt by mass of aggregate. Maintain the flow qualities of the precoated aggregate to allow uniform spreading with the aggregate spreader.

Calibrate aggregate spreaders before the start of project if directed. Calibrate the longitudinal and transverse spread rates.

Apply aggregate uniformly at the optimum application rate determined from the accepted control strip. Apply the aggregate immediately after the asphalt material is applied. Operate the aggregate spreader so asphalt is covered with the aggregate before wheels pass over it. For part-width construction, leave an uncovered 6-inch-wide asphalt strip to allow an overlap of asphalt material.

Cover excess asphalt with blotter.

Correct excesses and deficiencies by adding or removing aggregate to achieve a uniform texture before the asphalt cures.

Operate rollers at a maximum speed of 5 miles per hour. Do not allow the aggregate to be displaced by pickup or sticking of material to the tire surface. Roll the surface to bond the aggregate uniformly and thoroughly over the full width. Complete rolling within 1 hour after asphalt is applied to the surface. Perform three passes with the rollers. Do not allow traffic to travel over aggregate until rolling is completed and if used, the fog seal has cured.

Submit documentation for calibrations and application rates at the end of each day's production.

Use a pilot car according to Section 635 to limit traffic speeds to 10 miles per hour for at least the first 45 minutes after rolling. Limit speeds to 20 miles per hour for the next 24 hours.

Vacuum sweep the surface when the air temperature is below 90 °F. Do not displace embedded material. Lightly vacuum sweep the roadway surface within 24 hours of aggregate application. Vacuum sweep the roadway surface within 48 hours after aggregate application to remove excess aggregate from the roadway surface unless otherwise approved. Hand broom in select locations if directed. Dispose of material according to Subsection 203.07.

407.11 Placing and Finishing. Apply the asphalt and aggregate according to Subsections 407.09 and 407.10, and Table 407-1. The application rates in these tables are for estimating purposes only. Determine the exact rates based on accepted control strips.

Within 7 days of completing the chip seal, apply a fog seal according to Section 406.

Table 407-1
Approximate Quantities of Material for Single Course Chip Seal

Type	Nominal Maximum Size of Aggregate	Aggregate Gradation(1)	Estimated Quantity of Aggregate, pounds per square yard(2)	Estimated Quantity of Asphalt Binder, gallons per square yard	Estimated Quantity of Emulsified Asphalt, gallons per square yard
1A	¾ in	A	44 to 53	0.31 to 0.42	0.48 to 0.65
1B	½ in	B	29 to 33	0.25 to 0.34	0.39 to 0.53
1C	⅜ in	C	24 to 28	0.18 to 0.28	0.27 to 0.43
1D	No. 4	D	18 to 24	0.14 to 0.19	0.27 to 0.43

(1) See Table 703-5 for aggregate gradations.
(2) Aggregate masses are for aggregates having a bulk specific gravity of 2.65, as determined by AASHTO T 84 and AASHTO T 85. Make proportionate corrections if the aggregate provided has a bulk specific gravity above 2.75 or below 2.55.

407.12 Double Course Chip Seal. Apply each asphalt and aggregate layer according to Subsections 407.09 and 407.10, and Table 407-2. Table 407-2 application rates are for estimating purposes only. Determine the exact rates based on accepted control strips.

If using emulsified asphalt, wait at least 24 hours between applications. If using asphalt binder, no wait is required between applications. Lightly vacuum sweep the first layer to remove loose material.

Within 7 days of completing the double course chip seal, apply a fog seal according to Section 406.

Table 407-2
Approximate Quantities of Material for Double Course Chip Seal

Type (Thickness)	Nominal Maximum Size of Aggregate	Aggregate Gradation(1)	Estimated Quantity of Aggregate, pounds per square yard(2)	Estimated Quantity of Asphalt Binder, gallons per square yard	Estimated Quantity of Emulsified Asphalt, gallons per square yard
2A (⅞ inch)					
1st Application	¾ in	A	44 to 53	0.29 to 0.41	0.43 to 0.60
2nd Application	⅜ in	C	24 to 29	0.41 to 0.46	0.60 to 0.70
2B (¾ inch)					
1st Application	½ in	B	33 to 44	0.27 to 0.31	0.39 to 0.48
2nd Application	⅜ in	C	22 to 26	0.29 to 0.38	0.45 to 0.58
2C (½ inch)					
1st Application	⅜ in	C	29 to 39	0.17 to 0.27	0.27 to 0.39
2nd Application	No. 4	D	13 to 18	0.27 to 0.31	0.39 to 0.48

(1) See Table 703-5 for aggregate gradations.
(2) Aggregate masses are for aggregates having a bulk specific gravity of 2.65, as determined by AASHTO T 84 and AASHTO T 85. Make proportionate corrections if the aggregate provided has a bulk specific gravity above 2.75 or below 2.55.

407.13 Acceptance. See Table 407-3 for sampling, testing, and acceptance requirements.

Emulsified asphalt and asphalt binder will be evaluated under Subsections 106.03 and 106.04. Provide a production certification with each load of emulsified asphalt or asphalt binder.

Chip seal aggregate gradation will be evaluated under Subsection 106.05.

The upper and lower specification limits are equal to the calculated mean of all test results plus or minus the allowable deviations shown in Tables 703-5 and 703-2, except as follows:

(a) If the calculated mean value for a tested sieve exceeds the maximum gradation range value shown in Table 703-5, then the upper specification is equal to the maximum gradation value in Table 703-5 plus or minus the allowable deviation in Table 703-2.

(b) If the calculated mean value for a tested sieve is less than the minimum gradation range value shown in Table 703-5, then the lower specification is equal to the minimum gradation value in Table 703-5 plus or minus the allowable deviation in Table 703-2.

Construction of asphalt chip seals will be evaluated under Subsections 106.02 and 106.04.

Fog seal will be evaluated under Section 406.

Measurement

407.14 Measure the Section 407 pay items listed in the bid schedule according to Subsection 109.02.

Payment

407.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 407 pay items listed in the bid schedule, except the chip seal contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for the chip seal will be made at a price determined by multiplying the contract price by the material pay factor. The material pay factor is the lowest single pay factor determined for each specified sieve of the aggregate gradation for each aggregate gradation provided.

If two gradations are provided for a double chip seal the material pay factor is weighted for the quantity of each aggregate gradation spread as a percent of the total. The material pay factor is calculated as follows:

$$PF_{Material} = PF_{1st}\left[\frac{SR_{1st}}{SR_{1st} + SR_{2nd}}\right] + PF_{2nd}\left[\frac{SR_{2nd}}{SR_{1st} + SR_{2nd}}\right]$$

where:

$PF_{Material}$ = Material pay factor.

PF_{1st} = Pay factor for first aggregate gradation. PF_{1st} is the lowest single pay factor determined for each specified sieve.

PF_{2nd} = Pay factor for second aggregate gradation. PF_{2nd} is the lowest single pay factor determined for each specified sieve.

SR_{1st} = Spread rate for the first aggregate per square yard.

SR_{2nd} = Spread rate for the second aggregate per square yard.

Table 407-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)[3]	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Chip seal aggregate[1] (703.09)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 703.09	1 per material type	Source of material	Yes	Before producing	–
	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required if using a pre-crushed commercial source
Blotter (703.12)	"	"	–	Subsection 703.12	"	"	"	"	–
Asphalt binder[2] (702.01) or emulsified asphalt[2] (702.02)	Measured & tested for conformance (106.04)	Quality	–	Section 702	1 per material type	Point of shipment or delivery	Yes[5]	Before incorporating into work	–

Table 407-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)[3]	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Chip seal aggregate[1] (703.09)	Statistical[3] (106.05)	Gradation (See Table 703-5 for applicable sieves)	I	AASHTO T 27 & T 11	[3]	Production belt or spreader discharge[4]	Yes	24 hours	–
	Process control (153.03)	Moisture on surface of aggregates	–	Visual inspection (407.10)	Contractor determined	Stockpile or spreader discharge	No	Before incorporating into work	–
Asphalt binder[2] (702.01) or emulsified asphalt[2] (702.02)	Measured & tested for conformance (106.04)	Quality	–	Section 702	1 per tanker truck including trailer	Tanker or Distributor	Yes[5]	–	Tested by Government
	Process control (153.03)	Placement temperature	–	–	1 per distributor truck minimum	Distributor truck	No	Before incorporating into work	–

(1) Applies to each aggregate grade provided.
(2) Applies to each asphalt material provided.
(3) For plan quantities less than 40,000 square yards, material will be accepted according to Subsection 106.03. For plan quantities equal to or greater than 40,000 square yards, material will be accepted according to Subsection 106.05. For plan quantities between 40,000 and 240,000 square yards, the sampling frequency will be determined by dividing the plan quantity by eight. If plan quantity exceeds 240,000 square yards, the sampling frequency will be one every 30,000 square yards.
(4) Select one point of sampling. Use the same point of sampling throughout project or lot.
(5) Two 1-quart samples for asphalt binder. One 1-gallon sample for emulsified asphalt.

Section 408. — ULTRATHIN BONDED WEARING COURSE

Description

408.01 This work consists of placing an ultrathin bonded wearing course (UTBWC).

Material

408.02 Conform to the following Subsections:

Antistrip additive	702.05
Asphalt binder	702.01
Polymer-modified emulsified asphalt membrane	702.02(e)
Ultrathin bonded wearing aggregate	703.18

Construction Requirements

408.03 Composition of Mix (Job-Mix Formula). Provide mixes of aggregate, asphalt binder, and antistrip additive that meet the aggregate gradation shown in Table 703-10 and design parameters shown in Table 408-1 at the proposed optimum binder content (OBC). Include additional design trial points that bracket the OBC with at least one point at 0.4 percent above and below the OBC. Test draindown and determine film thickness on these trial points. Do not propose an OBC less the 5.0 percent by total weight of mix.

Table 408-1
Ultrathin Bonded Wearing Course Requirements

Design Parameters	Test Method	Requirement
Film thickness, µm	Asphalt Institute MS-2 Table 8.1(1)	12.0 minimum
Drain down, %	AASHTO T 305(2)	0.10 maximum
Moisture susceptibility	AASHTO T 283(3)	0.70 minimum

(1) Film thickness is calculated based on effective asphalt content and determined as follows:

$$FT = \left(\frac{P_{be}}{SA \times G_b \times 1000}\right) \times 10^6$$

where:

FT = Film Thickness in µm

P_{be} = Effective asphalt content by total weight of mix according to Asphalt Institute, *MS-2 Asphalt Mix Design Methods, 7th edition*

SA = Estimated surface area of the aggregate blend in m^2/kg according to *MS-2 Asphalt Mix Design Methods, 7th edition*, Table 8.1

Gb = Specific gravity of asphalt binder

(2) Combine aggregate and asphalt binder at supplier's recommended mixing temperature. Return to the basket any coated aggregate that falls through the wire basket during loading and do not consider it as draindown.

(3) Make 4-inch diameter specimens with a compacted height of 2.5±0.05 inches. Compact specimens using methods according to AASHTO T 283. Use mixture and compaction temperatures recommended by the binder supplier.

(a) Recycled asphalt pavement use. Do not use RAP in the JMF.

(b) Submittals. Submit JMF at least 21 days before the control strip. Include the location of commercial mixing plants to be used and a separate JMF for each plant. Include a signed statement prepared by the testing laboratory that certifies the proposed JMF meets the requirements of the contract and can be placed in the field during production to meet contract requirements. For each JMF, submit the following:

(1) Aggregate.

(a) Designate target values within the gradation band specified for the aggregate grading shown in Table 703-10;

(b) Percent passing each sieve size for the aggregate blend;

(c) Source and percentage of each aggregate stockpile to be used;

(d) Average gradation of each aggregate stockpile from process control tests; and

(e) Results of aggregate quality tests. Include Los Angeles abrasion, sodium sulfate soundness, fractured faces, flat and elongated particles, sand equivalent, and specific gravity results from tests performed within 1 year of aggregate use.

(2) Asphalt binder.

(a) Target asphalt binder content by total weight of mixture;

(b) Recent test results from the supplier for the asphalt binder including a temperature-viscosity curve; and

(c) Laboratory mixing temperature range and laboratory compaction temperature range for the performance grade asphalt to be used in the mix.

(3) Antistrip additives. If part of the JMF:

(a) Name of product;

(b) Manufacturer; and

(c) Dosage rate.

(c) Changes and resubmissions. If a JMF is rejected or a material source is changed, submit a new JMF for approval. Allow 14 days for approval.

Do not start mix production until the JMF is approved.

408.04 Mixing Plant. Conform to Subsection 401.04.

408.05 Equipment.

(a) Pavers. Use pavers that are designed and built for applying the UTBWC. Provide a paver with the following:

(1) Self-propelled integrated distributor-paver with a receiving hopper, feed conveyor, insulated emulsion storage tank, spray bar, variable-width heated vibratory tamper bar screed, electronic device to determine rate of emulsion application, and variable width adjustment.

(2) Capable of applying polymer-modified emulsified asphalt membrane using a metered mechanical pressure spray bar at a temperature from 120 to 180 ºF. Capable of continuously monitoring the rate of spray and providing a uniform rate across the width of the paver.

(3) Capable of applying the UTBWC mix within 5 seconds of applying the polymer-modified emulsion.

(4) Capable of spreading and finishing the UTBWC mix to the required cross-section, grade, and at least 12 inches more than the required width and producing a uniformly finished surface without segregation, tearing, shoving, gouging, and other blemishes.

(5) Equipped with automatic screed controls with sensors that can sense grade from an outside reference line, sensing the transverse slope of the screed, and providing the automatic signals that operate the screed to maintain grade and transverse slope.

(6) Heated, vibratory, full-width feed auger screed extension.

(7) Operable at forward speeds consistent with satisfactory mix lay down.

(b) MTV. Conform to Subsection 401.05(b).

408.06 Surface Preparation. Thoroughly clean the existing surface of all loose material, dirt, and other deleterious substances by approved methods. Remove pavement markings. If needed, use pressurized water and vacuum systems to ensure a clean surface.

Protect stone masonry, manhole covers, drains, grates, catch basins, other utility structures, curb and gutter, sidewalks, and walls with plastic or building felt. Clearly mark protected and covered features that will be re-exposed.

Do not start placement of the UTBWC until patching according to Section 418 and crack filling according to Section 414 has been completed.

408.07 Weather Limitations. Place the UTBWC on a dry, unfrozen surface when the ambient air temperature in the shade is above 50 ºF and rising and the pavement surface temperature is above 50 ºF. Do not place UTBWC when temperatures below 32 °F are anticipated within 36 hours after application.

408.08 Preparing and Mixing Material. Conform to Subsections 401.08, 401.09, and 401.10.

408.09 Hauling. Conform to Subsection 401.11.

408.10 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-paving preparatory phase meeting according to Subsection 153.06(a) at least 3 days before the start of paving operations. Be prepared to discuss and provide the following:

(1) Proposed schedule of paving operations;

(2) List of all equipment (compaction, laydown, haul), and personnel used in the production and construction of the work;

(3) Proposed traffic control plan for paving operations including provisions for pavement drop-offs and moving operations;

(4) Procedures for constructing the control strip including placing, rolling, finishing, and roughness procedures;

(5) AASHTO T 308 asphalt binder and aggregate correction factors on Form FHWA 1640, *Worksheet for Ignition Furnace Binder Correction Factor* for each JMF;

(6) Proposed polymer-modified emulsified asphalt membrane application rate; and

(7) Proposed placement sequence and joint locations.

(b) Control strip. Provide at least 7 days' notice before starting production of an asphalt concrete mix.

Produce and place approximately 200 tons of mix to construct a control strip, one-lane wide, and at the designated lift thickness on the first day of production. Construct the control strip on the project at an approved location.

Construct the control strip using mix production, lay-down, and compaction procedures intended for the entire mix. Construct a control strip for each equipment combination and each plant from which production is intended. Stop production after construction of the control strip until the asphalt concrete mix and the control strip are evaluated and accepted.

Review the conditions of the existing pavement and propose a polymer-modified emulsified asphalt membrane application rate for approval 7 days before completing the control strip. It is estimated that the target application rate will be from 0.15 to 0.20 gallons per square yard. Evaluate and determine the application rate during the control strip. In coordination with the CO, adjust the application rate based on existing conditions and recommendations from the supplier.

Take and test at least three control strip UTBWC mix samples and evaluate according to Subsection 408.15 and Table 408-2.

Repeat the control strip process until an acceptable control strip is produced. Conform to Subsection 106.01 for the disposition of material in rejected control strips. Accepted control strips may remain in place and will be accepted and measured as a part of the completed pavement. After a control strip is accepted, full production may start.

Use start-up procedures if resuming production after a termination of production due to unsatisfactory quality.

408.11 Placing and Finishing. Do not use mixes produced from different plants unless the mixes are produced according to the same JMF, use material from the same sources, and are approved.

Apply the polymer-modified emulsified asphalt membrane at the rate approved in the control strip according to Subsection 407.08 and this Section. Apply the target application rate within a tolerance of ±0.02 gallons per square yard.

Do not allow wheels or other parts of the paving machine to come in contact with the polymer-modified emulsion membrane before the UTBWC mix is applied. Use a metered mechanical pressure spray bar at a temperature of 140 to 180 °F. Continuously monitor the rate of spray and provide a uniform application across the entire pavement width. Confirm the application rate of the polymer-modified emulsified asphalt membrane at least every 4 hours of production time by dividing the volume of polymer-modified emulsified asphalt membrane used by the area of paving for that timeframe.

Place the UTBWC mix at the temperature recommended in the JMF. Measure temperature of the mix in the hauling vehicle immediately before dumping into the MTV or measure it in the windrow immediately before pickup.

Place the UTBWC mix with a paver conforming to Subsection 408.05. Control horizontal alignment using a reference line. Automatically control the grade and slope from reference lines, a ski and slope control device, or dual skis. Use skis having a minimum length of 20 feet.

Place the UTBWC to the thickness shown in the plans. Measure thickness with a depth probe transversely across the mat in wheel paths and near centerline at least once every 500 feet. Submit certified weight tickets for the materials supplied.

Place the UTBWC mix as continuously as possible. Do not overlap or hot lap the asphalt. Pave through lanes after paving adjacent shoulders, tapers, driveways, road connections, turn pockets, and transitions. For UTBWC mix placed on the areas adjacent to through lanes, cut the hot asphalt as necessary to form neat, straight, vertical joints along the lane lines.

If polymer-modified emulsion membrane is spilled into the hopper of the paver, remove and dispose of the contaminated material according to Subsections 203.05 and 203.07.

In areas where mechanical spreading and finishing are impractical, place and finish the mix with alternate equipment to produce a uniform surface closely matching the surface obtained when using a mechanical paver.

Use an MTV on mainline construction if placing UTBWC mix. Suspend paving if the MTV malfunctions during paving operations. Do not resume mix placement until the MTV is operational.

408.12 Rolling. Provide at least two steel double drum asphalt rollers with a weight of at least 11 tons. Provide well maintained rollers with functioning water system and scrapers to prevent adhesion of the fresh mix onto the roller drums. A release agent (added to the water system) may be required to prevent adhesion of the fresh mix to the roller drums. Do not use diesel fuel as a release agent. Operate rollers according to the manufacturer’s recommendations.

Immediately after placing the UTBWC mix, make at least two passes with a double drum asphalt roller operated in the static mode. Complete compaction before the UTBWC mix temperature falls below 185 ºF. Do not allow the roller to remain stationary on the freshly placed UTBWC mix. Do not cause cracking, shoving, or undue displacement.

408.13 Joints, Trimming Edges, and Cleanup. Use butt joints for longitudinal and transverse joints. At connections to existing pavements and previously placed lifts, make the transverse joints vertical to the depth of the new pavement. Form transverse joints by cutting back the previous run to expose the full-depth course.

Dispose of material trimmed from the edges and any other discarded asphalt mix according to Subsection 203.07.

Protect the completed UTBWC from traffic until it has sufficiently hardened to resist abrasion, shoving, pickup, and raveling.

408.14 Pavement Straightedge Measurement. Use a 10-foot metal straightedge to measure at right angles and parallel to the centerline. Defective areas are surface deviations more than 0.25 inch, measured between any two contacts of the straightedge.

Correct defective areas. Obtain approval for the proposed method of correction.

408.15 Acceptance. See Table 408-2 for sampling and testing requirements and the acceptance quality characteristic category.

Antistrip additives will be evaluated under Subsections 106.02 and 106.03.

Asphalt binder and polymer-modified emulsified asphalt membranes will be evaluated under Subsections 106.03 and 106.04.

Construction of the UTBWC will be evaluated under Subsections 106.02 and 106.04.

Aggregate gradation and aggregate properties will be evaluated under Subsections 106.03 and 106.04.

Asphalt content will be evaluated under Subsection 106.04. The tolerance from the target for asphalt binder is ±0.5 percent.

Asphalt pavement crack filling will be evaluated under Section 418.

Asphalt pavement patching will be evaluated under Section 414.

Measurement

408.16 Measure the Section 408 pay items listed in the bid schedule according to Subsection 109.02.

Payment

408.17 The accepted quantities will be paid at the contract price per unit of measurement for the Section 408 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 408-2
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 703.18	1 per type & source of material	Source of materials	Yes	Before production	–
Asphalt binder	Measured & tested for conformance (106.04 & 105)	Quality	–	AASHTO M 320	1 per type & source of material	Asphalt supplier or mixing plant	Yes	Before production	–
Polymer-modified emulsified asphalt membrane	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 702.02(e)	1 per type & source of material	Membrane supplier	Yes	Before production	–
Mix Design									
UTBWC (mix design)	Measured & tested for conformance (106.04)	Gradation(2)	–	AASHTO T 11 & T 27	1 per each submitted mix design	Stockpiles	If requested	21 days before paving	–
		Film thickness	–	See Table 408-1	"	–	"	"	–
		Draindown	–	AASHTO T 305(3)	"	–	"	"	–
		Moisture susceptibility	–	AASHTO T 283(3)	"	–	"	"	–

Table 408-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (control strip)									
UTBWC	Measured & tested for conformance (106.04)	Gradation(2)	–	AASHTO T 30	3 minimum	Truck or paver hopper	Yes	24 hours	–
		Asphalt content(1)	–	AASHTO T 308	"	"	"	"	–
		Mix temperature	–	–	Each load & as directed	Hauling vehicle before dumping or windrow before pickup	–	As directed	–

Table 408-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
UTBWC	Measured & tested for conformance (106.04)	Gradation[(2)]	–	AASHTO T 30	1 per 300 tons	Truck or paver hopper	Yes	24 hours	–
		Asphalt content[(1)]	–	AASHTO T 308	"	"	"	"	–
		Mix temperature	–	–	Each load & as directed	Hauling vehicle before dumping or windrow before pickup	–	Upon completion of measurement	–
Polymer-modified emulsion membrane	"	Quality	–	Subsection 702.02(e)	1 per 700 tons of mix	Tanker or point of delivery	Yes	–	–
Asphalt binder	"	Quality	–	Subsection 702.01	1 per 700 tons of mix	In line between tank & mixing plant	Yes, tested by Government	Tested by Government	–

(1) Use AASHTO T 308, Method A. Calculate the asphalt binder content by weighing the sample before and after the burn using a calibrated external balance. Modify AASHTO T 308, parts 8.2 and 10.2 to allow the use of AASHTO T 255, Total Evaporable Moisture Content of Aggregate by Drying.
(2) Use only sieves indicated for the specified gradation.
(3) As modified by Table 408-1.

Section 409. — MICRO SURFACING

Description

409.01 This work consists of applying a polymer-modified micro surfacing mix on a pavement surface.

Material

409.02 Conform to the following Subsections:

Micro surfacing aggregate	703.10(b)
Mineral filler	725.05
Polymer-modified emulsified asphalt for micro surfacing	702.02(b)
Water for construction	725.01(c)

Construction Requirements

409.03 Qualifications. At least 14 days before starting micro surfacing work, submit a résumé for the foreperson describing experience on at least five micro surfacing projects of similar complexity for approval.

409.04 Composition of Mix (Job-Mix Formula). Submit a written JMF for micro surfacing which complies with ISSA A143, *Recommended Performance Guidelines for Micro Surfacing* for approval at least 14 days before production. Include the following:

(a) Aggregate gradation values. Percent passing for each sieve size for the aggregate blend;

(b) Emulsified asphalt content. Residual asphalt content, as a percent by mass of dry aggregate;

(c) Polymer-modifier. Type and quantity of polymer-modifier solids based on the residual asphalt content;

(d) Aggregate samples. 80-pound sample of each aggregate;

(e) Polymer-modified emulsified asphalt sample. 1-gallon sample with a production certification conforming to Subsection 106.03(b);

(f) Mineral filler samples. 10-pound sample of each proposed mineral filler; and

(g) Proposed application rate. Use ISSA A143 for guidance.

409.05 Equipment.

(a) Mixing and proportioning equipment. Conform to ISSA A143.

(b) Spreading equipment. Conform to ISSA A143.

(c) Secondary strike-off. Conform to ISSA A143.

(d) Sweeper. Provide a sweeper conforming to the following:

(1) Self-propelled;

(2) Vertical broom pressure control; and

(3) Vacuum capability.

(e) Pneumatic-tire rollers. Provide rollers conforming to the following:

(1) Self-propelled;

(2) 10-ton gross mass with a tire pressure of 50 pounds per square inch; and

(3) Water-spray system.

(f) Auxiliary equipment. Provide hand squeegees, shovels, and other equipment necessary to perform the work. Provide power brooms, air compressors, water flushing equipment, and hand brooms to clean the pavement surface.

Other equipment of proven performance may be used in addition to or instead of this equipment if approved.

409.06 Surface Preparation. Conform to Subsection 406.04(a).

409.07 Weather Limitations. Apply only when the following apply:

(a) Ambient air temperature is above 45 °F;

(b) Surface temperature in the shade is above 45 °F;

(c) Weather is not foggy or overcast; and

(d) Precipitation or temperatures below 32 °F are not anticipated for at least 24 hours after application.

409.08 Calibration. Calibrate mixing equipment according to ISSA A143. Submit calibration results before starting production.

409.09 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-surfacing preparatory phase meeting according to Subsection 153.06(a) at least 3 days before the start of surfacing operations.

(b) Control strip. On the first day of placement, construct one 300-foot-long control strip, one lane wide. Construct control strip on the project at an approved location. Construct the control strip using material, lay-down, and rolling procedures intended for the entire project. Start the control strip at the proposed application rate. Adjust the application rate for the surface conditions, if needed.

Cease production after construction of the control strip until the material and the control strip are evaluated and accepted. Repeat the control strip process until an acceptable control strip is produced.

Acceptable control strips may remain in place and will be accepted as a part of the completed surface treatment. Correct rejected control strips.

Use these start-up procedures if changing construction procedures, if resuming production after a termination of production due to unsatisfactory quality according to Subsection 106.04, or the starting of a new construction season.

409.10 Application. Fog the surface with water in front of the spreader.

Blend the additives with the aggregate. Pre-wet the aggregate in the pugmill before mixing with the polymer-modified emulsified asphalt.

Mix the surfacing material for no more than 4 minutes. Ensure the mix is of uniform consistency as it leaves the mixer and conforms to the approved JMF. Apply micro surfacing material at the application rate determined from the control strip. Adjust mineral filler and polymer-modified emulsified asphalt content during construction if approved to adjust for variations in field conditions.

Clean the spreader box before the start of each work shift.

Carry sufficient mix in the spreader to completely cover the surface. Spread the mix with a spreader box. In areas not accessible to the spreader, use hand squeegees to provide uniform coverage and match the finish of spreader.

Remove streaks and transverse ripples as defined by ISSA A143 from the finished surface.

Provide straight lines along curbs and shoulders and do not allow runoff onto these areas. Provide straight and neat starting and ending joints by masking surfaces. Mask surfaces to provide straight and neat longitudinal or transverse joints at required locations (such as intersections and irregular shaped areas).

For transverse joints, use a butt joint. Use building paper placed over previously placed micro surfacing or other suitable methods to avoid double placement of micro surfacing. Remove ridges or bumps in the finished surface.

For longitudinal joints, place joints on lane lines. Use half passes and odd-width passes only in turnouts and parking areas. Do not use half passes for the last pass in paved areas. Overlap longitudinal joints no more than 3 inches. Limit the elevation difference at joints to less than ¼ inch.

Start rolling after the mixture has cured to the point where it will not pick up on the roller tires. Roll parking areas and turnouts with at least two full-coverage passes with the roller. Rolling the mainline roadway is not required.

Allow treated areas to cure before opening to traffic. Cure is complete when clear water can be pressed out of the placed mix with a white piece of paper without discoloring the paper. Do not allow traffic in parking areas or pullouts for at least 48 hours after completing application.

Remove and dispose of material spills and associated debris at the end of each shift according to Subsections 203.05 and 203.07.

Two weeks to one month after completion of micro surfacing application and before placing permanent pavement markings, sweep the entire treated surface. Dispose of swept material according to Subsection 203.07.

409.11 Acceptance. See Table 409-1 for sampling, testing, and acceptance requirements.

Micro surfacing aggregate will be evaluated under Subsections 106.02 and 106.04.

Mineral filler will be evaluated under Subsections 106.02 and 106.03.

Polymer-modified emulsified asphalt will be evaluated under Subsections 106.03 and 106.04. Provide a production certification with each load of polymer-modified emulsified asphalt.

Construction of the micro surfacing will be evaluated under Subsections 106.02 and 106.04.

Measurement

409.12 Measure the Section 409 pay items listed in the bid schedule according to Subsection 109.02.

Payment

409.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 409 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 409-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Micro surfacing aggregate for surface mixture(1)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 703.10	1 per material type	Source of material	Yes	Before producing	–
	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required if using a pre-crushed commercial source
Polymer-modified emulsified asphalt(2)	Measured & tested for conformance (106.04)	Quality	–	Subsection 702.02(b)	1 per material type	Emulsified asphalt supplier	Yes, 2 1-quart samples	Before incorporating into work	–

Table 409-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Micro surfacing aggregate for surface mixture(1)	Measured & tested for conformance (106.04)	Gradation (See Table 703-6 for applicable sieves)	–	AASHTO T 27 & T 11	1 per 10,000 yd^2	Stockpile	Yes	24 hours	–
Polymer-modified emulsified asphalt(2)	Measured & tested for conformance (106.04)	Quality	–	Subsection 702.02(b)	1 per day	Mixing equipment or point of delivery	Yes, 2 1-quart samples	–	Tested by Government
	Process control (153.03)	Placement temperature	–	–	Daily at start-up & Contractor determined thereafter	Mixing equipment	No	Before incorporating into work	–

(1) Applies to each aggregate grade provided.
(2) Applies to each asphalt material provided.

Section 410. — SLURRY SEAL

Description

410.01 This work consists of applying an emulsified asphalt slurry seal mix on a pavement surface.

Material

410.02 Conform to the following Subsections:

Emulsified asphalt	702.02
Mineral filler	725.05
Slurry seal aggregate	703.10(a)
Water for construction	725.01(c)

Construction Requirements

410.03 Qualifications. Submit a résumé for the foreperson describing experience on at least five slurry seal projects of similar complexity for approval at least 14 days before starting slurry seal work.

410.04 Composition of Mix (Job-Mix Formula). Submit a written JMF for asphalt slurry seal that conforms to ISSA A105, *Recommended Performance Guideline for Emulsified Asphalt Slurry Seal* for approval at least 30 days before production. Include the following:

(a) Aggregate gradation values. Percent passing for each sieve size for the aggregate blend;

(b) Emulsified asphalt content. Residual asphalt content, as a percent by mass of dry aggregate;

(c) Aggregate samples. 80-pound sample of each aggregate;

(d) Emulsified asphalt sample. 1-gallon sample with a production certification conforming to Subsection 106.03(b); and

(e) Mineral filler samples. 10-pound sample of each proposed mineral filler.

410.05 Equipment.

(a) Mixing and proportioning equipment. Conform to ISSA A105.

(b) Spreading equipment. Conform to ISSA A105.

(c) Sweeper. Conform to Subsection 409.05(d).

(d) Pneumatic-tire rollers. Conform to Subsection 409.05(e).

(e) Auxiliary equipment. Conform to Subsection 409.05(f).

Other equipment of proven performance may be used in addition to or instead of this equipment if approved.

410.06 Surface Preparation. Conform to Subsection 406.04(a).

410.07 Weather Limitations. Conform to Subsection 409.07.

410.08 Calibration. Calibrate each mixing unit according to ISSA A105. Submit calibration results before starting production.

410.09 Production Start-Up Procedures. Conform to Subsection 409.09.

410.10 Application. Mix the material according to ISSA A105. Fog the surface with water in front of the spreader.

Blend the additives with the aggregate. Pre-wet the aggregate in the pugmill before mixing with the emulsified asphalt.

Mix the surfacing material no more than 4 minutes. Ensure the mix is of uniform consistency as it leaves the mixer and conforms to the approved JMF. Apply surfacing material at the application rate determined from the control strip. Adjust mineral filler and emulsified asphalt content during construction if approved to adjust for variations in field conditions.

Clean the spreader box before the start of each work shift.

Carry sufficient mix in the spreader to completely cover the surface. Spread the mix with a spreader box. In areas not accessible to the spreader box, use hand squeegees to provide uniform coverage and match the finish of spreader.

Remove streaks and transverse ripples as defined by ISSA A105 from the finished surface.

Provide straight lines along curbs and shoulders and do not allow runoff on these areas. Provide straight and neat starting and ending joints by masking surfaces. Mask surfaces to provide straight and neat longitudinal or transverse joints at required locations (such as intersections and irregular shaped areas).

For transverse joints, use a butt joint. Use building paper placed over previously placed slurry seal or other suitable methods to avoid double placement of slurry seal. Remove ridges or bumps in the finished surface.

For longitudinal joints, place joints on lane lines. Use half passes and odd-width passes only in turnouts and parking areas. Do not use half passes for the last pass in paved areas. Overlap longitudinal joints no more than 3 inches. Limit the elevation difference at joints to less than ¼ inch.

Start rolling after the mixture has cured to the point where it will not pick up on the roller tires. Roll parking areas and turnouts with at least two full-coverage passes with the roller. Rolling the mainline roadway is not required.

Allow treated areas to cure before opening to traffic. Cure is complete when clear water can be pressed out of the mix with a white piece of paper without discoloring the paper. Do not allow traffic in parking areas or pullouts for at least 48 hours after completing application.

Remove and dispose of material spills and associated debris at the end of each shift according to Subsections 203.05 and 203.07.

Two weeks to one month after completion of slurry seal application and before placing permanent pavement markings, sweep the entire treated surface. Dispose of swept material according to Subsection 203.07.

410.11 Acceptance. See Table 410-1 for sampling, testing, and acceptance requirements.

Emulsified asphalt will be evaluated under Subsections 106.03 and 106.04. Provide a production certification with each load of emulsified asphalt.

Mineral filler will be evaluated under Subsections 106.02 and 106.03.

Slurry seal aggregate will be evaluated under Subsections 106.02 and 106.04.

Construction of the slurry seal will be evaluated under Subsections 106.02 and 106.04.

Measurement

410.12 Measure the Section 410 pay items listed in the bid schedule according to Subsection 109.02.

Payment

410.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 410 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 410-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate for surface mixture(1)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 703.10	1 per material type	Source of material	Yes	Before producing	–
	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	2 per day per stockpile	Crusher belt (during production)	No	24 hours	Not required if using a pre-crushed commercial source
Emulsified asphalt(2)	Measured & tested for conformance (106.04)	Quality	–	Subsection 702.02	1 per material type	Emulsified asphalt supplier	Yes, 2 1-quart samples	Before incorporating into work	–

Table 410-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Aggregate for surface mixture[(1)]	Measured & tested for conformance (106.04)	Gradation. See Table 703-6 for applicable sieves	–	AASHTO T 27 & T 11	1 per 10,000 yd^2	Stockpile	Yes	24 hours	–
Emulsified asphalt[(2)]	"	Quality	–	Subsection 702.02	1 per day	Mixing equipment or point of delivery	Yes, 2 1-quart samples	–	Tested by Government
	Process control (153.03)	Placement temperature	–	–	Daily at start-up & Contractor determined thereafter	Mixing equipment	No	Before incorporating into work	–

(1) Applies to each aggregate grade provided.
(2) Applies to each asphalt material provided.

Section 411. — ASPHALT PRIME COAT

Description

411.01 This work consists of applying an asphalt prime coat on a prepared surface.

Material

411.02 Conform to the following Subsections:

Blotter	703.12
Crushed aggregate	703.06
Emulsified asphalt	702.02
Water for construction	725.01(c)

Construction Requirements

411.03 Equipment. Provide equipment conforming to Subsection 407.05.

411.04 Surface Preparation. If applying an asphalt prime coat to an aggregate surface, prepare the surface to be primed according to Subsection 301.06. If required, use sweeping or other approved methods to remove loose dust and fine material and lightly spray the surface with water. Protect manholes, valve covers, curb and gutter, and other adjacent facilities from damage or overspray.

411.05 Weather Limitations. Apply asphalt prime coat when the following apply:

(a) Surface is dry or slightly damp;

(b) Ambient air temperature is above 50 °F and rising;

(c) Surface temperature in the shade is above 50 °F and rising;

(d) Weather is not foggy; and

(e) Precipitation is not anticipated for at least 24 hours after completing the application.

411.06 Asphalt Prime Coat Application. Apply asphalt prime coat according to Subsection 407.09. If no application method is designated, use Method 1.

(a) Method 1 – topical. Dampen the surface with water before applying asphalt prime coat. Apply undiluted emulsified asphalt formulated as a penetrating prime coat uniformly at a rate of 0.10 to 0.30 gallons per square yard. Obtain approval of the exact application rate.

(b) Method 2 – inverted prime. Apply asphalt prime coat at a uniform rate of 0.20 to 0.30 gallons per square yard. Immediately apply crushed aggregate at a uniform rate of 20 to 25 pounds per square yard using an aggregate spreader. Obtain approval of the application rates for asphalt prime coat and aggregate.

Do not allow the wheels of the aggregate spreader to come in contact with the emulsified asphalt. Immediately seat the aggregate using a roller. Operate rollers at a maximum speed of 5 miles per hour.

411.07 Curing. Cure asphalt prime coat for at least 24 hours before allowing traffic or placing the covering course.

411.08 Maintenance. Maintain the primed surface by keeping it free of corrugations, potholing, and loose material until placing the covering course. If damaged, repair damaged areas and reapply asphalt prime coat.

Spread blotter to cover unabsorbed emulsified asphalt. Remove excess blotter after the emulsified asphalt is absorbed.

411.09 Acceptance. See Table 411-1 for sampling, testing, and acceptance requirements.

Crushed aggregate and blotter will be evaluated under Subsection 106.03.

Emulsified asphalt will be evaluated under Subsections 106.02 and 106.03.

Construction of the prime coat will be evaluated under Subsections 106.02 and 106.04.

Measurement

411.10 Measure the Section 411 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring prime coat by the square yard, measure the length along the centerline of the roadway. Include treated widened areas when measuring the width.

Payment

411.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 411 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 411-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Emulsified asphalt (702.02)	Process control (153.03)	Placement temperature	–	–	1 per distributor truck minimum	Distributor truck	No	Before incorporating into work	–
Prime coat (411.06)	Process control (153.03)	Application rate & daily yield	–	–	1 per day minimum	Contractor determined	No	End of shift	–

Section 412. — ASPHALT TACK COAT

Description

412.01 This work consists of applying an emulsified asphalt tack coat on a prepared surface.

Material

412.02 Conform to the following Subsections:

Emulsified asphalt	702.02
Water for construction	725.01(c)

Construction Requirements

412.03 General. Use equipment conforming to Subsection 407.05.

Current state approved tack coat material may be used if approved. Submit proof of compliance with state specifications.

412.04 Surface Preparation. Clean the existing surface of loose material, dirt, or other deleterious material by approved methods. If the surface is concrete, remove excess joint and crack filler material. Remove all pavement markings except waterborne or solvent borne traffic paint by approved methods. Protect manholes, valve covers, curb and gutter, and other adjacent facilities from damage or overspray.

412.05 Weather Limitations. Apply asphalt tack only when the following apply:

(a) Surface is dry and unfrozen;

(b) Ambient air temperature is above 35 °F and rising;

(c) Precipitation is not anticipated before the emulsified asphalt breaks; and

(d) Weather is not foggy.

412.06 Application. If using slow-setting emulsified asphalt, dilute by adding an equal quantity of water to the emulsified asphalt.

Apply the asphalt tack coat according to Subsection 407.09. Use AASHTO R 112 to determine application rates. Provide the CO with the target application rate for approval.

Set distributor spray bar height to ensure uniform coverage and at least a double overlap, but no more than triple overlap coverage. Set nozzle angle settings between 15 and 30 degrees from the center of the spray bar axis. Use the same size nozzles with all set at the same angle and open.

Apply the asphalt tack coat uniformly and completely by fogging with a hand spray attachment or by other approved methods if application with a distributor spray bar is not practical.

Squeegee the excess emulsified asphalt from the surface and dispose of according to Subsection 203.07. Allow the tacked surfaces to completely break before placing the covering course. Place the covering course within 4 hours of placing the asphalt tack coat.

412.07 Acceptance. See Table 412-1 for sampling, testing, and acceptance requirements.

Emulsified asphalt will be evaluated under Subsections 106.02 and 106.03.

Construction of the tack coat will be evaluated under Subsections 106.02 and 106.04.

Measurement

412.08 Measure the Section 412 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure asphalt tack coat including water added for dilution. Indicate a breakdown of total emulsion and water added on the load invoices provided to the CO.

Do not measure asphalt tack coat used for asphalt concrete pavement patching.

Payment

412.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 412 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 412-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Emulsified asphalt (702.02)	Process control (153.03)	Placement temperature	–	–	1 per distributor truck minimum	Distributor truck	No	Before incorporating into work	–
Tack coat (412.06)	"	Application rate & daily yield	–	–	1 per day minimum	Contractor determined	No	End of shift	–

Section 413. — ASPHALT PAVEMENT MILLING

Description

413.01 This work consists of removing asphalt pavement and base by a cold milling process.

Construction Requirements

413.02 Equipment.

(a) Milling machine. Provide a milling machine conforming to the following:

(1) Self-propelled;

(2) Sufficient power, traction, and stability to remove the required pavement thickness and to accurately maintain depth of cut;

(3) Automatic system to control grade elevations by referencing from the existing pavement with a ski, matching shoe, or from an independent grade control;

(4) Automatic system to maintain profile and cross slope;

(5) System to effectively limit dust and other particulate matter from escaping removal operations;

(6) Loading system or adequate support equipment to completely recover milled material at removal rate; and

(7) Cutting width equal to at least one-third of the lane width.

(b) Micro milling machine. When required, provide a micro milling machine conforming to the following:

(1) Conforms to the requirements of Subsection 413.02(a);

(2) Cutting drum with ¼ inch or less impact spacing between teeth; and

(3) Machine elevation control accurate to within $^{1}/_{16}$ inch.

(c) Sweeper. Provide a sweeper conforming to the following:

(1) Self-propelled;

(2) Vertical broom pressure control; and

(3) Vacuuming system to remove and collect debris and water.

413.03 General. Uniformly mill using a longitudinal reference to accurately guide the machine (such as a curb, edge of pavement, or string attached to the pavement surface).

Mill the transverse slope to within ¼ inch in 10 feet of the required slope. Transition from one transverse slope to another at a uniform rate. Uniformly mill the entire roadway lane width so the cross-section of the new surface forms a straight line.

Transition between different depths of cut at a uniform rate of ½ inch of depth per 10 feet. At the start and end of the milling work, construct a smooth transition to the original surface at this rate. Do not leave an exposed vertical edge perpendicular to the direction of travel. If the pavement remains open to traffic, limit differences in elevation between adjacent lanes to less than 3 inches or sign with "*Uneven Lanes*" warning signs and provide a 1V:3H fillet. Use a sweeper immediately behind the milling operations to remove and recover loose material. Minimize the escape of dust into the air by misting. Dispose of recovered milled material according to Subsection 203.07 unless required for use in Section 309 or 315.

Measure the milled surface using a 10-foot metal straightedge at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge more than ¼ inch measured between two contacts of the straightedge or deviations more than ¼ inch measured at the end of the straightedge. Submit a proposal to correct defective areas for approval.

Before opening to traffic, patch defects in milled surface as approved.

413.04 Micro milling. Limit travel speed to two-thirds of the cutting drum rotation speed.

413.05 Acceptance. Asphalt pavement milling will be evaluated under Subsections 106.02 and 106.04.

Measurement

413.06 Measure the Section 413 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring asphalt pavement milling by the square yard, measure the length horizontally along the centerline of the roadway.

Payment

413.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 413 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 414. — ASPHALT PAVEMENT CRACK AND JOINT SEALING AND FILLING

Description

414.01 This work consists of sealing and filling cracks and joints in asphalt pavement surfaces.

Material

414.02 Conform to the following Subsections:

Hot-applied asphalt aggregate-filled mastic	702.03
Joint sealants and crack fillers	712.01(a)

Construction Requirements

414.03 General. Complete crack and joint sealing and filling in a continuous operation.

Prevent debris from entering waterways, travel lanes open to public traffic, or areas designated not to be disturbed. Remove dirt, dust, vegetation, and other deleterious material from the crack and joint walls and cavity using a stream of air or other approved methods. Blow or brush dry material off the pavement surface.

414.04 Equipment. Provide equipment conforming to the following:

(a) Router. A power rotary impact router or vertical spindle router that can create a reservoir to the required depth and width without damaging adjacent pavement.

(b) Hot air lance. A hot compressed air lance that can provide clean, oil-free compressed air at a volume of 100 cubic feet per minute, a pressure of 120 pounds per square inch, and a temperature of 2000 °F.

(c) Application wand. A wand attached to a heated hose attached to a heated material chamber that maintains material temperature within the manufacturer's tolerances. Provide proper wand tips for desired application.

(d) Heating kettle. An indirect-heating double boiler that can provide constant and effective agitation. Fill the space between the inner and outer shells with oil or other heat transfer medium. Provide an accurate and calibrated thermometer with a range from 200 to 600 °F in 5 °F graduations located so the material temperature can be safely checked.

(e) Squeegee or screed. A hand-held squeegee or screed of appropriate configuration for filling cracks and joints flush with the surface, underfilling cracks and joints to recess below the surface, or overfilling cracks and joints to an overband shape.

(f) Compressor. A compressor that can produce oil- and water-free air at a rate of at least 100 cubic feet per minute with a continuous line pressure of at least 125 pounds per square inch.

414.05 Routing. Rout ⅛- to ½-inch wide cracks to produce vertical, intact walls and a flat bottom with a reservoir centered over the crack. Make the reservoir two to three times the width of the crack. Rout cracks to a depth of ½ to ¾ inch.

Do not allow traffic to damage routed cracks.

414.06 Sealing and Filling. Do not seal or fill cracks and joints when the pavement surface temperature is below 35 °F or weather conditions include precipitation or fog. Dry the crack and joint surfaces with a hot air lance before sealing or filling. Keep the hot air lance moving to prevent burning the pavement surface. Place and finish the material within 5 minutes after heating the pavement surface with the hot air lance.

(a) Sealing (routed cracks and cracks or joints averaging ¼ to 1 inch wide). Submit a copy of and follow the manufacturer's recommendations for heating and applying the hot applied crack material. Heat the material to pouring temperature in a heating kettle and continuously agitate the material.

Discard sealant if:

(1) Heated above the safe heating temperature recommended by the manufacturer;

(2) Held at pouring temperature for more than 12 hours;

(3) Reheated more than once;

(4) Not consistent or uniform in appearance; or

(5) Recommended by the manufacturer.

Use an application wand to place material in each crack and joint from the bottom up. Insulate the wand to maintain pouring temperature while placing material. Return the wand to the heating kettle immediately after sealing each crack. Use a squeegee or screed to strike off the material.

Seal joints between the pavement and curb and gutters.

(b) Filling (cracks averaging more than 1 inch wide). Fill each crack with an asphalt mastic according to the manufacturer's recommendations or asphalt mix according to Section 403, Type II. Use a squeegee, screed, or other suitable equipment to force the mix into the crack. Fill each crack flush with the pavement surface and compact the asphalt mixture.

Do not allow traffic on sealed or filled cracks until the sealant or filler has cured or is treated with an approved debonding material recommended by the manufacturer.

414.07 Resealing Cracks and Joints. Reseal cracks and joints exhibiting adhesion failure, damage, incomplete filling, or foreign objects in the sealant.

414.08 Acceptance. Material for asphalt pavement crack and joint sealing and filling will be evaluated under Subsections 106.02 and 106.03.

Asphalt pavement crack and joint sealing and filling will be evaluated under Subsections 106.02 and 106.04.

Measurement

414.09 Measure the Section 414 pay items listed in the bid schedule according to Subsection 109.02.

Payment

414.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 414 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 415. — PAVING GEOTEXTILES

Description

415.01 This work consists of installing paving geotextile and asphalt binder between pavement lifts.

Material

415.02 Conform to the following Subsections:

Asphalt binder	702.01
Blotter	703.12
Paving geotextile	714.01(d)

Construction Requirements

415.03 Submittals. At least 14 days before starting paving geotextile installation, submit the following according to Subsection 104.06:

(a) A production certification for the geotextile;

(b) An 18- by 18-inch sample from beyond the first outer wrap of the roll. Label the sample with the lot and batch number, date of sampling, project number, item number, manufacturer, and product name;

(c) The manufacturer's recommended asphalt binder application rate based on field conditions and geotextile asphalt retention properties; and

(d) A plan of operations for installing the geotextile.

415.04 General. Identify, store, and handle geotextile according to ASTM D4873 and the manufacturer's recommendations. Limit exposure to ultraviolet radiation to less than 2 days.

415.05 Surface Preparation. Clean the existing surface of loose material, dirt, or other deleterious material by approved methods.

415.06 Weather Limitations. Apply asphalt binder and paving geotextile when the following apply:

(a) Surface is dry and unfrozen; and

(b) Surface temperature is above 55 °F and rising.

415.07 Asphalt Binder Application. Apply asphalt binder to the pavement surface according to Subsection 407.09 at 290 to 325 °F.

Spray the asphalt binder 6 inches wider than the paving geotextile. Do not apply the asphalt binder further than the temporary traffic control zone for this work.

Use the same asphalt binder grade as required in the approved JMF.

415.08 Paving Geotextile Placement. Before the asphalt binder cools and loses tackiness, place the paving geotextile smoothly and with minimal wrinkling onto the binder. Use equipment designed to hold the roll and lay down the paving geotextile. Provide uniform tension and broom the geotextile smooth during placement. Slit, lay flat, and tack wrinkles or folds higher than 1 inch. Cut to remove folds that result in three or more layers of geotextile. Broom and roll the paving geotextile to maximize fabric contact with the pavement surface.

Overlap the geotextile 6 inches at longitudinal joints to ensure full closure. Do not overlap transverse joints. Butt adjacent geotextile ends together at transverse joints. Apply additional asphalt binder to paving geotextile overlaps to ensure proper bonding of the double fabric layer.

If asphalt binder bleeds through the fabric, treat the affected areas with blotter according to Section 411.

Broom the excess blotter from the geotextile surface before placing the overlay. Do not turn equipment on the geotextile. Repair damaged fabric before placing overlay.

Limit the lay-down temperature of the asphalt concrete overlay to no more than 300 °F.

415.09 Acceptance. Asphalt binder will be evaluated under Subsection 106.03.

Material for paving geotextiles will be evaluated under Subsections 106.02 and 106.03. Provide a production certification with each shipment of geotextile. Include the name of the manufacturer, product name, and style number.

Installation of the paving geotextile will be evaluated under Subsections 106.02 and 106.04.

Blotter will be evaluated under Section 411.

Measurement

415.10 Measure the Section 415 pay items listed in the bid schedule according to Subsection 109.02.

Payment

415.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 415 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 416. — RESERVED

Section 417. — RESERVED

Section 418. — ASPHALT CONCRETE PAVEMENT PATCHING

Description

418.01 This work consists of repairing distressed areas of asphalt concrete pavement by patching.

Construction Requirements

418.02 General. The approximate type, size, and location of asphalt concrete pavement patches are shown in the plans. The final area will be approved.

Place and compact asphalt concrete pavement according to Section 403 so the patched surface matches the same grade as the adjacent surface.

Dispose of debris and unsuitable and excess material according to Subsection 203.07.

418.03 Asphalt Concrete Pavement Patch, Type 1. Type 1 patching consists of removal and replacement of asphalt concrete pavement, base, and subgrade materials.

(a) Patch areas. Extend the repair area 12 inches beyond the distressed area. If patch limits are within 24 inches of the pavement edge, extend the patch limit to the pavement edge. Make the minimum transverse dimension of the patch one-half of the travel lane width and the minimum longitudinal dimension of the patch 36 inches.

(b) Pavement removal. Mill completely through the pavement or saw cut and remove the pavement. If sawcutting, cut through the existing pavement and around the perimeter of the patch area. Make saw cuts perpendicular to the roadway surface and at right angles to each other. Remove the pavement, base, and subgrade to the depth shown in the plans.

(c) Patching. If shown in the plans, place geogrid or geotextile according to Section 207. Place and compact crushed aggregate according to Section 302. Asphalt millings may be used for crushed aggregate material. Apply an asphalt tack coat to the edges of the patch area according to Section 412. Provide asphalt concrete pavement with a JMF meeting the requirements of Section 403.

418.04 Asphalt Concrete Pavement Patch, Type 2. Type 2 patching consists of removal and replacement of asphalt concrete pavement and a portion of the underlying materials. Remove asphalt concrete pavement and underlying materials to the depth shown in the plans.

(a) Patch areas. Extend the repair area 12 inches beyond the distressed area. If patch limits are within 24 inches of the pavement edge, extend the patch limit to the pavement edge. Make the minimum length and width of the patch 36 inches.

(b) Pavement removal. Remove pavement according to Subsection 418.03(b), except remove the pavement to expose subbase or subgrade as shown in the plans.

(c) Patching. Apply an asphalt tack coat to the edges of the patch area according to Section 412. Provide asphalt concrete pavement with a JMF meeting the requirements of Section 403.

418.05 Asphalt Concrete Pavement Patch, Type 3. Type 3 patching consists of removal and replacement of an asphalt concrete pavement.

(a) Pavement removal. Remove distressed asphalt concrete pavement by approved methods. Clean the patch area by sweeping or other approved methods.

(b) Patching. Apply an asphalt tack coat to asphalt concrete surfaces within the patch area according to Section 412. Provide asphalt concrete pavement with a JMF meeting the requirements of Section 403. Place the asphalt material either by hand, with a blade, or other approved methods.

418.06 Acceptance. Construction of asphalt concrete pavement patching will be evaluated under Subsections 106.02 and 106.04.

Asphalt concrete will be evaluated under Section 403.

Asphalt tack coat will be evaluated under Section 412.

Crushed aggregate will be evaluated under Section 302.

Separation and stabilization geotextiles and geogrid will be evaluated under Section 207.

Measurement

418.07 Measure the Section 418 pay items listed in the bid schedule according to Subsection 109.02.

Payment

418.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 418 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 500
RIGID PAVEMENTS

Section 501. — MINOR CONCRETE PAVEMENT

Description

501.01 This work consists of constructing minor concrete pavement on a prepared surface.

Material

501.02 Conform to the following Section and Subsections:

Coarse aggregate for concrete	703.02
Concrete curing material and additives	711
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Pozzolans	701.03
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01
Water for cementitious materials	725.01(a)

Construction Requirements

501.03 Composition (Concrete Mix Design). Design and produce concrete mixtures that conform to Table 501-1. Submit concrete mix designs for approval at least 30 days before production.

(a) Concrete pavement. Include the following in each mix design submittal:

(1) Type and sources of material;

(2) Material certification for material;

(3) Saturated surface dry mass of the fine and coarse aggregate per cubic yard of concrete;

(4) Gradation of fine and coarse aggregate;

(5) Fine and coarse aggregate quality;

(6) Water content in pounds per cubic yard of concrete;

(7) Water to cementitious material ratio. The water to cementitious material ratio for concrete is the ratio of the mass of water to the combined masses of hydraulic cement and cement substitute;

(8) Cement content in pounds per cubic yard of concrete. Pozzolans, ground iron blast-furnace slag, or silica fume may be substituted for cement according to Table 552-2;

(9) Type and dosage of admixtures and reinforcing fibers used;

(10) Target values for concrete air content;

(11) Target values for concrete slump;

(12) Concrete density;

(13) Compressive strength test results at 28 days according to Table 501-2, Note (1) & (4); and

(14) Material samples, if requested.

(b) Integral colored admixture. If integral color admixture is used, prepare five, 2- by 2-foot test panels. Construct the test panels using the approved mix design. Determine coloring agent batch amounts by weight. Use variable quantities of coloring agent as approved. Provide additional mixing time according to the manufacturer's recommendations. Cure the test panels according to Subsection 501.10. Transport the panels to an approved location. Provide at least 2 weeks outside exposure. The CO will select the acceptable test panel. Use the same rate of integral color admixture for the item of work.

Table 501-1
Composition of Concrete

Maximum Water/ Cementitious Material Ratio	Maximum Slump AASHTO T 119, inch	Minimum Air Content, percent	Maximum Coarse Aggregate Size AASHTO M 4, inch(1)	Minimum 28-Day Compressive Strength AASHTO T 22, pounds per square inch
0.45	4 (fixed form)	5.0	1½	4000

(1) Meet size number gradation and requirements from AASHTO M 43 for coarse aggregates. Blending of standard sizes to optimize gradation is allowed.

501.04 Equipment. Conform to the following:

(a) Forms. Provide straight, steel forms. For curved edges with radii less than 150 feet, provide flexible or curved forms. Provide forms conforming to the following:

(1) Height equal to the pavement thickness at the edge;

(2) 10-foot minimum length;

(3) Stabilizing devices to secure form to the prepared surface and to withstand paving operations and pressure of concrete with no visible movement or settlement;

(4) Joint locks to join form lengths tightly together; and

(5) Clean and free of hardened concrete, dirt, distortion, and rust.

(b) Paving and finishing.

(1) Fixed form construction. Provide equipment conforming to one of the following:

(a) Manual finishing machines or roller screeds that can consolidate and finish the concrete; or

(b) Mechanical, self-propelled, finishing machines that can consolidate and finish the concrete with minimal hand finishing. Coordinate the number of driving wheels, power of the motor, and the machine's mass to prevent slippage. Do not use machines that displace the fixed forms.

(2) Vibrators. Provide internal immersed tube or multiple spud type vibrators for paving more than 8 inches thick. Surface pan type vibrators are acceptable for full-width concrete consolidation of slabs 8 inches or less in thickness. Operate the vibrators at frequencies within 5000 to 8000 vibrations per minute, unless otherwise recommended by the manufacturer. Provide a tachometer for measuring vibration frequencies. Attach vibrators to the spreader or finishing machine or mount on a separate carriage that precedes the finishing machine. For construction of irregular areas, use hand-held vibrators operated at a frequency recommended by the manufacturer.

(3) Floats. Provide mechanical or hand-operated floats designed to finish pavement surfaces uniformly smooth.

(c) Concrete saws. Provide concrete saws that can saw new concrete for crack control to the required depth and alignment. Equip saws with blade guards and devices to control alignment and depth. Maintain a sufficient supply of replacement blades during sawing operations.

(d) Joint sealing. Provide sealing equipment according to the sealant manufacturer's recommendations.

501.05 Production Start-Up Procedures. At least 7 days before the start of concrete placement operations, conduct a pre-concrete pavement preparatory phase meeting according to Subsection 153.06(a). Coordinate attendance with the CO and applicable subcontractors. Submit and be prepared to discuss the following:

(a) Proposed pour sequence and placement schedule;

(b) Approved concrete mix design;

(c) QCP including technicians responsible for QC and batch tickets at the mixing plant and technicians responsible for QC, sampling, testing, and discharge at the project site;

(d) Equipment, batching, mixing, placing, and curing requirements;

(e) Subsections 106.03 and 106.04;

(f) Jointing plan, joint forming or sawing operations, precipitation protection plan, hot and cold weather paving plan, and opening to traffic requirements; and

(g) Temporary traffic control plan.

501.06 Surface Preparation, Setting Forms, and Steel Reinforcement. Maintain the roadbed surface according to Subsection 301.07. Maintain the surface to avoid the development of loose and uncompacted material.

Set and align forms to the plan dimensions and elevations and ensure there is no bulging or warping. Set forms so the entire length of the form is firmly in contact with the grade. Securely brace forms so they will not bulge or warp during concrete placement. Apply form release agent or form oil to the inside form faces. Do not vary the top face of the form from a true plane more than ⅛ inch in 10 feet.

Check the alignment and grade elevations of the forms immediately before placing the concrete and make any necessary corrections. Check and correct roadbed surface deformations and rutting exceeding ½ inch and uniformly dampen the surface before placing concrete.

Do not start placing concrete material until the forms, reinforcement, and roadbed surface have been approved.

Do not remove forms from freshly placed concrete until the concrete has set for at least 12 hours.

If shown in the plans, place steel reinforcement such as rebar, steel wire fabric, and steel mats according to Section 554. If placing reinforcement before placing concrete, position the reinforcement on acceptable supports. Do not use stones, concrete, or wood to support reinforcement. If placing reinforcement after placing concrete, mechanically insert the reinforcement to the required depth. Provide epoxy-coated steel reinforcement and steel supports. Keep epoxy-coated steel reinforcement free of damage and distortion.

501.07 Placing Concrete. Unless otherwise stated in this subsection, conform to Subsections 552.04 through 552.08 for mixing, delivery, QC, temperature limitations, weather limitations, handling, and placing of concrete. Do not walk in concrete with boots or shoes coated with earth or other contaminants. Deposit concrete between the forms to a uniform height. Deposit concrete to minimize rehandling and deposit without segregating the mix. Perform hand spreading with shovels, not rakes.

Consolidate concrete to remove voids and air pockets. Use vibrators to consolidate concrete. Uniformly vibrate the concrete across the full width and depth of the pavement. Do not operate hand vibrators more than 15 seconds, or less than 5 seconds in any one location unless approved. Place vibrators in and withdraw from concrete vertically in a slow deliberate manner. Do not move concrete horizontally with vibrators. Do not allow vibrators to contact reinforcement, load transfer devices, subgrade, and side forms.

Strike off and place concrete with a form-riding paving machine or manual fixed form paving equipment. In irregular areas where a paving machine is impractical, place concrete using templates, screeds, or other approved methods.

Carry a slight excess of concrete in front of the leading edge of the template or screed. After strike-off and before bleed water appears on the surface, float to the required grade and cross-section. Finish the concrete pavement to minus ¼ inch or plus ⅜ inch of the thickness required.

If concrete is placed adjoining a previously constructed lane of pavement, do not operate mechanical equipment on the existing lane until the lane has attained one of the following:

(a) A minimum flexural strength of 450 pounds per square inch according to AASHTO R 100 and AASHTO T 97; or

(b) A compressive strength of 3000 pounds per square inch according to AASHTO T 22 and AASHTO R 100.

When precipitation is threatening during paving operations, stop paving operations and protect the concrete pavement from precipitation with plastic sheeting or other approved methods. Remove, replace, or repair pavement damaged by precipitation as approved.

501.08 Joints. Construct joints at locations and dimensions shown in the plans. If jointing locations are not shown in the plans, submit a jointing plan according to Subsection 104.06. Show locations of contraction, construction, and isolation joints.

Saw joints before uncontrolled shrinkage cracking occurs, but after concrete has hardened sufficiently to prevent excessive tearing or raveling. If necessary, use continuous sawing operations regardless of weather or daylight conditions. Do not saw a joint if a crack occurs at or near the joint location before sawing. Discontinue sawing if a crack develops ahead of the saw.

Remove and replace newly placed concrete pavement where uncontrolled cracking occurs.

Do not vary longitudinal joints more than ½ inch and transverse joints more than ¼ inch from true alignment. If curbs or medians are constructed integral with the pavement, construct transverse joints continuous through the curb or median. Clean joints of deleterious material, including concrete slurry, and protect the joints until sealed.

For joints that are saw cut, produce a uniform and straight joint. Saw joints approximately ⅛ inch wide and to a depth of at least one-third the thickness of the concrete pavement. Do not ravel the joints while sawing. Saw longitudinal joints immediately after sawing transverse joints. Protect the sawed concrete faces from drying during the curing period.

Immediately clean freshly cut sawed joints by flushing with a jet of water under pressure and other necessary tools to remove the resulting slurry from the joint and immediate area. To clean joints, use air compressors equipped with suitable traps that can remove surplus water and oil from the compressed air.

Restore curing membrane disturbed during sawing operations by spraying disturbed areas with additional curing compound.

(a) Longitudinal joints. Where required, place deformed steel tie bars perpendicular to the longitudinal joints on rigidly secured chairs or supports. Along longitudinal construction joints, tie bars may be bent at right angles against the form of the first lane constructed and straightened into final position before placing concrete in the adjacent lane. Repair or replace broken or damaged tie bars.

Approved two-piece connectors may be used instead of tie bars.

(b) Transverse contraction joints. Where required, place dowel bars through and centered on traverse joints and in the middle of the slab depth. Align and hold dowels parallel to the surface and centerline of the slab by a metal assembly that remains in the pavement and is rigidly secured to the base or subgrade using stakes or nails. Limit deviations from parallel to ¼ inch in the length of the dowel bar. Ensure proper alignment of joint and dowel bar assemblies.

Coat each dowel bar with an approved bond breaker. Limit bond breaker coating thickness to 15 mils.

During concrete placement, do not displace the dowel joint assembly. Mark the center location of the dowel bar to facilitate sawing operations.

(c) Construction joints. Construct construction joints only at locations specified at the end of each work shift, and when concrete placement is interrupted for more than 30 minutes. If the quantity of concrete placed forms a slab less than 10 feet long at the time of interruption, remove and dispose of the excess concrete to the last preceding joint according to Subsections 203.05 and 203.07.

Where required, install dowel bars in construction joints according to Subsection 501.08(b).

Use a metal or wooden bulkhead to form the joint, shaped to the pavement cross-section and designed to allow the installation of dowel bars. Set and hold bulkhead firmly in place in a plane at right angles to centerline and perpendicular to the surface of the pavement.

(d) Isolation joints. Form isolation joints around manholes, utility boxes, foundations, other fixed objects, or as shown in the plans. Place a ½-inch pre-formed joint filler continuously around or along each structure that extends into or through the pavement before concrete is placed. After the concrete hardens, recess the joint filler about ¾ inch to allow a reservoir for sealant.

501.09 Surface Finishing. Protect the surface from precipitation damage.

Float finish the surface. Remove laitance or thin grout. After floating, check the surface of the fresh concrete with a 10-foot metal straightedge. Lap each successive check with the straightedge 5 feet over the previous check path. Correct deficiencies indicated by the straightedge while the concrete is still plastic. Fill depressions with freshly mixed concrete, then strike off, consolidate, and refinish. Cut and refinish high areas. Do not apply water to the surface of the concrete during finishing operations.

Before the concrete has initially set, work the pavement edges of isolation joints, transverse and longitudinal construction joints, and emergency construction joints to produce a ¼ inch or less continuous radius and a smooth, dense mortar finish. Do not use mortar buildup to round edges.

As soon as excess moisture has disappeared and while the concrete is still plastic enough to make a granular surface possible, texture the surface to produce a skid resistant surface. Use the method specified and conform to the following:

(a) Transverse tine finish. Drag two layers of moistened burlap along the pavement in the direction of paving without tearing or marring the surface. Following the burlap drag, use a tining comb to form grooves in the pavement surface. Space tines randomly ½ to ¾ inch apart. Produce grooves that are $^{1}/_{16}$ to $^{3}/_{16}$ inch wide and ⅛ to $^{3}/_{16}$ inch deep. Tine perpendicular to the centerline without tearing the concrete surface or loosening surface aggregate.

(b) Broom finish. Broom the surface with a steel or stiff-bristled fiber broom to produce corrugations between $^{1}/_{16}$ and ⅛ inch deep. Broom perpendicular to the centerline from edge to edge with adjacent strokes slightly overlapped. Use the same type and manufacture of broom for all paved surfaces to provide a consistent appearance.

(c) Exposed aggregate finish. Broom the surface. Use approved stiff brushes. Exercise care to prevent marring of the surface and cracking or chipping of slab edges or joints. If approved, apply a light spray of retardant to the unfinished surface to facilitate this work.

Broom transversely across the pavement. Pull the loosened semi-stiff mortar off the pavement. Remove the mortar from adjacent pavement. Broom parallel to the centerline. Continue this operation until coarse aggregate is exposed. Other methods of aggregate exposure may be used if approved.

After curing, wash the surface with water and brush to remove laitance and cement from the exposed coarse aggregate.

501.10 Curing Immediately after finishing and when marring will not occur, cure the surface and exposed sides of concrete for at least 72 hours. Do not leave the concrete exposed for more than 30 minutes during the curing period. Cure using one of the following methods:

(a) Water method. Cure according to Subsection 552.13(b); or

(b) Liquid membrane curing compound method. Cure according to Subsection 552.13(c).

Remove forms when the concrete has hardened sufficiently to resist damage, but no earlier than 12 hours after placing concrete. Protect the sides of the exposed slabs with a curing method equal to that provided for the surface. Prevent erosion of the base course beneath the exposed pavement edges until shoulders are constructed.

501.11 Sealing Joints. Saw cut and seal joints before the pavement is opened to construction or public traffic.

Where sealant reservoirs are required, clean each sealant reservoir of foreign material including membrane curing compound and concrete slurry. Blow dry joints with moisture free compressed air. Do not apply sealing material unless the joint faces are clean and surface dry, and the joint is free of incompressibles.

Use preformed joint seals, silicone sealant, or hot-poured sealant for isolation joints. Use silicone or hot-poured sealants for longitudinal and transverse contraction joints.

(a) Silicone or hot-poured sealants. Install backer rod with a steel-wheel to the depth required. Do not stretch or twist the backer rod during installation. Limit the length of backer rod installed to that which can be sealed during the same workday.

Place joint sealing material when the air temperature is over 40 °F or according to the manufacturer's recommendations. Remove excess or spilled material and clean the pavement surface. Do not use sand or similar material to cover the seal. For sealants that are not self-leveling, tool the surface of the sealant to the dimensions shown in the plans.

(b) Preformed joint seals. Provide the seal in one piece in the size specified for the joint opening. Install seals with a lubricant adhesive covering both sides of the joint. Compress the seal to between 20 and 50 percent of its nominal width or according to the manufacturer's recommendations. Install the top of the seal about ¼ inch below the pavement surface.

Remove and replace seals that are damaged, twisted, improperly positioned, or stretched more than 3 percent.

501.12 Pavement Straightedge Measurement. Measure the pavement surface after the concrete has cured. Use a 10-foot metal straightedge to measure at right angles and parallel to the centerline. Defective areas are deviations between the surface and the bottom of the straightedge more than ¼ inch, measured between two contacts of the straightedge, or deviations more than ¼ inch measured at the end of the straightedge.

Correct defective areas by diamond grinding, slab removal, or other approved methods.

501.13 Opening to Traffic. Do not allow traffic on new concrete pavement for 3 days and until one of the following conditions is met:

(a) Flexural strength of 550 pounds per square inch according to AASHTO T 97; or

(b) Compressive strength of 4000 pounds per square inch according to AASHTO T 22.

Complete testing on samples taken at the same frequency as shown in Table 501-2 for compressive strength testing.

Do not allow traffic on the pavement when joint sealant is tacky and traffic debris would imbed into the sealant.

501.14 Acceptance. See Table 501-2 for sampling, testing, and acceptance requirements.

Material for minor concrete pavement will be evaluated under Subsections 106.02 and 106.03.

The concrete mixture's slump, air content, density, temperature, and compressive strength will be evaluated under Subsections 106.02 and 106.04.

Construction of concrete pavement will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Measurement

501.15 Measure the Section 501 pay items listed in the bid schedule according to Subsection 109.02.

Payment

501.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 501 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 501-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (fine & coarse)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsections 703.01 & 703.02	1 per material type	Source of material	Yes	30 days before paving	–
Mix Design									
Concrete composition (501.03)	Measured & tested for conformance (106.04 & 105)	All	–	Subsection 501.03	1 per mix design	Source of material	If requested	30 days before paving	–

Table 501-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Concrete	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load[(2)]	Point of discharge[(3)]	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or T 196	"	"	"	"	–
		Slump	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	ASTM C1064	"	"	"	"	–
		Compressive strength[(1),(4)] (28-day)	–	AASHTO R 100 & T 22	1 set per 200 yd^2 but not less than 1 set per day	"	Yes	28 days	Deliver verification cylinders to the CO or designated laboratory for scheduled testing
Aggregate (coarse & fine)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	1 per day min	Bin discharge, conveyor belt, or stockpile	No	Before batching	–
		Moisture	–	AASHTO T 255	"	"	"	"	–
Concrete	"	Surface tolerance	–	Straightedge measurements Subsection 501.07	Subsection 501.07	Concrete surface, after floating	"	While concrete is still workable	–

Table 501-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Roadway									
Concrete pavement	Measured & tested for conformance (106.04)	Surface tolerance	–	Straightedge measurements Subsection 501.12	Successively, after concrete has hardened	Finished pavement surface	No	24 hours	–

(1) A single compressive strength test result is the average result from two 6- by 12-inch or three 4- by 8-inch cylinders cast from the same load.
(2) This frequency may be reduced by the CO if produced material proves to be consistent.
(3) Sample according to AASHTO R 60, except composite samples are not required.
(4) Cast at least four 6- by 12-inch or six 4- by 8-inch compressive strength test cylinders and transport the cylinders to the project curing facility.

Section 502. — CONCRETE PAVEMENT RESTORATION

Description

502.01 This work consists of concrete pavement restoration.

Material

502.02 Conform to the following Subsections:

Epoxy mortar	725.14(a)
Epoxy resin adhesives	725.12
Hydraulic cement	701.01
Non-shrink grout	701.04(b)(1)
Polyurethane grout	725.14(c)
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01
Water for cementitious materials	725.01(a)

502.03 General. Design the concrete mix according to Subsection 501.03. If colored concrete is required, submit preliminary samples of the colored concrete according to Subsection 601.03(b).

502.04 Equipment. Provide equipment conforming to the following:

(a) Water blaster. Provide a high-pressure water jet machine with at least 2500 pounds per square inch pressure and that can remove residual sealant, oil, or other foreign material in joints.

(b) Air compressors. Provide air compressors with a minimum nozzle pressure of 100 pounds per square inch and that can dislodge loose debris and dry joints and cracks.

(c) Grout plant. Provide a grout plant that consists of a positive displacement cement injection pump and a high-speed colloidal mill. Operate colloidal mill at speeds necessary to make a homogeneous mixture.

Provide an injection pump having a pressure capability of 275±25 pounds per square inch when pumping a grout slurry mixed to a 12-second flow cone time. Provide an injection pump that can continuously pump at a minimum rate of 1.5 gallons per minute. The system may be modified by adding a recirculating hose and valve at the discharge end of the pump.

Produce grout through a meter or scale that can measure the total day’s consumption. Provide hoses and fittings to produce a positive seal during grout injection.

(d) Drills. Provide drills that meet the following:

(1) Drills for pavement jacking. Provide rock drills that can drill straight holes through the concrete slab with a minimum diameter recommended by the grout manufacturer. Provide rock drills weighing no more than 60 pounds that can drill with a downward pressure of no more than 200 pounds. Provide an auger to open clogged holes and existing pavement jacking holes.

(2) Drills for dowels and tie bars. Provide drills that can drill specified hole diameters for dowel bars or reinforcing steel tie bars. Provide drills for dowel bars that can drill holes that meet the vertical and horizontal tolerance of ±¼ inch along the centerline of the dowel with respect to a horizontal line that is perpendicular to the plane established by the joint.

Operate equipment to prevent damage to the structural integrity of the existing slab.

(e) Surface diamond grinder. Provide power driven, self-propelled grinding equipment, specifically designed to improve smoothness and texture of concrete pavement with diamond blades. Provide equipment that:

(1) Cuts or planes at least 36 inches in width;

(2) Does not encroach on traffic outside of the work area; and

(3) Grinds the surface without causing spalling.

(f) Hydroblaster. Provide hydroblasting equipment conforming to Subsection 560.05.

(g) Cold planing (milling) machine. Provide a micro milling machine that does not exceed the bearing capacity of the concrete pavement and conforming to Subsection 413.02(b).

(h) Slab stabilization testing. Provide the following testing equipment:

(1) A 2-axle truck with dual rear wheels. Load the rear axle to 18 kips evenly distributed between the wheel paths;

(2) Static load measuring gauges consisting of 4 gauges on 2-gauge mounts, 2 gauges per mount, that can detect slab movement under load; and

(3) A modified Benkelman beam or similar approved device.

(i) Polyurethane grout pump. Provide a grout pump that can inject high density polyurethane material through a drilled hole and beneath a slab and can control the flow rate of the material as required to stabilize and lift the slab.

Provide control devices that can maintain proper temperature and proportionate mixing of polyurethane material according to the manufacturer's recommendations.

(j) Shotblasting. Provide equipment with an air stream free of oil according to ASTM D4285 and that can remove rust, oil, and other foreign material. Provide equipment meeting the requirements of ASTM D4259.

502.05 Partial-Depth Patching (less than 4 inches in depth). This work consists of patching spalls, potholes, corner breaks, or other surface distresses in concrete pavement.

(a) Patch material. Use a polymer concrete conforming to Section 572 for patches less than or equal to 1½ inches deep. Use hydraulic cement concrete conforming to Section 501 for patches greater than 1½ inches deep.

(b) Patch area preparation. Extend the limits of repair at least 4 inches outside the deteriorated area. Saw vertically along the perimeter of the patch area, parallel to the existing joint, and to at least 1½ inches deep. Near vertical edges from milling or grinding machines are acceptable. Repair saw overcuts and nicks to adjacent pavement outside the perimeter of the repair area with noncorrosive, non-shrink grout.

Break out concrete within the patch area to at least 1½ inches deep to expose sound concrete. Shot blast exposed concrete faces and reinforcing steel until free of rust and foreign material. Remove and replace deteriorated reinforcing steel. Clean patch area of loose particles, oil, dust, traces of asphalt concrete, and other contaminants, using clean water under pressure or compressed air, no more than 24 hours before patching. If compressed air is used, provide a filter in the airline to ensure that the air is oil-free.

Remove non-concrete shoulders adjacent to the patch longitudinally to the depth of the patch and to a maximum width of 12 inches to facilitate placing formwork.

Dispose of the concrete according to Subsection 203.07.

(c) Placing concrete. For hydraulic cement concrete, remove shot blast residue immediately before placing the epoxy resin adhesive. Apply an epoxy resin adhesive according to the manufacturer's recommendations. Delay hydraulic cement concrete placement until the epoxy becomes tacky.

Place and consolidate the concrete to eliminate voids at the interface of the patch and existing concrete. Place and consolidate hydraulic cement concrete according to Subsection 501.07. Place and consolidate polymer concrete according to Section 572 and methods recommended by the manufacturer.

(d) Joints. If a repair area abuts a working joint, repair the joint similar to the existing joint to maintain a working joint. Form a new joint to the same width as the existing joint. Use compressible joint filler material as inserts to prevent intrusion of the repair material into the joint. Seal the joint according to Subsection 502.07.

(e) Finishing concrete. Finish patches according to Subsection 501.09 to match the plane and texture of the adjacent existing pavement. Cure hydraulic cement concrete according to Subsection 501.10. Cure polymer concrete as recommended by the manufacturer.

Restore and compact shoulders with material similar to the existing shoulder.

502.06 Full Depth Patching. This work consists of removing existing concrete pavement the full depth and replacing with new concrete according to Section 501.

(a) Concrete removal. Saw cut slabs full depth leaving vertical edges at the limits of the patch. Do not damage adjacent concrete slabs.

Remove the concrete by lifting the slab without disturbing the underlying surface. Clean out the area with hand tools. Dispose of the concrete according to Subsection 203.07.

Remove and replace adjacent slabs damaged by concrete removal. Repair spalls using partial-depth patching methods according to Subsection 502.05.

Repair saw overcuts of repair areas and nicks to adjacent pavement outside the perimeter of the repair area with non-shrink grout.

(b) Roadbed preparation. Recondition the base and subgrade material within the patch area according to Subsection 303.06.

If required, excavate the underlying material to a maximum depth of 12 inches and replace with crushed aggregate according to Section 302. Prevent adjacent concrete slabs from being undermined.

(c) Joints. Construct joints according to Subsection 501.08.

Install dowels, tie bars, or both into existing concrete pavement slabs as shown in the plans. Drill dowel or tie bar holes into the face of the existing concrete at the required diameter, length, and spacing. Provide a drill conforming to Subsection 502.04(d)(2). Clean and dry the holes before installing the dowels or tie bars. Use an epoxy resin adhesive to permanently anchor the dowel or tie bar into the existing concrete. Place the epoxy resin starting from the back of the hole and use enough quantity to ensure the epoxy material is forced up and around the dowel or tie bar after insertion. Place a thin, donut-shaped grout retention disk around the dowel or tie bar and up against the face of the existing concrete to prevent epoxy resin adhesive material from flowing out of the hole.

Seal joints according to Subsection 501.11.

(d) Reinforcing steel. If required, provide welded steel wire fabric reinforcement for crack control. If required, provide and place reinforcing bars according to Section 554. Support reinforcing bars and welded steel wire fabric on chairs or bolsters.

(e) Concrete placement. Construct side forms to overlap the ends of the existing slab. Securely fasten side forms so they do not move when concrete is placed. To accommodate forms for the patch, excavate the adjacent shoulders a maximum width of 12 inches. Place concrete according to Subsection 501.07.

Cast each patch in one continuous full-depth operation. After removal of the forms, backfill, compact, and return the excavated shoulder area to its previous condition.

(f) Finishing concrete. Finish patches according to Subsection 502.05(e).

502.07 Resealing Joints and Crack Repair. This work consists of repairing or resealing joints and cracks in existing concrete pavement.

(a) Preparation of joints and cracks. Limit the length of joints and cracks prepared to that which can be resealed within the same shift. Do not damage joints or previously repaired patches.

Remove existing sealant from the crack faces to expose new, clean concrete. If the crack widths vary and the crack faces are raveling and irregular, cut a crack reservoir to a depth of ¾ inch.

Thoroughly clean the joint or crack of foreign material by shotblasting, waterblasting, or with a mechanical wire brush. Repeat the process until a new, clean concrete face is exposed. Dry the joint with compressed air.

Use sawing if other methods do not properly clean the joint. Limit sawing to exposing clean, new, concrete faces in the joint with a maximum allowable cut of ⅛ inch on each face of the joint.

(b) Backer rod. Install the backer rod to the required depth after the joints and cracks are clean and dry. Do not stretch or twist the backer rod during installation. Limit the length of backer rod installed to that which can be sealed during the same shift.

(c) Sealant application. Seal joints and cracks immediately after placing the backer rod. Apply sealant according to the manufacturer's recommendations. If the joint or crack becomes contaminated or damp, remove the backer rod, clean and dry the joint or crack, and reinstall a new backer rod before placing the sealant. For a non-self-leveling joint sealant, tool the sealant immediately after application to provide firm contact with the joint faces and to form the required recess below the slab surface.

502.08 Pavement Jacking. This work consists of raising and supporting the concrete pavement to the specified grade tolerances by drilling and injecting non-shrink or polyurethane grout.

(a) Drilling holes. Develop a pattern for grout injection holes and submit for approval. Drill vertical holes less than 2 inches in diameter.

(b) Jacking. Establish string lines from the pavement high points to monitor slab movement. Lower an expanding rubber packer or hose into the holes. Provide a positive seal and connection to the discharge hose on the grout plant. Do not allow the discharge end of the packer or hose to extend below the bottom of the concrete pavement.

If jacking continuously-reinforced concrete pavement, allow pumping to raise the pavement to within ⅛ inch of the string line grade. Allow pumping to raise the pavement to within ¼ inch of the transverse and longitudinal grades if jacking jointed pavement and bridge approach slabs.

Continuous jacking pressures to 200 pounds per square inch are allowed. Use pressures to 300 pounds per square inch only for short periods of 30 seconds or less. If the pavement is bonded to the subbase, brief pressure rises of 10 seconds or less to 600 pounds per square inch may be allowed. Stop pumping if grout extrudes through cracks, joints, or shoulders. Discontinue pumping if back pressure in the hose exceeds 600 pounds per square inch.

(c) Overjacking. Grind pavement raised above the specified tolerances to grade. Remove and replace the pavement according to Subsection 502.06 if the overjacking is greater than 1 inch.

(d) Cracks. Radial cracks from the grout injection holes will be considered caused by improper injection technique. For slabs with more than 10 feet of new cracks, remove and replace the slab or a portion of slab according to Subsection 502.06. For slabs with less than 10 feet of new cracks, seal cracks according to Subsection 502.07.

(e) Hole patching. After completing the jacking and the hole plugs are removed, fill drill holes flush with the pavement surface with a non-shrink grout or epoxy mortar.

502.09 Undersealing and Slab Stabilization. This work consists of pumping a non-shrink or polyurethane grout through holes drilled in the pavement into voids underneath the slabs to stabilize and underseal concrete pavement.

(a) Preliminary testing. Perform testing at night or when there is no evidence of slab lock-up due to thermal expansion. Testing may be allowed to continue if the slabs are not interlocked or under compression. Provide testing equipment conforming to Subsection 502.04(h). Test designated slab using a static method as follows:

(1) Position one set of gauges with one gauge referenced to the corner of the slab on both sides of the joint near the pavement edge;

(2) Set the gauges to zero with no load on the slab on each side of the joint;

(3) Move the test truck into position and stop with the center of the test axle 12 inches behind the joint and the outside test wheel 12 inches from the pavement edge. Read the back gauge;

(4) Move the test truck across the joint to a similar position 12 inches forward from the joint and stop. Read the forward gauge; and

(5) Underseal slabs with a deflection of more than $\frac{1}{32}$ inch.

(b) Drilling holes. Develop hole pattern and submit for approval. Drill vertical holes less than 2 inches in diameter to provide a positive seal for the pumping nozzle. For the first undersealing, drill holes to a depth that penetrates unbound base or subgrade. Avoid penetrating the subgrade by more than 3 inches.

(c) Cleaning holes. After the holes are drilled and before pumping the underseal grout, clean the hole with compressed air to remove debris and provide a passage for the grout.

(d) Pumping underseal grout. Pump grout in each hole. Seal the nozzle of the discharge hose in the hole to maintain the grout pressure underneath the slab. Do not allow the nozzle end to extend below the bottom of the concrete. Monitor slab lift according to Subsection 502.08. Limit upward movement of the pavement to $\frac{1}{8}$ inch.

Continue pumping into a hole until grout flows out other holes, joints, or cracks, or until the slab starts to lift. Stop grouting if there is lift in the slab or the adjacent shoulder.

During stabilization operations, limit continuous pumping pressures to 125 pounds per square inch. Allow a short pressure surge of up to 300 pounds per square inch when starting to pump grout into the hole to ensure grout penetrates the void structure. Do not plug other holes while grouting.

Grind pavement raised more than the $\frac{1}{8}$ inch.

(e) Cracks. If cracks develop, complete the required repairs according to Subsection 502.07.

(f) Hole patching. Patch holes according to Subsection 502.08(e).

(g) Stability testing. Test for stability 24 hours after designated slabs have been undersealed according to Subsection 502.09(a). Complete a second underseal operation on slabs that continue to show excess movement. Submit the number, depth, and location of holes for the second undersealing for approval. The CO may direct replacement of slabs that continue to show movement more than that specified after undersealing twice. Remove and replace designated slabs according to Subsection 502.06.

502.10 Surface Diamond Grinding. This work consists of grinding existing concrete pavement to eliminate joint or crack faults and providing positive lateral drainage. Uniformly transition auxiliary or ramp lane grinding from the mainline edge to provide positive drainage and an acceptable riding surface. Provide a grinding unit conforming to the requirements of Subsection 502.04(e).

Produce a pavement surface that is true to grade, smooth, and consisting of a longitudinal corduroy-type texture. Produce grooves from 0.08 to 0.15 inch wide with a space between the grooves from 0.065 to 0.125 inch wide. Produce peak ridges approximately $\frac{1}{16}$ inch higher than the grooves. Adjust blade spacing to achieve the specified texture. Establish a positive and immediate means for removal of grinding residue. Remove solid residue from the pavement surfaces before it is blown by traffic action or wind and dispose of residue according to Subsection 203.07. Do not allow residue to flow into gutters or drainage facilities.

Measure the ground pavement surfaces according to Subsection 501.12. Straightedge requirements do not apply across longitudinal joints or outside of ground areas.

502.11 Concrete Cleaning. This work consists of cleaning the existing concrete pavement surface with an approved high-pressure washing device. Remove dust, dirt, oil, and other foreign material, including the existing crack sealant material, without causing damage to the surface or exposing coarse aggregate.

Vacuum the concrete surface to remove and collect water and debris after the pavement cleaning. Dispose of the water and debris according to Subsection 203.07.

502.12 Opening to Traffic. Do not allow traffic on restored pavement until the concrete has a compressive strength of 4000 pounds per square inch if tested according to AASHTO T 22 or until the grout used for jacking or undersealing the pavement has attained 600 pounds per square inch if tested with a 0.25-square inch probe according to AASHTO T 197.

As an alternative method of determining the compressive strength of the restored pavement, in situ compressive strength can be measured by developing a strength-maturity relationship of the approved concrete mixture according to AASHTO T 325. Submit the strength-maturity relationship for approval at least 14 days before production. Provide a concrete maturity meter during the test placement and production that meets the following:

(a) Conforms to AASHTO T 325;

(b) Rugged, waterproof, and can withstand the construction environment;

(c) Able to operate without an external power source for at least 14 days;

(d) Able to collect and store temperature and maturity data for at least 14 days; and

(e) Able to determine equivalent maturity hours according to the Arrhenius function.

Do not allow traffic on sealed joints while the sealant is tacky and traffic debris embeds into the sealant.

502.13 Acceptance. See Table 502-1 for sampling, testing, and acceptance requirements.

Material for concrete pavement restoration will be evaluated under Subsections 106.02 and 106.03.

The concrete mixture's slump, air content, density, temperature, and compressive strength will be evaluated under Subsections 106.02 and 106.04.

Concrete pavement restoration construction will be evaluated under Subsections 106.02 and 106.04.

Crushed aggregate will be evaluated under Section 302.

Hydraulic cement concrete will be evaluated under Section 501.

Polymer concrete will be evaluated under Section 572.

Reinforcing steel will be evaluated under Section 554.

Measurement

502.14 Measure the Section 502 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring grout for pavement jacking and undersealing by the cubic foot, measure by metering.

Payment

502.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 502 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 502-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (703.01 & 703.02)	Measured & tested for conformance (106.04 & 105)	Quality	–	AASHTO M 80, M 6, & M 43	1 per material type	Source of material	Yes	14 days before paving	–
Mix Design									
Concrete composition (501.03)	Measured & tested for conformance (106.04 & 105)	All	–	Subsection 501.03	1 per mix design	Source of material	Yes	14 days before paving	–
Production									
Concrete	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load(2)	Point of discharge(3)	No	Upon completing tests	–
		Air content	–	AASHTO T 152	"	"	"	"	–
		Slump	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	Field measured	"	"	"	"	–

Table 502-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Concrete	Measured & tested for conformance (106.04)	Compressive strength(1),(4)	–	AASHTO T 23 & T 22	1 set per 200 yd^2 but not less than 1 set per day	Point of discharge(3)	(4)	"	Deliver verification cylinders to the CO or designated location within 28 days
Aggregate (coarse & fine)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	1 per day minimum	Bin discharge, conveyor belt, or stockpile	No	Before batching	–
		Moisture	–	AASHTO T 255	"	"	"	"	–
Concrete	"	Surface tolerance	–	Straightedge measurements Subsection 501.09	Subsection 501.09	Concrete surface, after floating	"	While concrete is still workable	–

Table 502-1 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Finished Product									
Concrete pavement	Measured & tested for conformance (106.04)	Surface tolerance	–	Straightedge measurements Subsection 501.12	Successively, after concrete has cured	Finished pavement surface	No	24 hours	–

(1) A single compressive strength test result is the average result from two 6- by 12-inch or three 4- by 8-inch cylinders cast from the same load and tested at 28 days.
(2) This frequency may be reduced by the CO if produced material proves to be consistent.
(3) Sample according to AASHTO R 60.
(4) Make at least four 6- by 12-inch or six 4- by 8-inch compressive strength test cylinders and carefully transport the cylinders to the project curing facility. Two or three cylinders will be used for 28-day compressive strength tests. The remaining cylinders will be used by the CO for verification testing or other designated purposes.

DIVISION 550
BRIDGE CONSTRUCTION

Section 551. — DRIVEN PILES

Description

551.01 This work consists of providing and constructing driven piles and concrete-filled pipe piles.

Material

551.02 Conform to the following Sections and Subsections:

Coating material	719
Non-shrink grout	701.04(b)(1)
Piling	715
Polyester resin grout	725.14(b)
Prestressing steel	709.02
Reinforcing steel	709.01
Sandbags	713.14

Construction Requirements

551.03 Qualifications. Provide a professional engineer and a pile specialty consultant with experience installing driven piles and provide AWS certified welders when installing steel piles. At least 30 days before starting driven pile work, submit the following for approval:

(a) Professional engineer. A résumé describing at least 3 years' experience in wave equation analyses.

(b) Pile specialty consultant. If dynamic load testing is specified, provide a résumé describing at least 3 years' experience in:

(1) Dynamic load testing and analysis;

(2) Signal matching analysis; and

(3) Wave equation analysis including the initial wave equation analysis.

(c) Welders. AWS certifications.

551.04 Submittals. At least 30 days before starting driven pile operations, submit the following according to Subsection 104.06:

(a) Construction sequence. Start date and proposed driven pile construction sequence;

(b) Wave equation analysis report. A wave equation analysis for the proposed pile driving system;

(c) Equipment and analysis. The following pile-driving equipment information:

(1) General. Project and structure identification, pile-driving Contractor or subcontractor, and auxiliary methods of installation such as jetting or preboring and the type and use of the equipment;

(2) Hammer. Manufacturer, model, type, serial number, rated energy (_____ at _____ length of stroke), ram weight, modifications, and a chart from the hammer manufacturer equating stroke and blows per minute for the hammer to be used. A speed versus stroke calibration may be used if approved.

For closed-end diesel hammers, a chart calibrated to actual hammer performance within 90 days of use equating bounce chamber pressure to either equivalent energy or stroke for the hammer to be used;

(3) Capblock (hammer cushion). Material, thickness, area, modulus of elasticity, and coefficient of restitution;

(4) Pile cap. Helmet weight, bonnet mass, anvil block mass, and drivehead mass;

(5) Pile cushion. Material, thickness, area, modulus of elasticity, and coefficient of restitution;

(6) Pile. Pile type, length (in leads), mass per linear foot, wall thickness, taper, cross-sectional area, design pile capacity, and tip treatment description;

(7) Test pile details. Location, type, estimated tip elevation, minimum allowable embedment, length, capacity, allowable compressive and tensile stresses;

(8) Subsurface conditions. Soil description, soil damping and quake parameters used in analysis, anticipated driving difficulties (if any);

(9) Bearing graph analysis results. Calculated maximum compressive and tensile stresses, penetration resistance (blow counts), hammer stroke and energy transferred to the pile for a range of nominal soil resistance values. Provide an inspector's chart with blow count versus stroke graph for the required nominal capacity;

(d) Splices. Details for pile field splices, pile section lengths, and elevations of splices;

(e) Pile shoes. Details for pile shoes;

(f) Pile installation log. Proposed form for recording installation of piles;

(g) Preboring. Preboring, hole cleaning and preparation, pile placement and equipment, and procedures for the ground conditions expected to be encountered. Include methods and certifications required for penetration of subsurface obstructions. If preboring disturbs the capacity of previously installed piles or structures, submit a plan with procedures to restore the required nominal capacity; and

(h) Static load test. Drawings of the proposed loading apparatus.

551.05 Pile Driving Equipment. Provide equipment conforming to the following requirements:

(a) Pile hammers.

(1) Gravity hammers. Gravity hammers may only be used to drive timber piles. Provide a hammer with a ram weighing between 2000 and 3500 pounds and limit the drop height to 12 feet or less. Select a ram mass greater than the combined mass of the drive head and pile. Provide hammer guides to ensure concentric impact on the drive head.

(2) Open-end diesel hammers. Use open-end diesel hammers with pure (B100) biodiesel. Equip open-end (single acting) diesel hammers with a device on the ram to allow visual determination of hammer stroke.

(3) Closed-end diesel hammers. Use closed-end diesel hammers with pure (B100) biodiesel. Equip hammers with a dial gauge for measuring pressure in the bounce chamber. Ensure the gauge is readable from ground level. Calibrate the dial gauge to allow for losses in the gauge hose. Verify the accuracy of the calibrated dial gauge during driving operations by ensuring that cylinder lift occurs when bounce chamber pressure is consistent with the maximum energy given in the hammer specifications. Do not use closed-end diesel hammers that do not achieve cylinder lift at the maximum energy-bounce chamber pressure relationship given in the hammer specification.

(4) Air or steam hammers. Provide plant and equipment for steam and air hammers able to maintain the volume and pressure specified by the hammer manufacturer. Equip the hammer with accurate pressure gauges that are easily accessible. Use a hammer with the mass of the striking parts at least one-third the combined mass of the driving head and pile. Ensure the combined mass is at least 2750 pounds.

Measure inlet pressures for double-acting and differential-acting air or stream hammers with a needle gauge at the head of the hammer when driving test piles. If required, also measure inlet pressures when driving production piles. A pressure versus speed calibration may be developed for specific driving conditions at the project as an alternative to periodic measurements with a needle gauge.

(5) Nonimpact hammers. Use nonimpact hammers with non-petroleum based hydraulic fluids and biodiesel fuels. If specified, use nonimpact hammers, such as vibratory hammers. Control the installation of production piles when using vibratory hammers by power consumption, rate of penetration, specified tip elevation, or other acceptable methods that ensure the required pile load capacity is obtained. Strike piles with an impact hammer of suitable energy to verify the required pile capacity is obtained on at least one of every ten piles.

(6) Hydraulic hammers. Use hydraulic hammers with pure vegetable oil or grape seed oil. Provide a power plant for hydraulic hammers with sufficient capacity to maintain the volume and pressure, specified by the manufacturer, at the hammer under working conditions. Equip the power plant and equipment with accurate pressure gauges that are easily accessible to the CO.

(b) Approval of pile-driving equipment. Provide pile-driving equipment that allows permanent piles to be driven with reasonable effort and to the required depths and resistances without damage.

Approval of pile-driving equipment will be based on a wave equation analysis.

Use the approved equipment represented in the wave equation analysis during pile-driving operations. Approval of the pile-driving system is specific to the equipment submitted. If the proposed equipment is modified or replaced, re-evaluate and resubmit the analysis and revised data for approval before using. Approval of a pile hammer does not relieve the Contractor of responsibility for piles damaged due to driving stress.

The required number of hammer blows indicated by the wave equation at the nominal pile capacity is from two to ten blows per inch.

Do not allow the pile stresses resulting from the wave equation analysis to exceed the following values:

(1) Steel piles. Limit the compressive driving stress to 90 percent of the yield strength of the pile material.

(2) Concrete piles. Limit the tensile (*TS*) and compressive (*CS*) driving stresses to:

$$TS \leq 3\, f'_c{}^{1/2} + EPV$$

$$CS \leq 0.85f\, f'_c - EPV$$

where:

f'_c = The 28-day design compressive strength of the concrete in pounds per square inch

EPV = The effective prestress value in pounds per square inch

(3) Timber piles. Limit the compressive driving stress to:

σ_{dr} = $\phi_{da}(F_{CO})$ where:

σ_{dr} = limiting driving stress (ksi)

ϕ_{da} = resistance factor, drivability analysis

F_{CO} = base resistance of wood in compression parallel to the grain (ksi)

(c) Driving appurtenances.

(1) Hammer cushion. Equip impact pile-driving equipment, except gravity hammers, with a suitable thickness of hammer cushion material to prevent damage to the hammer or pile and to ensure uniform driving behavior. Fabricate hammer cushions from durable, manufactured material according to the hammer manufacturer's recommendations. Do not use wood, wire rope, or asbestos hammer cushions. Place a striker plate, as recommended by the hammer manufacturer, on the hammer cushion to ensure uniform compression of the cushion material. Inspect the hammer cushion in the presence of the CO when starting pile driving at each structure or after each 100 hours of pile driving, whichever is less. Replace the cushion when its thickness is reduced by more than 25 percent of its original thickness.

(2) Pile drive head. Provide adequate drive heads for impact hammers. Provide appropriate drive heads, mandrels, or other devices for special piles according to the manufacturer's recommendations. Align the drive head axially with the hammer and pile. Fit the drive head around the pile head so that transfer of torsional forces is prevented during driving and proper alignment of hammer and pile is maintained.

(3) Leads. Support piles in line and position with leads while driving. Construct pile driver leads to allow freedom of movement of the hammer while maintaining axial alignment of the hammer and the pile. Fit swinging leads with a pile gate at the bottom of the leads and in the case of battered piles, fit with a horizontal brace between the crane and the leads. Embed leads in the ground or constrain the pile in a structural frame (template) to maintain proper alignment. Provide leads of sufficient length that do not require a follower but allows proper alignment of battered piles.

(4) Followers. Use followers only if approved. If followers are allowed, drive the first pile in each bent or substructure unit and every tenth pile thereafter, full length without a follower, to verify that adequate pile embedment is being achieved to develop the required nominal capacity. Provide a follower of such material and dimensions that allows the piles to be driven to the required penetration. Hold and maintain follower and pile in proper alignment during driving.

(5) Jetting. Use jetting only if approved. Provide jetting equipment with sufficient capacity to deliver a consistent pressure equivalent to at least 100 pounds per square inch at two ¾-inch jet nozzles. Jet so as not to affect the lateral stability of the final in-place pile. Remove jet pipes when the pile tip is at least 5 feet above the prescribed tip elevation and drive the pile to the required nominal capacity with an impact hammer. Control, treat if necessary, and dispose of jet water in an approved manner.

(6) Pile cushion. For concrete piles, use a new pile cushion to protect the head of each pile. Cut the pile cushion at least 4 inches thick and to match the cross-section of the pile top. Replace the pile cushion if it is compressed more than one-half its original thickness or starts to burn. For steel and timber piles, protect each pile with an approved driving cap. Enclose timber piles with approved collars or bands to prevent splitting or brooming. Replace caps when damaged. Do not reuse cushions or caps.

(7) Pile shoes. If specified, provide shoes to protect the pile tip from damage during driving. Fabricate shoes to snugly fit the pile tip. For concrete piles, attach the shoe to the pile using dowels or other approved methods. For steel piles, design and fit the shoe to the steel shape and weld the shoe to the pile so as not to stress the web or the flange. For timber piles, carefully shape the tip to secure an even uniform bearing for the pile shoe. Treat holes, cuts, or caps in treated timber piles with two-brush applications of creosote-coal tar solution according to American Wood Protection Association (AWPA).

551.06 Pile Lengths. Provide piles with sufficient length to obtain the required resistance and to extend into the pile cap or footing as indicated in the plans. Increase the length to provide fresh heading and to provide for the method of operation. If test piles are required, provide piles in the lengths determined by the test piles.

551.07 Test Piles. Install test piles if specified.

Place the piles designated as dynamic load test piles in a horizontal position and not in contact with other piles. Drill holes for mounting instruments near the head of the pile. Mount the instruments after the pile is in leads and take wave speed measurements.

Excavate the ground at the site of each test pile or production pile to the elevation of the bottom of the footing before the pile is driven. Provide test piles longer than the estimated length of production piles. Drive test piles with the same equipment as the production piles.

Drive test piles to the required nominal capacity at the estimated tip elevation. Allow test piles that do not attain the required nominal capacity at the estimated tip elevation to set up for 24 hours before re-driving.

Warm the hammer before re-driving starts by applying at least 20 blows to another pile. If the required nominal capacity is not attained on re-driving, drive a portion or the remaining test pile length and repeat the set up and re-drive procedure as directed. Splice and continue driving until the required nominal pile capacity is achieved.

Conform to the requirements for production piles when test piles are to be used in the completed structure. Remove test piles not incorporated in the completed structure to at least 24 inches below finished grade.

551.08 Driven Pile Capacity. Drive piles to the specified penetration and to the depth necessary to achieve the required nominal pile capacity. Splice piles not obtaining the required nominal capacity at the ordered length, and drive with an impact hammer until the required nominal pile capacity is achieved.

Use a Saximeter or other approved equipment to record the blow count and stroke versus depth for test and production piles.

Determine the nominal pile capacity of the in-place piles using dynamic load test results. If a dynamic load test is not specified use the wave equation to determine nominal pile capacity of the in-place pile.

(a) Wave equation. Adequate penetration is achieved when the specified wave equation resistance criteria are achieved within 5 feet of the designated tip elevation. Drive piles that do not achieve the specified resistance within these limits to a penetration determined by the CO.

(b) Dynamic formula. Do not use the dynamic formula to determine driven pile capacity.

551.09 Preboring. Use augering, wet rotary drilling, or other approved methods of preboring. Do not use a punch or a spud instead of preboring.

Prebore the pile hole to natural ground in compacted embankments more than 5 feet deep.

In natural ground, preboring may extend to the surface of the rock or hardpan for piles end-bearing on rock or hardpan. Seat the pile into the end-bearing strata.

Stop preboring at least 5 feet above the estimated pile tip elevation and drive the pile with an impact hammer to a penetration which achieves the required nominal pile capacity for piles not end-bearing on rock or hardpan. Prebore holes smaller than the diameter or diagonal of the pile cross-section while allowing penetration of the pile to the specified depth.

Increase the hole diameter to the least dimension adequate for pile installation if subsurface obstructions such as boulders or rock layers are encountered. Fill remaining void space around the pile with sand or other approved material after driving is complete.

Do not impair the capacity of existing piles or the safety or condition of adjacent structures. If preboring disturbs the capacity of previously installed piles or structures, restore the required nominal capacity of piles and structures by approved methods.

551.10 Preparation and Driving. Make the heads of piles plane and perpendicular to the longitudinal axis of the pile. Coordinate pile driving to prevent damage to other parts of the completed work.

Drive pile heads to within 3 inches of plan location at cutoff elevation for bent caps supported by piles and to within 6 inches of plan location for piles capped below final grade. Locate and drive piles at least

4 inches from any edge of the cap. Drive piles so that the axial alignment is no more than ¼ inch per foot along the longitudinal axis of the required alignment. The CO may stop driving to check the pile alignment. Check alignment before the last 5 feet are driven for piles that cannot be internally inspected after installation. Do not pull laterally on piles or splice to correct misalignment. Do not splice a properly aligned section on a misaligned pile.

Place individual piles in pile groups either starting from the center of the group and proceeding outward in both directions or starting at the outside row and proceeding progressively across the group.

Correct piles driven improperly, driven out of proper location, misaligned, or driven below the designated cutoff elevation in an approved manner. Replace piles damaged during handling or driving unless otherwise approved. Obtain approval for the proposed methods of correcting or repairing deficiencies.

Submit pile driving records including Saximeter readings at the end of each work shift.

(a) Steel piles. Provide full-length, un-spliced piles where practical.

Load, transport, unload, store, and handle steel piles to keep the metal clean and without damage. Do not use piles that exceed the allowed mill tolerance for camber and sweep. Steel piles damaged during installation are unacceptable unless the minimum tip elevation is achieved and load tests show the bearing capacity is 100 percent of the required nominal. Perform tests on damaged piles. If driving points are required, weld driving points to steel piles according to AWS, *Structural Welding Code - Steel D1.1* or AASHTO/AWS, *Bridge Welding Code D1.5* as applicable.

(b) Precast and precast prestressed concrete piles. Fabricate precast piles from Class P(AE) concrete and precast prestressed piles from Class P(AE) concrete according to Section 552. Conform to Section 554 for reinforcing steel. Conform to Section 553 for prestressing steel. If lifting anchors are used, maintain at least a 1-inch clearance from the pile reinforcing steel or prestressing steel.

Use metal, plywood, or dressed lumber forms that are watertight, rigid, and true to line. Use a 1-inch chamfer strip in corners of the forms.

Cast piles separately or, if alternate piles are cast in a tier, cast the intermediate piles at least 4 days after the adjacent piles are poured. Separate piles cast in tiers with tar paper or other suitable separating material. Place concrete in each tier in a continuous operation that prevents the formation of stone pockets, honeycombs, or other defects. Leave forms in place for at least 24 hours.

Make piles straight so when a line is stretched from butt to tip on any face, the line is no more than 1 inch from the face of the pile at any point. Make the pile surface true, smooth, even, and without honeycombs and voids.

Remove lifting anchors to a depth of at least 1 inch below the concrete surface and fill the resulting hole with concrete. Finish each pile with a Class 1 ordinary surface finish according to Subsection 552.14. Cure the piles according to Subsection 552.13 or 553.06 as applicable.

If concrete test cylinders are made and tested according to Section 552, do not move piles until the tests indicate a compressive strength of at least 80 percent of the design 28-day compressive strength. Do not transport or drive piles until tests indicate the minimum design 28-day compressive strength is attained.

If concrete test cylinders are not made, do not move piles until they have cured for at least 14 days at a minimum temperature of 60 °F or 21 days at a minimum temperature of 40 °F. Do not transport or drive piles until cured for at least 21 days at 60 °F or higher or 28 days at 40 °F or higher. If high early strength cement is used, do not move, transport, or drive piles until cured for at least 7 days.

Support concrete piles during lifting or moving at the points shown in the plans. Provide support at the quarter points if not specified. Avoid bending the pile or breaking edges when lifting or moving the piles.

Reject concrete piles with reduced strength caused by external defects such as spalls, cracks, or internal defects such as cavities revealed with non-destructive testing.

(c) Concrete-filled steel pipe piles. Provide and handle the steel pipes according to Subsection 551.10(a). Cutting shoes may be inside or outside the pipe. Use high-carbon structural steel with a machined ledge for pipe bearing or cast steel with a ledge designed for attachment with a simple weld.

Use the class of concrete designated in the plans according to Section 552. Drive pile pipes before placing concrete in the pipes. Do not drive piles within 15 feet of concrete-filled pile pipe until 80 percent of the design strength is attained. Do not drive pile pipe after it is filled with concrete.

(d) Timber piles. Do not use piles with checks wider than ½ inch. Drive treated timber piles within 6 months after treatment. Handle and care for pressure-treated piles according to AWPA, *Standard M4 Standard for the Handling, Storage, Field Fabrication and Field Treatment of Preservative-Treated Wood Products*.

551.11 Splices. Align and connect pile sections so the axis of the spliced pile is straight.

(a) Steel piles. Splices are allowed when piles lengths exceed 60 feet. Space splices at least 10 feet apart. Use no more than 2 splices per pile.

Use welders certified for structural welding.

Make surfaces to be welded smooth, uniform, and without loose scale, slag, grease, or other material that prevents proper welding. Steel may be oxygen cut. Carbon-arc gouging, chipping, or grinding may be used for joint preparation.

Weld according to AWS, *Structural Welding Code - Steel D1.1* or AASHTO/AWS, *Bridge Welding Code D1.5*. Weld the entire pile cross-section using prequalified AWS groove weld butt joints. Weld so there is no visual evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size. Manufactured splices may be used in place of full penetration groove butt welds if approved or shown in the plans. Ensure the splice develops the full strength of the pile in compression, tension, and bending.

Perform non-destructive examination on splices located in the upper half of the total pile length by performing one of the following tests:

(1) Radiographic testing according to the requirements of AWS, *Structural Welding Code - Steel D1.1* or AASHTO/AWS, *Bridge Welding Code D1.5*.

(2) Ultrasonic testing according to the requirements of AWS, *Structural Welding Code - Steel D1.1* or AASHTO/AWS, *Bridge Welding Code D1.5*.

Repair weld defects according to AWS, *Structural Welding Code - Steel D1.1* or AASHTO/AWS, *Bridge Welding Code D1.5*.

(b) Concrete pile splices. Use dowels or other approved mechanical means to splice precast concrete or precast prestressed concrete piles.

If dowels are used, cast the dowels into the tip end of the following pile with corresponding holes at the butt end of the driven pile. Serrate the holes to provide a mechanical bond. Clean surfaces and dowel holes. Separate the ends of the piles by at least ½ inch. Grout the dowels in place and allow the grout to cure. Enclose the gap with forms and inject a bonding agent that can withstand the impact and driving forces and has the same compressive strength as the pile. Follow the manufacturer's recommendations for the use and curing of grouting and bonding products.

Attach manufactured splices to the concrete piles according to the manufacturer's recommendations. Ensure the splice develops strengths in compression, tension, and bending at least the strength of the pile being spliced.

(c) Concrete pile extensions.

(1) Precast concrete piles. Extend precast concrete piles by removing the concrete at the end of the pile and leaving 40 bar diameters of reinforcement steel exposed. Remove the concrete to produce a face perpendicular to the axis of the pile. Securely fasten reinforcement of the same size as that used in the pile to the projecting reinforcing steel. Form the extension to prevent leakage along the pile.

Immediately before placing concrete, wet the top of the pile thoroughly and cover with a thin coating of neat cement, re-tempered mortar, or other approved bonding material. Place concrete of the same mix design and quality as that used in the pile. Keep forms in place for at least 7 days after the concrete has been placed. Cure and finish according to Section 552.

(2) Precast prestressed piles. Extend precast prestressed piles according to Subsection 551.11(b). Include reinforcement bars in the pile head for splicing to the extension bars. Do not drive extended prestressed precast piles.

(d) Timber piles. Do not splice timber piles.

551.12 Heaved Piles. Check for pile heave during the driving operation. Take level readings immediately after each pile is driven and again after piles within a radius of 15 feet are driven. Re-drive piles that heave more than ½ inch. Re-drive to the specified resistance or penetration.

551.13 Pile Load Tests. Perform dynamic load tests at the locations shown in the plans. Static load tests are not required unless specified.

(a) Dynamic load test. Provide equipment and perform dynamic load tests according to ASTM D4945 in the presence of the CO. Mount the instruments according to Subsection 551.07.

Drive the pile to the depth at which the dynamic test equipment indicates that the required nominal pile capacity is achieved. If necessary to maintain stresses in the pile below the values in Subsection 551.05(b)(1), reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer. Realign the driving system if nonaxial driving is indicated.

At least 24 hours after the initial driving, re-drive each dynamic load test pile with instrumentation attached. Warm the hammer before re-driving by applying at least 20 blows to another pile. Re-drive the dynamic load test pile for a maximum penetration of 3 inches, a maximum of 20 blows, or to practical driving refusal, whichever occurs first. Practical driving refusal is defined as 12 blows per inch for steel piles, 10 blows per inch for concrete piles, and 5 blows per inch for timber piles.

Verify the assumptions used in the initial wave equation analysis submitted according to Subsection 551.04(b) using signal matching analysis. Analyze one blow from the original driving and one blow from the re-driving for each pile tested.

Perform additional wave equation analyses with adjustments based on the signal matching analysis results. Provide a graph showing blow count versus nominal capacity. Provide a blow count versus stroke graph for the nominal capacity of open-ended diesel hammers. Provide the driving stresses, transferred energy, and pile capacity as a function of depth for each dynamic load test.

Within 3 days of the completion of testing, submit the dynamic load test results according to Subsection 104.06.

Based on the results of the dynamic load testing, signal matching analyses, and wave equation analyses, the order list and production driving criteria may be approved and the required cut-off elevations provided, or additional test piles and load testing may be specified. This information will be provided within 7 days after receipt of the order list and required test data for the test piles driven.

(b) Static load tests. Perform static load tests according to ASTM D1143 using the quick load test method, except as modified in this Section.

(1) Provide a loading system that can apply 150 percent of the nominal pile capacity or 1000 tons, whichever is less.

(2) Construct the loading apparatus to allow increments of load to be placed gradually without causing vibration to the test pile.

Perform test at least 5 days after test pile was driven unless approved. If tension (anchor) piles are required, drive tension piles at the location of permanent piles. Do not use timber or tapered piles installed in permanent locations as tension piles. Take the test to plunging failure or the capacity of the loading system, whichever occurs first.

The nominal bearing resistance is defined as 50 percent of the failure load. The failure load is defined as follows:

For piles no more than 24 inches in diameter, length of side for square piles or diagonal width, the load that produces a settlement at failure of the pile head equal to:

Sf = S + (0.15 + 0.008D)

For piles greater than 24 inches in diameter, length of side for square piles or diagonal width:

$$S_f = S + \frac{D}{30}$$

where:

Sf = Settlement at failure (in)

D = Pile diameter or diagonal width (in)

S = Elastic deformation of pile (in)

Determine top elevation of the test pile immediately after driving and again immediately before load testing to check for heave. Wait at least 3 days between the driving of anchor or load test piles and the start of the load test. Before testing, re-drive or jack to the original elevation piles that heaves more than ¼ inch.

After completion of the load testing, remove or cut off test or anchor piling not a part of the finished structure at least 24 inches below either the bottom of footing or the finished ground elevation.

Within 7 days of the completion of testing, submit the static load test results according to Subsection 104.06.

Based on the results of the static load testing, the order list and production driving criteria may be approved and the required cut-off elevations provided or additional load tests may be specified. This information will be provided within 7 days after receipt of the order list and required test data for the test piles driven.

(c) No load test. If no load test is specified, drive each pile to the minimum tip elevation as shown in the plans or to practical driving refusal. Practical driving refusal is defined as 12 blows per inch for steel piles, 10 blows per inch for concrete piles, and 5 blows per inch for timber piles.

551.14 Pile Cutoffs. Cut off the tops of permanent piles and pile casings at the required elevation. Cut off the piles clean and straight and parallel to the bottom face of the structural member in which they are embedded. Dispose of cutoff lengths according to Subsection 203.07.

Treat the heads of treated timber piles which are not embedded in concrete by one of the following methods:

(a) Reduce the moisture content of the wood to no more than 25 percent with no free moisture on the surface. Brush apply one application of creosote-coal tar solution as required in AWPA Standards.

Build up a protective cap by applying alternate layers of loosely woven fabric and hot asphalt or tar, similar to membrane waterproofing, using three layers of asphalt or tar and two layers of fabric. Use fabric at least 6 inches wider in each direction than the diameter of the pile. Turn the fabric down over the pile and secure the edges by binding with two turns of No. 10 galvanized wire. Apply a final layer of asphalt or tar to cover the wire. Neatly trim the fabric below the wires.

(b) Cover the sawed surface with three applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brush coat with three applications of hot creosote and cover with hot roofing pitch. Place a covering of galvanized sheet metal over the coating and bend down over the sides of each pile.

551.15 Unsatisfactory Piles. Correct unsatisfactory piles by an approved method. Methods of correcting unsatisfactory piles may include one or more of the following:

(a) Use the pile at a reduced capacity.

(b) Install additional piles.

(c) Repair damaged piles.

(d) Replace damaged piles.

551.16 Placing Concrete in Steel Pipe Piles. Clean the inside of pipe piles by removing material to the depth of limits of concrete fill shown in the plans. If a soil plug leaves a void deeper than the limits of concrete fill, fill to that depth using concrete or a bentonite grout mix batched in the proportions shown in Table 551-1 or other approved mix.

Table 551-1
Pipe Pile Fill

Material	Quantity
Cement	94 lb
Bentonite	25 lb
Water	30 gal

Remove water before placing concrete or place the concrete using a tremie when water is present in the pile. Dispose of water according to Federal, state, and local rules and regulations. Provide suitable equipment for inspecting the entire inside surface of the driven pipe immediately before placing concrete.

(a) Reinforcing steel. Make the spacing between adjacent cage elements at least five times the maximum size of aggregate in the concrete when reinforcing steel is required.

Securely tie concrete spacers or other approved spacers at fifth points around the perimeter of the reinforcing steel cage. Install spacers at intervals no more than 10 feet measured along the length of the cage.

Place the reinforcement cage into the driven pipe when the concrete reaches the planned bottom elevation of the reinforcement. Support the reinforcement so it remains within 2 inches of the required vertical location. Support the cage from the top until the concrete reaches the top of the pile.

(b) Concrete. Construct concrete according to Section 552. Place concrete in one continuous operation from the bottom to the top of the pile. Consolidate the top 10 feet of the concrete pile using approved vibratory equipment before the initial concrete set.

551.17 Acceptance. Pile material will be evaluated under Subsections 106.02 and 106.03. Provide production certifications with each shipment of the following:

(a) Concrete piles;

(b) Sheet piles, steel H-piles, and steel pipes; and

(c) Treated timber piles.

Driving piles will be evaluated under Subsections 106.02 and 106.04.

Concrete will be evaluated under Section 552.

Prestressing steel will be evaluated under Section 553.

Reinforcing steel will be evaluated under Section 554.

Measurement

551.18 Measure the Section 551 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring piles by the linear foot, measure the length of pile from the cutoff elevation to the tip.

When measuring preboring by the linear foot, measure from the ground surface to the base of the prebored pile hole.

Measure splices required to drive piles deeper than the estimated tip elevation.

Payment

551.19 The accepted quantities will be paid at the contract price per unit of measurement for the Section 551 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 552. — STRUCTURAL CONCRETE

Description

552.01 This work consists of constructing structural concrete in bridges, culverts, and other structures.

Material

552.02 Conform to the following Section and Subsections:

Coarse aggregate for concrete	703.02
Concrete curing material and additives	711
Fine aggregate for concrete	703.01
Grout	701.04
Hydraulic cement	701.01
Pozzolans	701.03
Penetrating stain for concrete	719.05
Sealants, fillers, and seals	712.01
Structural steel	717.01
Water for cementitious materials	725.01(a)

Construction Requirements

552.03 Composition (Mix Design). Design and produce concrete mixtures that conform to the class specified. Submit concrete mix designs for approval at least 36 days before production.

Provide a new mix design for approval if there is a change in a source of material or when the fineness modulus of the fine aggregate changes by more than 0.20.

Table 552-1
Composition of Concrete

Class of Concrete	Minimum Compressive Strength @ 28-Days, f'_c, pounds per square inch	Maximum Water-Cementitious Material Ratio	Maximum Coarse Aggregate Size, inch[1]	Air Content for Air Entrained Concrete, percent
A, A(AE)	4500	0.45	1.5	4.0 to 7.0
C, C(AE)	4500	0.45	0.75	4.5 to 7.5
D(AE)[2]	5000	0.40	1.5	4.0 to 7.0
P, P(AE)[3]	See plans	–	1.0	4.0 to 6.0
S (Seal)	–	0.54	1.5	–

(1) Meet size number gradation and requirements from AASHTO M 43 for coarse aggregates. Blending of standard sizes to optimize gradation is allowed.
(2) The maximum water-soluble chloride ion content is 0.15 percent by mass of cement. Determine the water-soluble chloride ion content of concrete made with mix ingredients at an age between 28 and 48 days according to ASTM C1218. Submit test results with the concrete mix design for approval.
(3) The maximum water-soluble chloride ion content is 0.06 percent by mass of cement. Determine the water-soluble chloride ion content of concrete made with mix ingredients at an age between 28 and 48 days according to ASTM C1218. Submit test results with the concrete mix design for approval.

Table 552-2
Cementitious Material Requirements for Concrete

Cementitious Material	Maximum Percent of Total Cementitious Material by Mass
Fly ash or other pozzolans, AASHTO M 295	25
Slag, AASHTO M 302	50
Silica fume, AASHTO M 307	10
Total fly ash or other pozzolans, slag, & silica fume	50[1]
Total fly ash or other pozzolans & silica fume	35[1]

(1) Limit fly ash or other pozzolans to no more than 25 percent of the total mass of cementitious material and limit silica fume to no more than 10 percent of the total mass of cementitious material.

(a) Structural concrete. Design and produce concrete mixtures that conform to Tables 552-1 and 552-2 for the class specified. Determine design strength values according to Section 4 of ACI 301, *Specifications for Concrete Construction*.

Verify mixture design with trial mixes prepared according to Section 4 of ACI 301 from proposed sources or with previous concrete production data for the mixture design submitted from proposed sources.

Submit concrete mix designs on Form FHWA 1608, *552 Structural Concrete Mix Design Submittal*.

Include the following in each mix design submittal:

(1) Project identification;

(2) Name and address of Contractor and concrete producer;

(3) Mix design designation;

(4) Class of concrete and intended use;

(5) Material proportions;

(6) Name and location of material sources for aggregate, cement, admixtures, and water;

(7) Type of cement and other cementitious material, if used. Fly ash, slag cement, or silica fume may partially replace cement in the mix;

(8) Cement content in pounds per cubic yard of concrete;

(9) Saturated surface dry batch mass of the coarse and fine aggregate in pounds per cubic yard of concrete;

(10) Water content in pounds per cubic yard of concrete;

(11) Water to cementitious material ratio for modified concrete is the ratio of the mass of water to the combined masses of hydraulic cement and cement substitute;

(12) Dosage of admixtures required using the job site material, trial mixtures, and admixture manufacturer's recommendations. Do not combine chemical admixtures together in a mix unless they are compatible. Include supporting documentation of compatibility from the manufacturers.

(a) Air-entraining admixtures. Entrained air may be obtained with air-entraining hydraulic cement or air-entraining admixture.

(b) Set accelerating admixtures. Do not use chloride accelerators. Do not use set accelerating admixtures in prestressed concrete applications.

(c) Hydration stabilizing admixtures. Hydration stabilizing admixtures may be used to extend the allowable delivery time for concrete. Base the dosage on the time needed to delay the initial set of the concrete for delivery and discharge on the job. Include the design discharge time limit shown in Table 552-3.

(13) Fine and coarse aggregate quality;

(14) Sieve analysis of fine and coarse aggregate;

(15) Absorption of fine and coarse aggregate;

(16) Bulk specific gravity (dry and saturated surface dry) of fine and coarse aggregate;

(17) Dry rodded density of coarse aggregate in pounds per cubic foot;

(18) Fineness modulus of fine aggregate;

(19) Material certifications for cementitious material, admixtures, and aggregate;

(20) Target values for concrete slump or slump flow, as appropriate, with and without high-range water reducers;

(21) Target values for concrete air content. Include the proposed range of air content for concrete to be incorporated in the work. Describe the methods by which air content will be monitored and controlled;

(22) Concrete density;

(23) Specified design strength and required average strength (f'_{cr}) for the concrete mixture at 28 days as determined by the process described in Section 4 of ACI 301. This process and associated calculations are outlined on Form FHWA 1608, pages 4 and 5. Pending 28-day strength results, a mix design may be approved on the basis that 7-day compressive strength results are at least 85 percent of the required average strength (f'_{cr}) at 28 days;

(24) Compressive strengths test results at 7 and 28 days according to Table 552-10, Note (3);

(25) Material samples, if requested;

(26) Fiber samples, if used;

(27) Integral color admixture, if used. Do not to exceed 10 percent of the weight of the cementitious material; and

(28) Strength-maturity relationships, if used, according to AASHTO T 325.

(b) Internally cured concrete (ICC). Design and produce concrete mixtures that conform to Tables 552-1 and 552-2 for the class of concrete specified. Provide aggregate according to the class specified, except substitute a portion of the normal weight fine aggregate (on a cubic yard basis) for lightweight fine aggregate (LWFA) conforming to AASHTO M 195.

Determine the quantity of LWFA (lb/yd^3) by the following calculations:

cementitious factor = cementitious content (lb/yd^3) /100

where:

cementitious content is the inclusion of portland cement and supplementary cementitious materials in the submitted concrete mixture;

$$LWFA\ quantity\ = \frac{cementitious\ factor \times 7.0}{\left(\frac{\frac{percent\ absorption\ of\ LWFA}{100}}{\left(1+\left(\frac{percent\ absorption\ of\ LWFA}{100}\right)\right)}\right)}$$; and

Round calculated LWFA quantity to nearest pound per cubic yard.

Adjust the concrete mix design normal weight fine aggregate quantity after determining the saturated surface dry (SSD) volume of the LWFA. Subtract the SSD LWFA volume from the original volume of normal weight fine aggregate. Calculate new adjusted SSD weight of normal weight fine aggregate on a pound per cubic yard basis.

Determine design strength values according to Section 4 of ACI 301. In addition, design structural concrete mixes according to the following:

(1) ACI 211.1, *Standard Practice for Selecting Proportions for Normal, Heavy Weight and Mass Concrete*; and

(2) ACI 211.3, *Guide for Selecting Proportions of No-Slump Concrete*.

Submit ICC mix designs according to Subsection 552.03(a).

(c) Self-consolidating concrete (SCC). Design and produce SCC mixtures that conform to Section 4 of ACI 301. Provide a maximum water to cementitious material ratio of 0.40. See Table 552-1 for minimum compressive strength requirements and air entrainment. Provide maximum coarse aggregate size less than or equal to 1 inch. Conform to size number gradation and requirements from AASHTO M 43 for coarse aggregates. Blending of standard sizes to optimize gradation is allowed. Design the mix to have slump flow according to ASTM C1611, static segregation according to ASTM C1610, and passing ability according to ASTM C1621 suitable for the application of SCC.

Submit SCC mix designs according to Subsection 552.03(a).

(d) Integral color admixture. When an integral color admixture is specified, prepare five 2- by 2-foot test panels. Construct the test panels using the proposed mix design. Determine coloring agent batch amounts by weight. Use variable quantities of coloring agent as approved. Provide additional mixing time according to the manufacturer's recommendations. Complete a Class 1 finish according to Subsection 552.14(a). Cure the test panels similar to the structure. Transport the panels to an approved location. Provide at least 2 weeks outside exposure. The CO will select the acceptable test panel. Use the same rate of integral color admixture for the item of work.

552.04 Mixing. Use a batching plant, mixer, and agitator conforming to AASHTO M 157. Mix the concrete in a central-mix plant or in truck mixers. Operate equipment according to the manufacturer's recommendations. Produce concrete of uniform consistency.

(a) Batching tolerances. Batch the concrete according to the approved mix design and Table 552-3.

Table 552-3
Batching Tolerances

Material	Tolerance, Percent (±)
Cement	1
Water	1
Aggregate	2
Additive	3

(b) Central-mix plant. Dispense liquid admixtures through a controlled flowmeter. Use dispensers with sufficient capacity to measure, at one time, the full quantity of admixture required for each batch. If more than one admixture is used, dispense each with separate equipment.

Charge the coarse aggregate, one-third of the water, and all air-entraining admixture into the mixer first, then add remainder of the material.

Mix for at least 50 seconds. Start mixing time after all cement and aggregate are in the drum. Add the remaining water during the first quarter of the mixing time. Add 4 seconds to the mixing time if timing starts the instant the skip reaches its maximum raised position. Transfer time in multiple-drum mixers is included in mixing time. Mixing time ends when the discharge chute opens.

Remove the contents of an individual mixer before a succeeding batch is charged into the drum.

(c) Truck mixer. Do not use mixers with blades worn 1 inch or more below the original manufactured height. Do not use mixers and agitators with accumulated hard concrete or mortar in the mixing drum.

Add admixtures to the mix according to the manufacturer's recommendations.

Charge the batch into the drum so a portion of the mixing water enters before the cement.

Mix each batch of concrete according to AASHTO M 157.

552.05 Delivery. Produce and deliver concrete to allow a continuous placement with no concrete achieving initial set before the remaining concrete being placed adjacent to it. Deliver, handle, and place concrete to minimize rehandling of the concrete and prevent damage to the structure. Do not place concrete that has developed an initial set or exceeds discharge time limits shown in Table 552-4. Do not re-temper concrete by adding water.

If a hydration stabilizing admixture is approved for use in the concrete mix, deliver and place the concrete within the approved design discharge time limit. Limit the slump loss to no more than 2 inches during the stabilization period. An approved and compatible hydration activator may be used at the discharge site to ensure proper placement and testing.

(a) Truck mixer and agitator. Use the agitating speed for rotation after mixing. When a truck mixer or truck agitator is used to transport concrete that is completely mixed in a stationary central construction mixer, mix during transportation at the manufacturer's recommended agitating speed. Do not exceed 100 total revolutions at mixing speed, including both initial mixing and remixing. Do not exceed 300 total revolutions, including both mixing and agitating speed.

If the concrete has not obtained an initial set, water and admixtures in the approved mix design may be added one time at the project to obtain the required slump or air content. Limit the total of water in the mix to not exceed the maximum water to cementitious material ratio of the approved mix design. Remix the concrete and added water or admixtures with 30 revolutions at mixing speed. After the initial introduction of mixing water to cement or cement to aggregates, complete the remixing within the time shown in Table 552-4. After starting the addition of the cement, complete the discharge of the concrete within the time shown in Table 552-4.

Table 552-4
Concrete Remixing and Discharge Time Limits

Cement Type[1]	Admixtures	Remixing Time Limit, hour	Discharge Time Limit, hour
Type I, IA, II, IIA, V, or approved blended hydraulic cement	None	0.75	1.00
Type I, IA, II, IIA, V, or approved blended hydraulic cement	AASHTO M 194, Type B, D, or G	1.25	1.50
Type I, IA, II, IIA, V, or approved blended hydraulic cement	Hydration stabilizer	3.00	Approved design discharge time limit, 3.50 maximum
Type III	None	0.50	0.75
Type III	AASHTO M 194, Type B, D, or G	1.00	1.25

(1) AASHTO M 85 or AASHTO M 240 as applicable.

(b) Non-agitating equipment. Non-agitating equipment may be used to deliver concrete if the concrete discharge is completed within 20 minutes from the starting of the addition of the cement to the mixing drum. Use equipment with smooth, mortar tight, metal containers that can discharge the concrete at a controlled rate without segregation. Provide covers when needed for protection.

552.06 Quality Control of Mix. Prevent segregation, contamination, or other harmful effects during handling and storage of material. Do not use cement and fly ash containing evidence of moisture contamination. Provide aggregate with uniform moisture content at the time of batching.

Submit and follow a QCP according to Section 153 and the following:

(a) Preparatory phase meeting. Conduct a pre-concrete preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of structural concrete production operations. Include a representative from the QC testing lab. Be prepared to discuss the following:

(1) Proposed concrete placement schedule;

(2) Approved concrete mix design and determination of batch weights;

(3) Contractor QC, and the minimum frequency schedule for sampling and testing;

(4) Batching, mixing, placing, and curing requirements; and

(5) Subsections 106.03, 106.04, and 106.05.

(b) Mixing. Provide a supplier representative to be responsible for the mixing operations and QC including:

(1) Proper storage and handling of components of the mix;

(2) Proper maintenance and cleanliness of plant, trucks, and other equipment;

(3) Sampling and testing according to Table 552-10;

(4) Adjusting the mix proportions to maintain the required water to cementitious material ratio;

(5) Computing batch masses for each day's production;

(6) Checking of the plant's calibration; and

(7) Completing batch tickets. Include the following:

(a) Concrete supplier;

(b) Ticket serial number;

(c) Date and truck number;

(d) Contractor;

(e) Structure or location of placement;

(f) Mix-design and concrete class;

(g) Component quantities and concrete total volume;

(h) Moisture corrections for aggregate moisture;

(i) Total water in mix at plant;

(j) Time of batching;

(k) Maximum water that may be added to the mix at the project; and

(l) If a hydration stabilizing admixture is used, the slump at the plant after adding the stabilizer.

Provide documentation for Subsections 552.06(b)(3), (4), (5), and (7) as they are completed.

(c) Delivery and discharge. The QCM is responsible for concrete delivery and discharge including:

(1) Verifying adjustments to the mix comply with the specifications before discharge; and

(2) Completing the batch ticket for each load by recording the apparent water to cementitious material ratio and the time.

552.07 Temperature, Weather, and Mass Concrete Conditions. Maintain the temperature of the concrete mixture immediately before placement between 50 and 90 °F, except for bridge decks between 50 and 80 °F.

(a) Cold weather. Cold weather is defined as a period when the following conditions exist for more than 3 consecutive days:

(1) Average of the highest and the lowest temperatures occurring during the period from midnight to midnight is less than 40 °F; and

(2) Air temperature is not greater than 50 °F for more than one-half of a 24-hour period.

When cold weather is expected or has occurred within 7 days of anticipated concrete placement, submit a detailed plan for the producing, transporting, placing, protecting, curing, and temperature monitoring of concrete during cold weather. For each concrete placement and concrete element type, submit a plan for temperature recording device placement. ACI 306, *Guide to Cold Weather Concreting* may be used for guidance in developing the plan. Include procedures for accommodating abrupt changes in weather conditions. Allow at least 7 days for review and approval of the plan. Do not start placement until the plan is approved.

Have material and equipment required for protection available at the project before starting cold weather concreting.

Remove snow, ice, and frost from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. Heat surfaces that come into contact with fresh concrete to at least 35 °F and maintain the temperature of these surfaces at 35 °F or above during concrete placement.

Place heaters and direct ducts to avoid concrete drying or fire hazards. Vent exhaust flue gases from combustion heating units to the outside of enclosures. Do not damage the mix while heating the concrete components. Do not heat cement or allow the cement to come into contact with aggregates that are hotter than 100 °F. Do not heat aggregates with a direct flame or on sheet metal over fire. Do not heat fine aggregate by direct steam. Do not add salts to prevent freezing.

Use protection measures for at least 7 days as identified in the cold weather plan to meet the requirements shown in Table 552-5.

Provide and place continuously recording surface temperature measuring devices that are accurate within ±2 °F. Provide a datalogging device and collect temperature data every 15 minutes in the first 48 hours and at 1-hour intervals after that for at least 14 days. Verify that data logger and temperature sensors are working before starting cold weather concrete placement. Download and submit data daily.

At a minimum, place temperature recording devices at corners and selected surfaces of the concrete placement. Install temperature recording devices at a depth of 2 inches from the surface of the concrete. For circular cross-sections place at least three surface measuring devices at 120-degree intervals. Place two temperature measurement devices at the center of the concrete placement.

Do not exceed a temperature differential of 60 °F during the protection period as measured from the center of the placement and a point 2 inches from the surface along the shortest line from the geometric center to the nearest surface of the element. Notify the CO if maximum allowable differential is exceeded and adjust protection to reduce temperature differential to below 60 °F.

At the end of the protection period, allow the concrete to cool gradually over 24 hours at a rate less than the maximum values shown in Table 552-5. Start the cooling process when the average wind speed is less than 10 miles per hour as measured 3 feet from the concrete surface. Remove protection when the concrete surface temperature is within 25 °F of the ambient air temperature.

Table 552-5
Cold Weather Concrete Surface Temperatures

Minimum Section Size Dimension	< 12 inches	12 to < 36 inches	36 to 72 inches	> 72 inches
Minimum temperature of concrete during protection period	55 °F	50 °F	45 °F	40 °F
Maximum allowable temperature drop in a 24-hour period after end of protection	50 °F	40 °F	30 °F	20 °F

(b) Hot weather. Hot weather is defined as any time during the concrete placement when the ambient air temperature at the work site is above 90 °F.

Cool surfaces that come in contact with the mix to below 90 °F by covering with wet burlap or cotton mats, fog spraying with water, covering with protective housing, or by other approved methods.

During placement, maintain concrete temperature by using any combination of the following:

(1) Shade the material storage areas or production equipment.

(2) Cool aggregate by sprinkling.

(3) Cool aggregate and water by refrigeration or replacing a portion or all the mix water with flaked or crushed ice to the extent that the ice completely melts during mixing of the concrete.

(c) Evaporation. When placing concrete in bridge decks or other exposed slabs, limit expected evaporation rate to less than 0.1 pound per square foot per hour as determined by Figure 552-1.

When necessary, take one or more of the following actions:

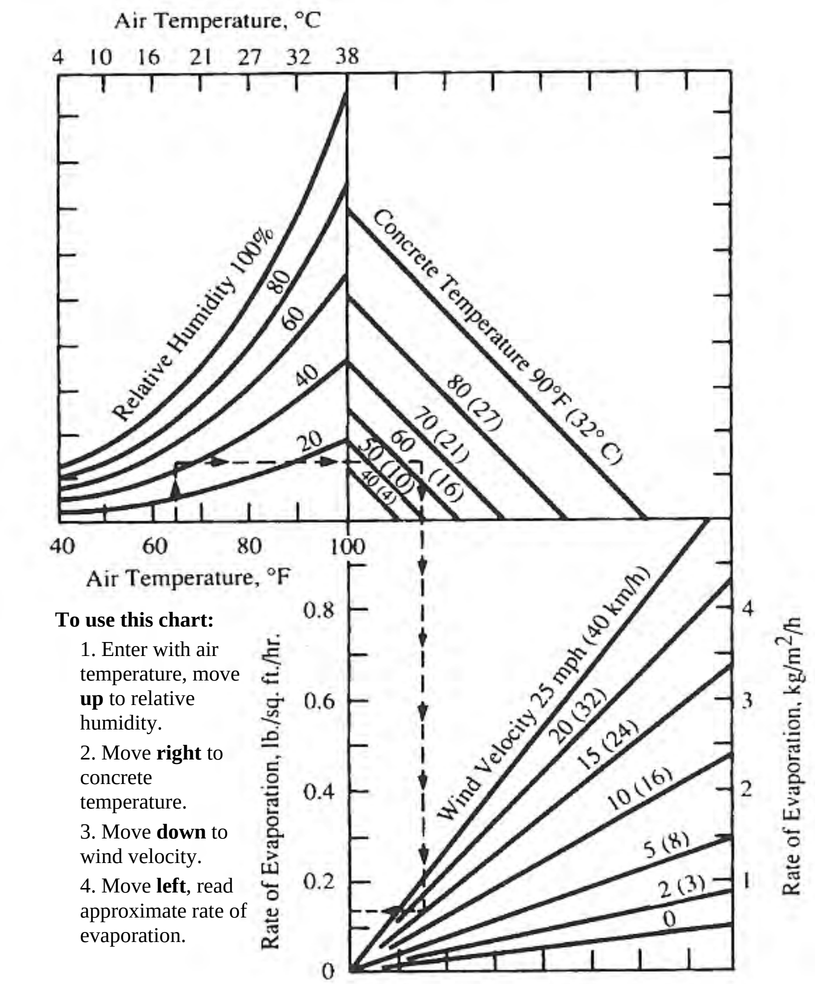
(1) Construct windbreaks or enclosures to effectively reduce the wind velocity throughout the area of placement.

(2) Use fog sprayers upwind of the placement operation to effectively increase the relative humidity.

(3) Reduce the temperature of the concrete according to Subsection 552.07(b).

(d) Precipitation. Protect the concrete from precipitation during and after placement.

Figure 552-1
Evaporation Rate of Surface Moisture



Source: "Plastic Cracking of Concrete." Engineering Information, National Ready Mixed Concrete Association/National Sand and Gravel Association, July 1960, 2 pp.

Note: Example shown by dashed lines is for an air temperature of 65 °F, relative humidity of 45 percent, concrete temperature of 65 °F, and a wind velocity of 15 miles per hour. This results in a rate of evaporation of 0.13 pounds per square foot per hour.

(e) Mass concrete. Mass concrete is considered any element shown in the plans with a least dimension greater than or equal to 4 feet and having a volume to surface ratio (V/S) greater than 1.5 feet.

Provide temperature control of mass concrete to minimize potential cracking and to limit the maximum temperature of concrete during the curing process. Provide temperature control according to ACI 207.1R, *Guide to Mass Concrete* and ACI 207.4R, *Report on Cooling and Insulating Systems for Mass Concrete*.

(1) Temperature limitations. Limit the maximum temperature differential between the geometric center and a point 2 inches from the nearest surface to the requirements shown in Table 552-6.

Table 552-6
Maximum Temperature Differential During Curing Period

Curing Period	Maximum Temperature Differential
Less than 48 hours	40 °F
Next 2 to 7 days	50 °F
Next 8 to 14 days	60 °F

Maintain these temperature conditions from time of concrete placement until all interior concrete temperatures are decreasing. Do not allow surface mounted temperature sensors to measure differential temperatures.

Do not remove protection until the temperature difference between the geometric center of the mass and forecasted low ambient temperature in the next 48 hours is less than 60 °F.

Do not exceed 160 °F for the maximum peak curing temperature.

(2) Temperature control. Control the maximum temperature and temperature differentials in the mass concrete according to the following:

(a) Submittals. Submit a mass concrete placement and curing plan for approval at least 14 days before the scheduled concrete placement for a particular mass concrete element. Include the following information in the plan:

(1) A heat generation analysis for the geometry of each mass concrete element according to ACI 207.2R, *Report on Thermal and Volume Change Effects on Cracking of Mass Concrete*. Determine the predicted concrete temperature at the center and 2 inches inside of the exterior surface exposed to air for a time period until all concrete temperatures are decreasing and the maximum temperature differential has been reached and starts to decrease, and estimate the protection period. Perform analyses for the anticipated mean weekly ambient or enclosure air temperatures for the period of the proposed placement, and for temperatures ±10 °F of the mean weekly ambient air temperature;

(2) Models developed for thermal dissipation analyses (such as the Schmidt method according to ACI 207.1R) with the site and element specific input data, output, and results;

(3) Placement and curing methods indicating how temperature controls are to be achieved; and

(4) Proposed changes to the approved concrete mix design.

(b) Temperature monitoring. Provide temperature monitoring devices to record temperature development between the interior and the exterior of the element at points shown in the approved mass concrete placement and curing plan. Monitor at least two independent sets of interior and exterior points for each element to provide redundancy in case of device failure. Locate monitoring points at the geometric center and a point 2 inches to the nearest surface of the element for the exterior point.

Use automatic sensing and monitoring devices that record information at a maximum interval of one hour. Provide devices that operate within a temperature range of 0 to 180 °F with an accuracy of ±2 °F. Take readings and record data at intervals less than six hours to ensure that the automatic devices are working properly and that the temperatures are within allowable limits. Start the intervals of one and six hours immediately after placing is complete and continue until 24 hours after the following:

(1) Maximum temperature differential is reached and starts to drop;

(2) Maximum peak curing temperature is reached and starts to drop; and

(3) Curing is complete and protection is removed.

Submit temperature readings to the CO daily.

If monitoring indicates the maximum temperature differential or curing temperature will, or has exceeded the temperature requirements, take immediate action to retard further increase in temperatures. Make necessary revisions to the approved plan to not exceed the maximum differential and curing temperatures on remaining placements. Submit revisions to the mass concrete placement and curing plan for approval before implementation.

(3) Crack repair. Submit a crack repair plan for approval.

Repair mass concrete cracks between 0.010 and 0.060 inch in width according to Section 561.

Evaluate mass concrete cracks greater than 0.060 inch in width to determine whether the cracks compromise the structure. Submit findings and proposed corrective work for approval.

Do not repair cracks until all concrete cooling operations are completed.

552.08 Handling and Placing Concrete. Handle, place, and consolidate concrete by methods that do not cause segregation and will result in dense homogeneous concrete that is free of voids and rock pockets. Construct reinforcing steel according to Section 554. Do not displace reinforcing steel or other material that is to be embedded in the concrete during concrete placement. Do not retemper concrete by adding water to the mix. Use temporary form spreader devices as appropriate.

Place concrete continuously between planned construction or expansion joints. Control the delivery rate, placing sequence, and construction methods to ensure fresh concrete is placed and consolidated against previously placed pre-initial set concrete. Do not allow time between the placement of successive batches to exceed 30 minutes.

Do not damage previously placed concrete or break the bond between the concrete and reinforcing steel. Keep workers off fresh concrete. Do not support platforms for workers and equipment directly on reinforcing steel. Once the concrete is set, do not disturb the forms or reinforcing bars that project from the concrete until it is of sufficient strength to resist damage.

Remove and replace concrete represented by cylinders having a compressive strength less than 90 percent of the minimum 28-day strength (f'_c).

Design and construct temporary works according to Section 562. Remove mortar, debris, and foreign material from the forms and reinforcing steel. Do not place concrete until the forms, embedded material, and the adequacy of the foundation material have been inspected. Uniformly moisten the forms and subgrade immediately before concrete is placed against them. Use an approved form release agent to produce a minimum of staining, air holes, and hydration discoloration.

(a) Sequence of placement. For strength determination, use either AASHTO T 22 or T 325.

(1) Substructures. Do not place loads on substructure elements including foundations, bents, piers, or abutments until concrete cylinder tests from the same concrete cured under the same conditions as the substructure element indicate that the concrete has at least 80 percent of its required 28-day compressive strength.

(2) Vertical members. For vertical members less than 15 feet in height, allow the concrete to set for at least 30 minutes before placing integral horizontal members. For vertical members 15 feet or greater in height, allow the concrete to set for at least 12 hours. Do not transfer loads from horizontal members until the concrete has attained the specified strength and has been in place at least 7 days.

Do not mount friction collars or falsework brackets on vertical members until the concrete has cured for at least 7 days or has attained the specified strength.

(3) Superstructures. Strip substructure forms and inspect concrete for defects before placing superstructure concrete.

For concrete placed in T-beams or deck girders with depths greater than 48 inches, allow 5 days cure time for the stem concrete before placing the top or deck slab.

For box girders, do not place the top slab until the stems have 5 days cure time.

(4) Arches. Place concrete for arches in alternate lateral sections to minimize shrinkage stresses. Consider deflections of the arch centering. Place other sections symmetrically with respect to the center of the bridge span. Where wide barrel arches require a longitudinal joint, place concrete on each side of the joint independently of the centering to avoid relative settlements. Bond the sections together using suitable keys or dowels.

(5) Box culverts. Place the box culvert base slab and allow 24 hours before constructing the remainder of the culvert.

(b) Placing methods. Use equipment of sufficient capacity that is designed and operated to prevent mix segregation and mortar loss. Do not use equipment that causes vibrations that could damage the freshly placed concrete. Do not use equipment with aluminum parts that come in contact with the concrete. Remove set or dried mortar from inside surfaces of placing equipment.

Place concrete as close as possible to its final position. Consolidate concrete in horizontal layers greater than 18 inches thick. Do not exceed the vibrator capacity to consolidate and merge the new layer with the previous layer. Do not place concrete at a rate that exceeds the design loading of the forms.

Do not drop unconfined concrete more than 5 feet. Concrete may be confined by using a tube fitted with a hopper head or other approved devices that prevent mix segregation and mortar spattering. This does not apply to cast-in-place piling or drilled shaft when concrete placement is completed before initial set occurs in the bottom of the piling.

Operate concrete pumps so that a continuous stream of concrete without air pockets is delivered at the tube discharge.

(c) Consolidation. Provide sufficient hand-held internal concrete vibrators or mechanical vibrator gangs suitable for the conditions of concrete placement. Use vibrators conforming to Table 552-7. Provide rubber-coated vibrators when epoxy-coated reinforcement is used.

Provide a spare vibrator on site in case of breakdown. Use external form vibrators only if the forms have been designed for external vibration and if internal vibration is not possible.

Table 552-7
Hand-held Vibratory Requirements

Head Diameter, inch	Frequency, vibrations/minute	Radius of Action, inch
¾ to 1½	9000 to 15,000	3 to 6
1¼ to 2½	8500 to 12,500	5 to 10
2 to 3½	8000 to 12,000	7 to 14

Consolidate concrete by mechanical vibration immediately after placement. Manipulate vibrators to thoroughly work the concrete around reinforcement, embedded fixtures, corners, and angles in the forms. Do not cause segregation. Do not consolidate concrete placed under water. Supplement vibration with spading, as necessary, to ensure smooth surfaces and dense concrete along form surfaces, in corners, and at locations impossible to reach with the vibrators.

Vibrate the concrete at the point of deposit and at uniformly spaced points not farther apart than one and one-half times the radius over which the vibration is visibly effective. Insert vibrators so that the affected vibrated areas overlap. Do not use vibrators to move concrete. Insert vibrators vertically and slowly withdraw from the concrete. Vibrate with sufficient duration and intensity to thoroughly consolidate the concrete, but not to cause segregation. Do not vibrate at one point long enough to cause localized areas of grout to form. Do not vibrate reinforcement.

Mechanical vibration or consolidation is not required for SCC.

(d) Underwater placement. Underwater placement of concrete is allowed only for concrete mixtures designed for underwater placement according to Subsection 552.03. Use tremies, concrete pumps, or other approved methods for placement.

(1) Tremies. Use watertight tremies, with a diameter sufficient to ensure that aggregate-induced blockages will not occur. Use multiple tremies as required. Make tremies that can be rapidly lowered to slow or stop the flow of concrete.

Seal the discharge end and fill the tremie tube with concrete at the start of concrete placement. Keep the tremie tube full of concrete to the bottom during placement. If water enters the tube, withdraw the tremie and reseal the discharge end. Maintain continuous concrete flow until the placement is completed.

(2) Concrete pumps. Use pumps with a device at the end of the discharge tube to seal out water while the tube is first being filled with concrete. When concrete flow is started, keep the end of the discharge tube full of concrete and below the surface of the deposited concrete until placement has been completed.

Place underwater concrete continuously from start to finish in a dense mass. Place each succeeding layer of concrete before the preceding layer has taken initial set using more than one tremie or pump if necessary. Keep the concrete surface as horizontal as practical. Do not disturb after placement. Maintain still water at the point of deposit.

Dewater after test specimens cured under similar conditions indicate that the concrete has sufficient strength to resist the expected loads. Remove laitance or other unsatisfactory material from the exposed concrete.

(e) Concrete railings and parapets. Use smooth, tight-fitting, rigid forms. Neatly miter corners. Place concrete railings and parapets after the falsework for the supporting span is released. Remove forms without damaging the concrete. Finish corners to be true, clean-cut, and without cracks, spalls, or other defects.

552.09 Construction Joints. Place construction joints at locations shown in the plans. Obtain approval for additional construction joints.

Extend reinforcing steel uninterrupted through construction joints. Embed lap splices or mechanical splices within the concrete. Do not use dowels. At horizontal construction joints, place gauge strips inside the forms along exposed faces to produce straight joint lines.

When the joint is between fresh and newly hardened concrete, rough float the first placement to thoroughly consolidate the surface and leave the surface in a roughened condition. Clean the joint surface of laitance, curing compound, and other foreign material. Use an abrasive blast or other approved methods to expose the aggregate on the joint surface. Re-tighten forms where the joint overlaps the first placement. Immediately before placing new concrete, flush the joint surface with water and allow it to dry to a surface dry condition.

When the joint is between existing concrete and a new placement, abrasive blast clean or use other approved methods to remove laitance and foreign material, to expose clean aggregate, and to roughen the joint surface. Before concrete placement, apply approved bonding products to the joint surface according to the manufacturer’s recommendations.

552.10 Expansion and Contraction Joints.

(a) Open joints. Form open joints with a wooden strip, metal plate, or other approved material. Remove the joint forming material without chipping or breaking the corners of the concrete. Do not extend reinforcement across an open joint.

(b) Filled joints. Cut pre-molded expansion joint filler to the shape and size of the surface being jointed. Secure the joint filler on one surface of the joint using galvanized nails or other approved means. Splice according to the manufacturer’s recommendations. After form removal, remove and neatly cut concrete or mortar that has sealed across the joint. Fill joint gaps ⅛ inch or wider with approved filler. Place necessary dowels, load transfer devices, and other devices as shown in the plans or as directed.

(c) Steel joints. Fabricate plates, angles, or other structural shapes accurately to conform to the concrete surface. Submit proposed joint opening to ensure optimal joint operation for the ambient temperature at the time of placement for approval. Securely fasten the joints to keep them in the correct position. Maintain an unobstructed joint opening during concrete placement.

(d) Compression joint seals. Use one-piece compression joint seals for transverse joints and the longest practical length for longitudinal joints. Clean and dry joints and remove spalls and irregularities. Apply a lubricant adhesive as a covering film to both sides of the seal immediately before installation. Compress the seal and place it in the joint according to the manufacturer's recommendations. Ensure the seal is in full contact with the joint walls throughout its length.

Remove and discard seals that are twisted, curled, nicked, or improperly formed. Remove and reinstall joint seals that elongate more than 5 percent of their original length when compressed. Remove excess lubricant-adhesive before it dries.

(e) Elastomeric expansion joint seal. Install the joint according to the manufacturer's recommendations and as shown in the plans.

(f) Asphaltic plug joint. Install the joint according to the manufacturer's recommendations and as shown in the plans.

552.11 Watertight Integrity Test. After completion of each expansion joint within the limits of the bridge, perform a watertight integrity test on the top surface to detect leakage. Notify the CO 5 working days before performing watertight integrity test. For each joint, perform the watertight integrity test and inspection in the presence of the CO.

Cover the entire joint system with either water ponded to a depth of at least 1 inch or continuously flowing water directly over full plan area of joint for at least 4 hours. Inspect the underside of the joints for evidence of dripping water or moisture for the duration of water application and for 2 hours after water supply is removed.

The joint system is considered watertight when no free dripping water or moisture on underdeck surfaces beneath and adjacent to the joint is observed. Before performing the test, submit a detailed procedure for the watertight integrity test for approval. Submit photographic documentation performing the watertight integrity test. Include date, time, and location of joint inspections.

If the joint system leaks, locate the place of leakage and perform repair measures necessary to stop the leakage according to the manufacturer's recommendations.

After repair measures to eliminate leakage are taken, perform a subsequent water integrity test subject to the same conditions as the original test until watertight integrity results show no dripping water or moisture. Subsequent tests carry the same responsibility as the original test.

552.12 Finishing Plastic Concrete. Strike off concrete surfaces that are not placed against forms. Float finish the concrete surface. Remove laitance or thin grout. Carefully tool non-chamfered edges with an edger. Leave edges of joint filler exposed.

Protect the surface from precipitation damage.

Provide at least two non-sagging and non-vibrating work bridges that can support the workers and equipment during placement, finishing, and curing operations. Place the work bridges at a reasonable height above the concrete surface to not impede worker performance and not touch the finished or fresh concrete surface.

(a) Striking off and floating. For bridge decks or top slabs of structures serving as finished pavements, use an approved power-driven finishing machine equipped with a screed that oscillates in a transverse direction. A power-screed or roller-screed is not allowed. Use hand-finishing methods for irregular areas if approved.

Strike off surfaces. Do not support rails within the limits of the concrete placement without approval.

Set rails or headers on non-yielding supports so the finishing equipment operates without interruption over entire surface being finished. Extend rails beyond both ends of the scheduled concrete placement a sufficient distance to enable finishing machine to finish the concrete being placed.

Set rails the entire length of continuous girder structures before placing deck concrete.

Adjust rails, headers, and strike-off equipment to the required profile and cross-section allowing for anticipated settlement, camber, and deflection of falsework.

At least 1 day before starting delivery and placement of concrete, operate the finishing machine over the entire area to be finished to check for excessive rail deflections, deck thickness, reinforcing steel cover, and to verify proper operation of equipment. Make necessary corrections before concrete placement starts.

After placing the concrete, operate finishing machine over the concrete as needed to obtain the required profile and cross-section. Always keep a slight roll of excess concrete in front of the cutting edge of the screed. Maintain this excess of concrete to the end of the pour or form and then remove and waste it. Adjust rails or headers as necessary to correct for unanticipated settlement or deflection.

Remove rail supports embedded in the concrete to at least 2 inches below the finished surface. Clean the voids of dust and debris using compressed air or other means. Apply approved bonding material in the voids. Fill the voids with fresh concrete of the same type and property as previously placed. Finish the surface with a float, roller, or other approved devices as necessary to remove local irregularities.

Remove excess water, laitance, and foreign material brought to the surface using a squeegee or straightedge drawn from the center of the slab towards each edge. Do not apply water to the surface of the concrete during finishing operations.

(b) Straightedge measurement. Check horizontal surfaces with a 10-foot metal straightedge. Check the entire surface parallel to the centerline of the bridge. Overlap the straightedge at least one-half of the length of the previous straightedge placement.

Correct deviations more than ⅛ inch from the testing edge of the straightedge. For deck surfaces that are to receive an overlay, correct deviations more than ¼ inch.

(c) Texturing. Finish after floating or at a time when finishing operations will not displace aggregate. Produce a skid-resistant surface texture on driving surfaces by grooving. Use one of the following or a combination for other surfaces as required.

(1) Grooved finish. Use a float having a single row of fins. Space fins ½ to ¾ inch on centers. Make the grooves $^1/_{16}$ to $^3/_{16}$ inch wide and ⅛ to $^3/_{16}$ inch deep. Groove perpendicular to the centerline without tearing the concrete surface or loosening surface aggregate.

On bridge decks, discontinue grooving 12 inches from curb face and provide a longitudinal troweled finish on the surface of gutters.

(2) Sidewalk finish. Strike off the surface using a strike board and then float the surface. Use an edging tool on edges and expansion joints. Broom the surface using a broom with stiff bristles, broom perpendicular to the centerline from edge to edge with adjacent strokes slightly overlapped. Produce regular corrugations not over ⅛ inch in depth without tearing the concrete. Correct porous spots, irregularities, depressions, small pockets, and rough spots while the concrete is plastic. Groove contraction joints at the required interval using an approved grooving tool.

(3) Troweled and brushed finish. Use a steel trowel to produce a slick, smooth surface free of bleed water. Brush the surface with a fine brush using parallel strokes.

(4) Exposed aggregate finish. Strike off the surface using a strike board and then float the surface. Use an edging tool on transverse and longitudinal joints that are against forms or existing pavement. Do not edge transverse joints in a continuous lane pour or longitudinal joints in a continuous dual lane pour.

Broom the surface as soon as the concrete hardens sufficiently to prevent particles of gravel from being dislodged. Use approved stiff brushes. Exercise care to prevent marring the surface and cracking or chipping of slab edges or joints. Apply a light spray of retardant to the unfinished surface to facilitate this work, if approved.

Broom transversely across the pavement. Pull the loosened semi-stiff mortar off the pavement. Remove the mortar from adjacent pavements. Then broom parallel to the pavement centerline. Continue this operation until coarse aggregate is exposed. Other methods of aggregate exposure, such as using a water spray attachment on a special exposed aggregate broom, will be allowed if satisfactory results are demonstrated.

After curing according to Subsection 552.13(b) or (c), wash the surface with water and brush to remove laitance and cement from the exposed coarse aggregate.

(d) Surface underneath bearings. Finish bearing surfaces to within ⅛ inch of plan elevation.

If a masonry plate is to be set directly on the concrete or on filler material less than ⅛ inch thick, finish the surface with a float to an elevation slightly above plan elevation. Grind the surface as necessary to provide a full and even bearing after the concrete has set.

If a masonry plate is to be set on filler material between ⅛ and ½ inch thick, finish the surface with a steel trowel. Finish or grind the surface so that it does not vary from a straightedge in any direction by more than ¼ inch.

If a masonry plate is to be set on filler material greater than ½ inch thick or when an elastomeric bearing pad is to be used; finish the surface to a plane surface free of ridges.

(e) Surface underneath waterproofing membrane deck seal. Finish to a smooth surface, free of ridges and other projections.

552.13 Curing Concrete. Start curing immediately after the free surface water has evaporated and the finishing is complete. If the surface of the concrete starts to dry before the selected cure method can be implemented, keep concrete surface moist using a fog spray without damaging the surface.

Keep surfaces to be rubbed moist after forms are removed. Cure immediately following the first rub.

Cure the top surfaces of bridge decks using the liquid membrane curing compound method combined with the water method. Apply liquid membrane curing compound immediately after finishing. Apply the water cure within 4 hours after finishing.

Cure concrete uninterrupted for at least 7 days. If pozzolans more than 10 percent by mass of the hydraulic cement are used in the mix, cure uninterrupted for at least 10 days.

(a) Forms in-place method. For formed surfaces, leave the forms in-place without loosening. If forms are removed during the curing period to facilitate rubbing, only strip forms from those areas able to be rubbed during the same shift. During rubbing, keep the surface of the exposed concrete moist. After the rubbing is complete, continue curing process using the water method for the remainder of the curing period.

(b) Water method. Keep the concrete surface continuously wet by ponding, spraying, or covering with material that is kept continuously and thoroughly wet. Covering material may consist of cotton mats, multiple layers of burlap, or other approved material that does not discolor or otherwise damage the concrete.

Cover the covering material with a waterproof sheet material that prevents moisture loss from the concrete. Use the widest sheets practical. Lap adjacent sheets at least 6 inches, and tightly seal seams with pressure sensitive tape, mastic, glue, or other approved methods. Secure material so that wind does not displace it. Immediately repair sheets that are broken or damaged.

(c) Liquid membrane curing compound method. Do not use the liquid membrane method on surfaces to receive a rubbed finish. Use on construction joint surfaces is allowed only if the compound is removed by sandblasting before placement of concrete against the joint.

Only use Type 2, white-pigmented liquid membrane on the top surfaces of bridge decks or on surfaces not exposed to view in the completed work. Use Type 1-D, clear curing compounds, on other surfaces and on colored concrete.

Mix membrane curing solutions containing pigments before use. Continue to agitate during application. Use equipment that can produce a fine spray. Apply the curing compound at a minimum rate of 1 gallon per 150 square feet in one or two uniform applications. If the solution is applied in two applications, follow the first application with the second application within 30 minutes, and apply at right angles to the first application.

Immediately apply a new coat over the damaged areas if the membrane is damaged by precipitation or other means during the curing period.

552.14 Finishing Formed and Deck Concrete Surfaces. Before finishing, remove and replace or repair rock pockets or honeycombed concrete, as approved. Refinish concrete surfaces exposed to view that have become streaked or unsightly according to the appropriate class. Finish sound, formed concrete surfaces as follows:

(a) Class 1 – Ordinary surface finish. Finish the following surfaces with a Class 1, ordinary surface finish:

(1) Under surfaces of slab spans, box girders, filled spandrel arch spans, and the roadway deck slab between superstructure girders;

(2) Interior vertical surface or T-girders of superstructures; and

(3) Surfaces to be buried and culvert surfaces above finished ground that are not visible from the traveled way or a walkway.

Start finishing as soon as the forms are removed. Remove fins and irregular projections from surfaces that are exposed or will be waterproofed. Remove bulges and offsets with carborundum stones or discs. Remove localized, poorly-bonded rock pockets or honeycombed concrete, and replace with sound concrete or packed mortar in an approved manner. Fill holes using a mortar composed of cement and fine sand from the approved mix design and mixed in the same proportions as the concrete being finished. Float to an even, uniform finish. A bonding agent may be used with approval.

Clean and point form tie cavities, holes, broken corners and edges, and other defects. Saturate the area with water. Finish the area with mortar that is less than 1-hour old. After the mortar is set, rub it if required, and continue curing. Match exposed surfaces to surrounding concrete.

Carefully tool and remove free mortar and concrete from construction and expansion joints. Leave joint filler exposed for its full length with clean, true edges.

Rub or grind bearing surfaces on piers and abutments to the specified elevation and slope.

If the final finished surface is not true and uniform, rub the surface according to Subsection 552.14(b).

(b) Class 2 – Rubbed finish. Finish the following surfaces with a Class 2, rubbed finish:

(1) Surfaces of bridge superstructures, except those surfaces designated to receive another finish;

(2) Surfaces of bridge piers, piles, columns and abutments, and retaining walls above finished ground and to at least 12 inches below finished ground;

(3) Surfaces of open spandrel arch rings, spandrel columns, and abutment towers;

(4) Surfaces of pedestrian undercrossings, except floors and surfaces to be covered with earth;

(5) Surfaces of culvert headwalls and endwalls that are above the finished ground and visible from the traveled way or walkway;

(6) Inside surfaces of culvert barrels higher than 48 inches that are visible from the traveled way. Finish for a distance inside the barrel at least equal to the height of the culvert; and

(7) Surfaces of railings.

Finish according to Subsection 552.14(a).

Thoroughly wash the surface of the concrete with water.

Apply mortar composed of cement and fine sand from the approved mix design and mixed in the same proportions as the concrete being finished. Apply mortar that can be finished in the same day.

Rub the mortar with burlap or a piece of carpet as soon as it takes initial set. If the mortar has attained final set, then rub the surface with a carborundum stone and water until form marks, projections, and irregularities are removed. Grinding is not allowed.

Fog-spray water over the finish as soon as the mortar has attained final set. Keep the surface damp for at least 2 days.

Leave a uniform surface without unsound patches, paste, powder, and objectionable marks. Continue to apply a Class 2 rubbed finish until the entire surface has a smooth texture and uniform color.

(c) Class 3 – Tooled finish. Finish according to Subsection 552.14(a). Do not use mortar blocks or wires to set reinforcing steel near the formed surface of areas to receive a tooled finish. Let the concrete set for 14 days or longer if necessary to prevent the aggregate particles from being picked out of the surface. Produce a tooled finish using pneumatic power tools. Chip away the surface mortar and break the aggregate particles to expose a grouping of broken aggregate particles in a matrix of mortar. Produce a tooled finish on a small test area for approval before proceeding. Adjust the work procedures to produce a satisfactory finish and use the same procedures to finish the designated area.

(d) Class 4 – Sandblasted finish. Finish according to Subsection 552.14(a). Let the concrete cure for at least 14 days. Protect adjacent surfaces that are not to be sandblasted. Sandblast a small test area for approval before proceeding. Use hard, sharp sand to produce an even fine-grained surface in which the mortar is cut away leaving the aggregate exposed. Do not remove mortar beyond one-third the diameter of the coarse aggregate.

(e) Class 5 – Wire brushed or scrubbed finish. Finish according to Subsection 552.14(a). Start as soon as the forms are removed. Scrub the surface with stiff wire or fiber brushes using a solution of muriatic acid. Mix the solution in the proportion of 1 part acid to 4 parts water. Scrub until the cement film or surface is completely removed and the aggregate particles are exposed. Leave an evenly pebbled texture having the appearance of fine granite to coarse conglomerate depending upon the size and grading of aggregate. Wash the entire surface with water containing a small quantity of ammonia.

(f) Class 6 – Penetrating stain. Build at least three 2- by 2-foot concrete color sample panels with varying shades of color. Use concrete from the approved mix design. After the test panels have had at least 2 weeks of outside exposure, the CO will select a test panel to serve as a guide for the colored finish. Preserve the approved color sample panel. Color designated surfaces to match the color of the approved sample.

Complete the designated finish. Do not apply the stain finish until concrete placement for the structure is complete. Remove dust, foreign matter, form oil, grease, and curing compound with a 5 percent solution of trisodium phosphate and rinse the concrete surface with clean water.

Use paper, cloth, or other means to protect surfaces not to be stain finished. Apply the finish to a dry concrete surface when the surface temperature is 40 °F or higher and the air temperature in the shade is anticipated to be 40 °F or higher during the 24 hours following application.

Apply the stain finish according to the manufacturer's recommendations. Spray, brush, or roll on the first coat of penetrating sealer and stain base. Spray, brush, or roll on the finish coat after the first coat has thoroughly dried. Apply finish to provide a uniform, permanent stain, without runs and sags to the surfaces.

Remove stain from areas not intended to be covered by the finish using an approved method.

(g) Class 7 – Grooved finish. Texture the riding surfaces by mechanical grooving. Cut grooves into the hardened concrete using a mechanical water-cooled diamond edge blade saw device which produces straight, uniformly spaced grooves at ¾-inch intervals. Provide a groove width of ⅛ inch ±0.02 inch and a groove depth of ⅛ inch plus $^1/_{16}$ inch or minus zero inch. Apply grooved finish after defects to riding surfaces have been corrected.

552.15 Concrete Anchorage Devices. Use chemical, grouted, or cast-in-place concrete anchorage devices for attaching equipment or fixtures to concrete.

Provide the following for approval:

(a) Concrete anchorage device sample;

(b) Manufacturer's installation instructions; and

(c) Material data and certifications.

Fabricate metal parts of the anchorage devices from stainless steel or from steel protected with a corrosion resistant metallic coating that does not react chemically with concrete. Provide anchorage devices complete with hardware.

For chemical or grouted anchors, conduct a system approval test on one anchor on the project, not to be incorporated in the work. Conduct a static load test according to ASTM E488. Demonstrate that the anchorage device can withstand a sustained direct tension test load according to Table 552-8 for at least 48 hours with movement no more than $^1/_{32}$ inch. Demonstrate that when loaded to failure the anchor device demonstrates a ductile failure of the anchor steel, not a failure of the chemical, grout, or concrete.

Table 552-8
Sustained Load Test Values

Anchorage Device Stud Size, inch	Tension Test Load, pound
¾	5000
⅝	4100
½	3200
⅜	2100

Install concrete anchorage devices according to the manufacturer's recommendations and so that the attached equipment or fixtures bear firmly against the concrete. Torque installed nuts to the values shown in Table 552-9 unless otherwise specified in the manufacturer's recommendations. Set bearing anchor bolts according to Subsection 564.09.

In the presence of the CO, proof load a random sample of at least 10 percent of the anchors to 90 percent of the yield stress of the steel. If an anchor fails, reset the failed anchor and proof load the reset anchor and 100 percent of remaining anchors. The proof load may be applied by torquing against a load indicator washer, applying a direct tension load to the anchor, or another approved method. After proof loading, release the load on the anchor and retighten the nuts to the torque shown in Table 552-9 or according to the manufacturer's recommendations.

Table 552-9
Torque for Anchorage Devices

Anchorage Device Stud Diameter, inch	Torque, foot-pound
¾	125
⅝	90
½	60
⅜	35

552.16 Loads on New Concrete Structures. Do not allow traffic on concrete approach slabs and bridge decks until concrete has attained the design compressive strength and has been in place 14 days or longer. Construction loads less than 4000 pounds may be placed on the approach slab or deck 7 days after the concrete is placed and the concrete in the entire span has attained a compressive strength of at least 70 percent of the specified design strength.

For precast concrete multi-beam sections, do not allow vehicles on any span until the grout has attained a strength of 3000 pounds per square inch and tie rods have been tightened.

For post-tensioned concrete structures, do not allow vehicles over 4500 pounds on any span until the prestressing steel for that span is tensioned, grouted, and cured; the grout has obtained a strength of 3000 pounds per square inch; and the tie rods are tightened. Vehicles weighing less than 4500 pounds may be allowed on a span if the mass of the vehicle was included in the falsework design.

552.17 Geocomposite Sheet Drain System and Weep Hole System. Place geocomposite sheet drain system and weep hole system according to Section 605.

552.18 Acceptance. See Table 552-10 for sampling, testing, and acceptance requirements.

Material for concrete will be evaluated under Subsections 106.02 and 106.03. Provide production certifications with each shipment of cementitious material.

The concrete mixture's slump, air content, density, and temperature will be evaluated under Subsections 106.02 and 106.04.

Concrete compressive strength will be evaluated under Subsection 106.05. The lower specification limit is the minimum required compressive strength at 28 days (f'_c) specified.

Construction of concrete structures will be evaluated under Subsections 106.02 and 106.04.

Concrete crack repair will be evaluated under Section 561.

Geocomposite sheet drain systems and weep hole systems will be evaluated under Section 605.

Reinforcing steel will be evaluated under Section 554.

Temporary works will be evaluated under Section 562.

Measurement

552.19 Measure the Section 552 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring structural concrete by the cubic yard, measure in the structure.

Do not measure the volume of concrete required, outside the neat lines of a footing, to pour against rock as shown in the plans.

Do not measure concrete for precast and prestressed concrete structural members.

Payment

552.20 The accepted quantities will be paid at the contract price per unit of measurement for the Section 552 pay items listed in the bid schedule, except the structural concrete contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05. Payment for structural concrete will be made at a price determined by multiplying the contract price by the compressive strength pay factor.

Table 552-10
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (fine & coarse)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsections 703.01 & 703.02	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Concrete composition	Measured & tested for conformance (106.04)	All	–	Subsection 552.03	1 per mix design	Source of material	If requested	Before producing	–
Production									
Produced aggregate (fine & coarse)	Process control (153.03)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–

Table 552-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Concrete (552.03)(1)	Process control (153.03)	Density	–	AASHTO T 121	1 per load after 0.25 yd^3 minimum is discharged(4)	Point of discharge at truck	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or T 196	"	"	"	"	–
		Slump(5)	–	AASHTO T 119	"	"	"	"	–
		Slump flow(6)	–	ASTM C1611	"	"	"	"	For SCC mixes only
		Temperature	–	ASTM C1064	"	"	"	"	–
Concrete (552.03)(1)	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load after 0.25 yd^3 minimum is discharged(4)	Discharge at point of placement	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or T 196	"	"	"	"	–
		Slump(5)	–	AASHTO T 119	"	"	"	"	–
		Slump flow(6)	–	ASTM C1611	"	"	"	"	For SCC mixes only
		Temperature	–	ASTM C1064	"	"	"	"	–

Table 552-10 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Concrete (552.03)[(1)]	Statistical (106.05)	Compressive Strength[(2),(3)] (28-day)	II	AASHTO R 100 & T 22	1 set per 30 yd^3 but not less than 1 per day & at least 5 sets total	Discharge stream at point of placement	Yes	28 days	Deliver verification cylinders to the CO or designated laboratory for scheduled testing

(1) Sample according to AASHTO R 60, except composite samples are not required.
(2) Cast at least four compressive strength test cylinders for 6- by 12-inch specimens or six compressive strength cylinders for 4- by 8-inch specimens and transport the cylinders to the job site curing facility.
(3) A single compressive strength test result is the average result from two 6- by 12-inch or three 4- by 8-inch cylinders cast from the same load.
(4) If three successive samples are tested and compliance with the specifications is indicated, screening tests may be reduced to an approved frequency. Resume testing frequency if a test shows a failing temperature, air content, or slump, or if directed.
(5) If a hydration stabilizer is used, limit slump loss to 2 inches as compared to slump recorded at the batch plant.
(6) Use ASTM C1611 instead of AASHTO T 119 for SCC mixes.

Section 553. — PRESTRESSED CONCRETE

Description

553.01 This work consists of prestressing precast or cast-in-place concrete by providing, placing, and tensioning prestressing steel. This work also includes installing precast, prestressed members, except piling.

Material

553.02 Conform to the following Subsections:

Anchorage devices	722.01
Grout for post-tensioned structures	701.04(c)
Non-shrink grout	701.04(b)(1)
Prestressing steel	709.02

Construction Requirements

553.03 Qualifications. Provide a professional engineer, a precast concrete manufacturing plant and QCM, grouting supervisor, and grouting personnel with experience in prestressing precast or cast-in-place concrete. At least 30 days before starting prestressed concrete work, submit the following for approval:

(a) Professional engineer. PCI Plant Quality Control Technician/Inspector Certification, Level I or higher;

(b) Precast concrete manufacturing plant and QCM. Appropriate certifications;

(c) Grouting supervisor. A résumé describing experience on projects of similar complexity and American Segmental Bridge Institute (ASBI) grouting certification;

(d) Grouting personnel. A résumé for each individual describing experience on projects of similar complexity; and

(e) Plant certification. PCI or equivalent NPCA certification.

553.04 Submittals. Perform prestressing by either pre-tensioning or post-tensioning methods. If a method is proposed that is not in the contract, submit detailed drawings of the method, material, and equipment proposed for approval at least 30 days before starting prestressing. At least 30 days before starting prestressed concrete work, submit the following according to Subsection 104.06:

(a) Method and sequence of stressing;

(b) Complete details and test results for the prestressing steel and anchoring devices;

(c) Anchoring stresses;

(d) Arrangement of the prestressing steel in the members;

(e) Tendon elongation calculations for jacking procedures;

(f) Number, spacing, and method of draping pre-tensioned strands;

(g) Other substantiating calculations for the pre-tensioning or post-tensioning method;

(h) Type of tendon ducts for post-tensioning;

(i) Pressure grouting material and equipment for post-tensioning;

(j) Locations of grout inlets and outlets;

(k) Samples of wire or strand; and

(l) Additions or rearrangement of reinforcing steel and changes in concrete dimensions.

553.05 Prestressing Steel. Provide prestressing steel that is bright and free of corrosion, dirt, grease, wax, scale, rust, oil, and other foreign material that may prevent bond between the steel and the concrete. Do not use prestressing steel that has sustained physical damage or is pitted.

Do not splice prestressing steel strands.

Do not weld or ground welding equipment on forms or other steel in the member after the prestressing steel is installed.

Failure of one wire in a 7-wire prestressing strand is acceptable if 85 percent of the required tension load is attained before failure and if the failed strand does not constitute more than 2 percent of the total area of strands in an individual beam or girder.

Extend bars using couplers which, when assembled, have at least the tensile strength of the bars.

Package prestressing steel to protect it from physical damage and corrosion during shipping and storage. Place a corrosion inhibitor in the package. Use a corrosion inhibitor that has no deleterious effect on the steel, concrete, or bond strength of steel to concrete. Replace or restore damaged packaging.

Mark the shipping package with a statement that the package contains high-strength prestressing steel and a warning to use care in handling. Identify the type, kind, and quantity of corrosion inhibitor used, including the date when placed, safety regulations, and instructions for use. Assign a lot number and tag for identification purposes to wire, strand, anchorage assemblies, and bars.

Provide representative samples of prestressing steel from prestressed members fabricated off site. In the case of wire or strand, take the sample from the same master roll.

(a) Pre-tensioning method. Provide a sample at least 6 feet long of each strand size from each coil.

(b) Post-tensioning method. Provide samples of the following lengths:

(1) For wires requiring a head, 15 feet.

(2) For wires not requiring a head, sufficient length to make up one parallel-lay cable 5 feet long consisting of the same number of wires as the cable to be provided.

(3) For strands provided with fittings, 5 feet between near ends of fittings.

(4) For bars to be provided with threaded ends and nuts, 5 feet between threads at ends.

553.06 Concrete. Construct concrete according to Section 552. Construct reinforcing steel according to Section 554.

Make at least one set of release strength test cylinders according to AASHTO T 23 in addition to those required to determine the 28-day compressive strength. Cure the release strength test cylinders with the concrete member they represent.

Rough cast the top surface of members against which concrete will be cast. Rake the top surface of members receiving a concrete overlay to a depth of ⅜ inch. Sidewalk finish the top surface of members receiving an asphalt overlay according to Subsection 552.12(c)(2). For bridge deck surfaces to be covered with a waterproofing membrane, finish to a smooth surface without ridges and other projections, and according to the waterproofing membrane manufacturer's recommendations.

Cure the girder in a saturated atmosphere of at least 90 percent relative humidity. Cure time may be shortened by heating the outside of impervious forms with radiant heat, convection heat, conducted steam, or hot air.

Apply radiant heat by pipes circulating steam, hot oil, hot water, or electric heating elements. Inspect casting beds to ensure uniform heat application. Use a suitable enclosure to contain the heat. Minimize moisture loss by covering exposed concrete surfaces with plastic sheeting or liquid membrane curing compound according to Subsection 552.13. Sandblast curing compound from concrete bonded surfaces.

Envelop the entire surface with saturated steam. Completely enclose the casting bed with tightly constructed housing to prevent the escape of steam and exclude outside air. Use steam at 100 percent relative humidity. Do not apply the steam directly to the concrete.

If using hot air, obtain approval of the method to envelop and maintain the girder in a saturated atmosphere. Do not allow dry heat to touch the girder surface.

For heat curing methods:

(a) Keep unformed girder surfaces in a saturated atmosphere throughout the curing time.

(b) Embed a thermocouple, linked with a thermometer accurate to ±5 °F, 6 to 8 inches from the top or bottom of the girder on its centerline and near its midpoint.

(c) Monitor with a recording sensor, accurate to ±5 °F, arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle.

(d) Submit the temperature record when requested.

(e) Heat concrete to no more than 100 °F during the first 2 hours after placing concrete, and increase the temperature no more than 40 °F per hour to a maximum of 160 °F.

(f) Cool concrete, after curing is complete, no more than 40 °F per hour until a temperature 20 °F above the temperature of the air to which the concrete will be exposed has been attained.

(g) Keep the temperature of the concrete above 60 °F until the girder attains release strength.

Cure precast, prestressed members to the release compressive strength. Release compressive strength is attained when the average strength of two representative test cylinders is greater than the minimum required strength and the individual strength of any one cylinder is no more than 5 percent below the required strength.

Do not expose the concrete to temperatures below 40 °F for at least 7 days after casting.

553.07 Tensioning. Use hydraulic jacks to tension prestressing steel.

Calibrate measuring devices at least once every 6 months and if they appear to be giving erratic results. Calibrate the jack and gauge as a unit with the cylinder extension in the approximate position that it will be at final jacking force. Keep a certified calibration chart with each gauge.

If a pressure gauge is used, only gauge loads from one-fourth to three-fourths of the total graduated capacity of the gauge, unless calibration data clearly establishes consistent accuracy over a wider range. Use a pressure gauge with an accurate reading dial at least 6 inches in diameter.

Measure the force induced in the prestressing steel using calibrated jacking pressure gauges, load cells, or a calibrated dynamometer. Take elongation measurements of the prestressing steel. Determine the required elongation from average load-elongation curves for the prestressing tendons used.

For pre-tensioned members, if there is a discrepancy between the gauge pressure and elongation of more than 5 percent in tendons over 50 feet in length or 7 percent in tendons of 50 feet or less in length, determine the source of error before proceeding. Do not allow discrepancies in post-tensioned members to exceed 7 percent.

If the jacking system is equipped with an automatic release valve that closes when the required prestressing force is achieved, measure strand elongation for the first and last tendon tensioned and for at least 10 percent of the remaining tendons.

If a load cell is used, do not use the lower 10 percent of the manufacturer's rated capacity of the load cell to determine the jacking force.

Do not exceed a temporary tensile stress of 80 percent of the specified minimum ultimate tensile strength of the prestressing steel. Anchor prestressing steel at an initial stress that will result in the retention of the required working stress after all losses.

For pre-tensioned members, do not allow the initial release stress after seating, and before other losses, to exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel for stress-relieved strands and 75 percent for low-relaxation strands. For post-tensioned members, do not allow the initial release stress after seating to exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel.

553.08 Pre-tensioned Members. Construct pre-tensioned members to the tolerances shown in Table 553-1.

(a) Prestressing steel. Protect prestressing steel placed in the stressing bed from contamination and corrosion if the stressing bed is to be exposed to weather for more than 36 hours before encasement in concrete.

Ensure strands are free of kinks or twists. Accurately hold prestressing steel in position and tension. Do not allow strands to unwind more than one turn. Keep a record of the jacking force and elongation measurements after the strands are tensioned to 20 percent of final jacking force.

Tension prestressing steel to the required stress. Provide a professional engineer to perform elongation computations. Include in elongation computations the strand anchorage slippage, splice slippage, in place horizontal movement of the structural member during prestressing operations, and prestressing steel temperature changes between the time of tensioning and the time when the concrete takes its initial set.

Maintain the prestress bed forms, strands, and reinforcement bar temperature within 25 °F of the temperature of the concrete to be placed in the forms. Support strands with rollers at points of direction change when strands are tensioned in a draped position. Use free-running rollers with minimal friction. Initially, when strands are tensioned and then pulled into the draped position, tension to no more than the required tension minus the increased tension due to forcing the strand to a draped profile. If the load in a draped strand at the dead end, as determined by elongation measurements, is less than 95 percent of the jack load, tension the strand from both ends of the bed. Ensure the load, as computed from the sum of elongations produced by jacking at both ends, is within 5 percent of the jack load.

Within 3 hours before placing concrete, check the tension on the prestressing strands. Obtain approval for the method and equipment for checking the loss of prestress. If strands are tensioned individually, check each strand for loss of prestress. Retension to the original computed jacking stress for strands that show a loss of prestress more than 3 percent. If strands are tensioned in a group, check the entire group for total loss of prestress. Release and retension the entire group if the total prestress shows a loss more than 3 percent or if individual strands appear significantly different from the rest of the strands in the group.

(b) Releasing steel. Release the prestress load to the concrete after the concrete has attained its required release compressive strength. Cut or release strands so that lateral eccentricity of the prestress force is minimized. Cut off prestressing steel flush with the end of the member, except as shown in the plans.

(c) Debonding strands. Use solid or split plastic sheathing with a thickness of at least $\frac{1}{32}$ inch to debond strands. Before placing concrete, use tape to thoroughly seal split and solid sheathing including ends to prevent the migration of concrete mortar along the strand.

Table 553-1
Prestressed Concrete Member Tolerances

Property	Tolerance
Post-Tensioned Members	
Position of post-tensioning ducts	±¼ in
Position of tendon anchorage bearing plates	±¼ in
Precast Concrete I-Beams and T-Beams	
Length	±⅛ in per 10 ft
Width (overall)	+⅜ in, -¼ in
Depth (overall)	+½ in, -¼ in
Depth (flanges)	-¼ in
Width (web)	+⅜ in, -¼ in
Deviation from straight line parallel to centerline of member	⅛ in/10 ft
Variation from end squareness or skew	±3/16 in/ft, ±1 in maximum
Camber variation from design camber	±⅛ in/10 ft, ±1 in maximum
Position of strands	±¼ in
Position of hold-down points for depressed strands	±6 in
Position of plates other than bearing plates	±1 in
Position of bearing plates	±⅝ in
Tipping and flushness of plates	±¼ in
Tipping and flushness of bearing plates	±⅛ in
Position of inserts for structural connections	±½ in
Position of stirrups: Longitudinal spacing Projection above top	 ±2 in ±¾ in
Local smoothness(1)	±¼ in per 10 ft

(1) Does not apply to top surface left rough to receive a topping or to visually concealed surfaces.

Table 553-1 (continued)
Prestressed Concrete Member Tolerances

Property	Tolerance
Precast Concrete Box Beams, Flat Slabs, and Decked Girders	
Length	±⅛ in per 10 ft
Width (overall)	±¼ in
Depth (overall)	±¼ in
Depth (top flange)	±½ in
Depth (bottom flange)	+½ in, -⅛ in
Width (web)	±⅜ in
Deviation from straight line parallel to centerline of member:	
Up to 40 ft member length	±¼ in
40 to 60 ft member length	±⅜ in
Greater than 60 ft member length	±½ in
Variation from end squareness or skew	±⅛ in per ft
Horizontal	±½ in maximum
Vertical	±½ in
Camber variation from design camber	±¼ in per 10 ft, ±½ in maximum
Differential camber between adjacent members of the same design	±⅛ in per 10 ft, ½ in maximum
Position of strands	±¼ in
Position of hold-down points for depressed strands	±6 in
Position of plates other than bearing plates	±1 in
Position of inserts for structural connections	±½ in
Position of stirrups:	
Longitudinal spacing	±1 in
Projection above top	+¼ in, -¾ in
Position of dowel tubes	±⅝ in
Position of tie rod tubes:	
Parallel to length	±½ in
Vertical	±⅜ in
Position of slab void:	
End of void to center of tie hole	±½ in
Adjacent to end block	±1 in
Local smoothness(1)	±¼ in per 10 ft

(1) Does not apply to top surface left rough to receive a topping or to visually concealed surfaces.

553.09 Storing, Transporting, and Erecting. Do not ship prestressed concrete members until concrete cylinder tests, manufactured of the same concrete and cured under the same conditions as the members; indicate that the concrete in each member has attained the minimum required design strength and is at least 7 days old or at least 10 days old for decked Bulb-T sections.

Before transporting prestressed concrete members, provide written certification from a professional engineer that the members were fabricated, visually inspected, and meet minimum quality requirements.

Install points of support designed by a professional engineer to prevent cracking or damage during hoisting and handling. Store, transport, and erect precast, prestressed girders, slab units, and box units in the upright position with the points of support and directions of the reactions, with respect to the member, approximately the same as when the member is in its final position. Prevent cracking or damage during hoisting, handling, and storing of the precast units.

Use high-pressure water blasting to remove debris and paste in the keyways immediately before placing mortar. Remove free-standing water and allow keyways to surface dry. Use non-shrink grout in keyways between multibeam members, blockouts, and set anchor bolts and dowels. Strike off exposed grout on surfaces until flush. Cure the non-shrink grout according to the manufacturer's recommendations. Apply the same surface texture finish to the surrounding concrete as soon as the non-shrink grout or concrete has sufficiently set.

Repair concrete defects according to Section 572. Replace units damaged by improper handling or storing if the CO determines them irreparable.

553.10 Post-Tensioned Members. Construct post-tensioned members to the tolerances shown in Table 553-1. Construct supporting falsework so that the superstructure is free to lift off the falsework and shorten during post-tensioning. Detail formwork left inside box girders to support the roadway slab to offer minimum resistance to girder shortening due to shrinkage and post-tensioning.

(a) Ducts. Use mortar-tight ducts that are sufficiently rigid to maintain their shape and alignment during concrete placement and grout installation. Use ducts with minimum wall thicknesses conforming to Table 553-2.

Table 553-2
Minimum Duct Wall Thicknesses

Duct	Minimum Thickness, gauge
Metal duct, diameter ≤ 2⅝ in	26
Metal duct, diameter > 2⅝ in	24
HDPE	14
HDPP	14
Metal duct with bar tendons preassembled with duct	31

For tendons composed of single prestressing bars, provide ducts with an internal duct diameter of at least ¼ inch larger than the outside diameter of the prestressing bar. For multiple wire, bar, or strand tendons, provide a duct nominal internal cross-sectional area of at least 2¼ times the net area of the prestressing steel. When tendons are to be placed by the pull through method, provide a duct nominal internal cross-sectional area of at least 2½ times the net area of the prestressing steel.

Make positive joints between duct sections. Do not make angles at the joints. Use waterproof tape at the joints. Do not use duct tape. Bend ducts without crimping or flattening. Use ferrous metal or polyethylene couplings to connect ducts to anchoring devices.

Protect ducts against crushing, excessive bending, dirt contamination, and corrosive elements during transport, handling, and storing.

In case of duct damage, seal duct with waterproof tape, or splice a duct coupler over the damaged section to form a seal that prevents cement paste from entering the duct during the placement of concrete and to prevent leakage during grouting operations.

Provide ducts and anchorage assemblies with inlets for the injection of grout into the duct after prestressing according to PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide ducts with outlets to allow the escape of air, water, grout, and bleed water according to PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide inlets and outlets with an inner diameter of at least ¾ inch for strand tendons and of at least ½ inch for single bar tendons. Extend the length of outlets a sufficient distance out of the concrete member to allow for the proper closing of the outlets.

Place inlets and outlets, at a minimum, in the following locations:

(1) Anchorage area of the tendon;

(2) High points of the duct, when the vertical distance between the highest and lowest point is more than 24 inches;

(3) Inlet at or near the lowest point of the tendon;

(4) Outlet at low points of the duct;

(5) Major changes in the cross-section of the duct, such as couplers and anchorages; and

(6) Outlet at a distance less than 36 inches downstream from high point outlets.

Provide positive mechanical shut-off valves for inlets and outlets. Provide inlets and outlets with valves, caps, or other devices that can withstand the grouting pressure.

Securely fasten ducts in place to prevent movement. Maintain distances from the forms by stays, blocks, ties, hangers, or other approved supports. Use precast mortar blocks of approved shape and dimensions. Separate layers of ducts by mortar blocks.

Space duct supports according to PTI, *Guide Specification for Grouting of Post-Tensioned Structures*. Cover the ends of ducts to prevent the entry of water or debris.

Connect inlets and outlets to the duct with metallic or plastic structural fasteners. Do not use components that react with concrete, cause corrosion of the prestressing steel, or contain water soluble chlorides.

(b) Placing concrete. Where the end of a post-tensioned assembly is not covered by concrete, recess the anchoring devices so that the ends of the prestressing steel and all parts of the anchoring devices are at least 2 inches inside the end surface of the members.

Before placing concrete, demonstrate that ducts are unobstructed. Immediately after concrete placement, blow out ducts with compressed, oil-free air to break-up and remove mortar in the conduit before it hardens. Approximately 24 hours after the concrete placement, flush ducts with water containing lime (calcium oxide) or slaked lime (calcium hydroxide) at a rate of 0.1 pound per gallon. Blow the water out with compressed, oil-free air.

For post-tensioned members that are to be steam cured, do not install prestressing steel until curing is complete.

(c) Anchorages and distribution. Provide at least 10 days' notice before installing end fittings or heading wires.

When wires are used, provide an edge distance for any hole for prestressing wire through a stressing washer, unthreaded bearing ring, or plate of at least ¼ inch from the root of any threads or the edge of any ring, plate, or washer.

Anchor post-tensioned prestressing steel at the ends by permanent type anchorage devices that can develop equal to or greater than 95 percent of the ultimate tensile strength of the prestressing steel. Provide a steel distribution plate or assembly to effectively distribute the compressive stresses from the anchoring device to the concrete.

Do not exceed 3000 pounds per square inch for the final unit compressive stress on the concrete directly beneath the plate or assembly. Do not allow bending stresses induced by prestressing to exceed the yield point of the material in the plates or assemblies or cause visible distortion in the anchorage plate when 100 percent of the nominal load is applied.

Enclose loop tendon anchorages in ducts for their entire length.

(d) Prestressing steel. Use a corrosion inhibitor to protect prestressing steel installed in ducts before placing and curing the concrete. Use a corrosion inhibitor that does not adversely affect the steel, concrete, or bond strength of the steel to concrete.

If prestressing steel is installed in the ducts within 10 days after concrete curing, stressing, and grouting are completed, no corrosion inhibitor is required.

(e) Post-tensioning. Wait at least 10 days after the last concrete has been placed in the member or until tests on concrete cylinders indicate that the concrete has attained the minimum required compressive strength. Demonstrate that the prestressing steel is free and unbonded in the duct. Straighten wires if necessary to produce equal stress in all wires, wire groups, or parallel lay tendons that are stressed simultaneously. Remove side forms for girders before post-tensioning.

Record gauge pressures and prestressing steel elongation continuously while tensioning prestressing steel and submit records.

Determine the loss due to friction in the prestressing process according to AASHTO, *LRFD Bridge Design Specifications*.

Use shims or other approved devices to achieve the specified anchor set loss.

(f) Grouting. Provide grout and prestressing steel that is free of dirt, loose rust, grease, or other deleterious material. Bond post-tensioned prestressing steel to the concrete by filling the void space between the duct and tendon with grout according to PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Before starting grouting operations, provide the required testing equipment on site for checking grout workability (flow cone), temperatures, and other specified tests.

Use grouting equipment that can operate continuously with little variation of pressure, which also includes a system for recirculating the grout while actual grouting is not in progress. Use grouting equipment that can maintain a pressure on completely grouted ducts and id fitted with a valve that can be locked off without loss of pressure in the duct.

Provide written certification that ingredients used in the grout meet the ASTM requirements contained in PTI, *Guide Specification for Grouting of Post-Tensioned Structures*. Include the following:

(1) Cement mill test reports;

(2) Mineral additives test reports;

(3) Chemical admixtures reports; and

(4) Test reports for other ingredients used in the grout.

For prepackaged grouts, provide the manufacturer's current certified mill test reports for the product.

Do not use compressed air to aid in the pumping of grout.

Provide grout pumps of a positive displacement type, that can provide a continuous flow of grout and maintain an outlet pressure of at least 150 pounds per square inch and has a pressure gauge with a full-scale reading of no more than 300 pounds per square inch.

Grout only when the efflux time of a grout sample immediately after mixing is between 11 and 30 seconds according to ASTM C939. When hot weather conditions may cause quick setting of the grout, cool the grout by approved methods, as necessary, to prevent blockages during pumping operations. When freezing weather conditions are possible during and following placement of grout, protect the grout from damage by freezing according to PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Provide a supply of potable water and standby flushing equipment that can develop a pumping pressure of 250 pounds per square inch with sufficient capacity to flush out partially grouted ducts.

Clean ducts of material that would impair bonding of the grout or interfere with grouting procedures. Blow out each duct with compressed, oil-free air. Check inlets and outlets for their capacity to accept injection of grout by blowing compressed, oil-free air through the system and proving each inlet and outlet in turn.

Pass grout through a screen with ⅛-inch maximum clear openings before entering the grout pump. Open grout vents before the start of grouting. Completely fill the duct by injecting grout from the lowest end of the tendon in an uphill direction. Pump grout continuously through the duct and waste at the outlet until no visible slugs of water or air are ejected, and the efflux time of ejected grout is between 11 and 30 seconds. Maintain a continuous, one-way flow of grout within a grouting stage.

Close outlets in a similar manner one after the other in the direction of the flow. Close outlets placed a short distance downstream from a high point before the associated high point outlet. Increase the grouting pressure at the injection end to at least 100 pounds per square inch and hold for at least 10 seconds. Do not remove or open valves and caps until the grout has set.

Abrasive blast clean the concrete surface of recessed anchorage assemblies. Fill anchor recesses with concrete conforming to the requirements for the structure and finish flush.

Remove ends of vents 1 inch below the roadway surface after grouting has been completed. Permanently seal recess areas.

Do not release the falsework under the bottom slab supporting the superstructure until at least 48 hours after grouting the post-tension prestressing steel or until the grout strength is obtained.

553.11 Coating Steel. Use a wire brush or abrasive blast to remove dirt and residue not firmly bonded to the metal or concrete surfaces. Clean and coat the exposed ends of the prestressing steel, post-tensioned anchor head assemblies, and a 1-inch strip of adjoining concrete.

Mix zinc-rich coating material conforming to MIL-DTL-24441. Work the coating material into voids in the prestressing tendons. Apply one thick coat to surfaces that will be covered with concrete. Apply two coats to surfaces not covered with concrete.

553.12 Continuity of Prestressed Girders. Construct continuity diaphragms between precast girders at least 90 days after girders have been prestressed. Submit supporting calculations conforming to AASHTO, *LRFD Bridge Design Specifications* when establishing continuity less than 90 days after girders have been prestressed.

553.13 Acceptance. See Tables 552-10 and 553-3 for sampling, testing, and acceptance requirements. Prestressing steel, anchor devices, and material for concrete and grout will be evaluated under Subsections 106.02 and 106.03. Provide production certifications with each shipment of hydraulic cement and prestressing steel.

Grouting will be evaluated under Subsections 106.02 and 106.04.

Concrete will be evaluated under Section 552.

Concrete repairs will be evaluated under Section 572.

Reinforcing steel will be evaluated under Section 554.

Temporary works will be evaluated under Section 562.

Measurement

553.14 Measure the Section 553 pay items listed in the bid schedule according to Subsection 109.02.

Payment

553.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 553 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 553-3
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Concrete composition	Measured & tested for conformance (106.04)	All	–	Subsection 552.03	1 per mix design	Source of material	If requested	Before producing	–
Production									
Concrete (552.03)[1]	Process control (153.03)	Density	–	AASHTO T 121	1 per load after 0.25 yd^3 minimum is discharged[4]	Point of discharge at truck	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or T 196	"	"	"	"	–
		Slump[5]	–	AASHTO T 119	"	"	"	"	–
		Slump flow[6]	–	ASTM C1611	"	"	"	"	For SCC mixes only
		Temperature	–	ASTM C1064	"	"	"	"	–

Table 553-3 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
Concrete (552.03)(1)	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load after 0.25 yd^3 minimum is discharged(4)	Discharge at point of placement	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or T 196	"	"	"	"	–
		Slump(5)	–	AASHTO T 119	"	"	"	"	–
		Slump flow(6)	–	ASTM C1611	"	"	"	"	For SCC mixes only
		Temperature	–	ASTM C1064	"	"	"	"	–
Concrete (552.03)(1)	Measured & tested for conformance (106.04)	Compressive strength(2),(3)	–	AASHTO R 100 & T 22	1 per 30 yd^3	Discharge stream at point of placement	No	Upon completing tests	–
Grout(7)	Measured & tested for conformance (106.04)	Compressive strength	–	ASTM C109	1 set of 3 per day	Grout plant	No	Upon completing tests	–

(1) Sample according to AASHTO R 60, except composite samples are not required.
(2) Cast at least four compressive strength test cylinders for 6- by 12-inch specimens or six compressive strength cylinders for 4- by 8-inch specimens and transport the cylinders to the job site curing facility. In addition to the test cylinders required to determine 28-day strength, cast two release cylinders for each concrete member. Cure the release-strength cylinders with the concrete member that they represent
(3) A single compressive strength test result is the average result from two 6- by 12-inch or three 4- by 8-inch cylinders cast from the same load.
(4) If three successive samples are tested and compliance with the specifications is indicated, screening tests may be reduced to an approved frequency. Resume testing frequency if a test shows a failing temperature, air content, or slump, or if directed.
(5) If a hydration stabilizer is used, limit slump loss to 2 inches as compared to slump recorded at the batch plant.
(6) Use ASTM C1611 instead of AASHTO T 119 for SCC mixes.
(7) Sample and test according to PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

Section 554. — REINFORCING STEEL

Description

554.01 This work consists of providing and placing reinforcing steel.

Material

554.02 Conform to the following Subsection:

Reinforcing steel	709.01

Construction Requirements

554.03 Order Lists. On reinforcing steel order lists, use the same respective bar marks for labeling as shown in the plans. Submit order lists and bending diagrams for approval. Approval does not relieve the Contractor of responsibility for the accuracy of the lists and diagrams. Do not order material until the lists and diagrams are approved.

Do not fabricate vertical reinforcement in columns, walls, piers, and shafts until footing elevations are established in the field.

554.04 Identification. Ship bar reinforcement in standard bundles, tagged and marked according to CRSI, *Manual of Standard Practice*.

Provide the following information with each shipment of steel to the project:

(a) Name and location of the steel rolling mill;

(b) Manufacturing process;

(c) Heat numbers;

(d) Sizes;

(e) Specifications;

(f) Copies of mill test analyses for chemical and physical tests; and

(g) Consignee and destination of shipment.

554.05 Bending. Fabricate reinforcing bars according to ACI SP-66, *ACI Detailing Manual*. Cold bend reinforcing bars that require bending. Limit the overall height or drop bending tolerance of deck truss bars to plus 0 inch or minus ¼ inch. Do not bend bars that are partially embedded in concrete, except as shown in the plans or otherwise allowed.

Provide standard hooks conforming to ACI SP-66.

554.06 Protection of Material. Store reinforcing steel above the ground on platforms, skids, or other supports. Protect reinforcing steel from physical damage, rust, and other surface deterioration.

Use reinforcing steel only when the surface is clean and the minimum dimensions, cross-sectional area, and tensile properties conform to the physical requirements for the size and grade of steel specified.

Do not use reinforcing steel that is cracked, laminated, or is covered with dirt, rust, loose scale, paint, grease, oil, or other deleterious material.

554.07 Epoxy-Coated Reinforcing Steel. Support coated bars on padded contact areas. Lift with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar-to-bar abrasion. Do not drop or drag bundles.

Before placement, inspect bars for coating damage. Replace and do not use bars with a total damaged area in any 12-inch length that is more than 5 percent of the surface area of that length of the bar.

Clean other damaged coatings by removing surface contaminants and the damaged coating. Roughen the area around the damage and remove rust by blast cleaning or power tool cleaning. Patch defects in the coating that are discernible to the unaided eye using a prequalified patching material conforming to ASTM A934 for epoxy-coated prefabricated reinforcement or ASTM A775 for epoxy-coated reinforcement. Overlap the patching material onto the original coating for 2 inches or according to the manufacturer’s recommendations. Provide at least 8-mil dry film thickness on the patched areas.

Take necessary steps to minimize damage to the coating of installed bars. Clean and patch damage to coatings noted after installation. Promptly treat the bar according to the resin manufacturer’s recommendations and before detrimental oxidation occurs.

For epoxy-coated prefabricated reinforcement conforming to ASTM A934, coat mechanical splices after splice installation according to ASTM A934 for patching damaged epoxy coatings. For epoxy-coated reinforcement, coat mechanical splices after splice installation according to ASTM A775 for patching damaged epoxy coatings.

554.08 Placing and Fastening. Place, fasten, and support the bars according to the CRSI, *Manual of Standard Practice*. Coat chairs, tie wires, and other devices used to support, position, or fasten epoxy-coated reinforcement with a dielectric material.

Use precast concrete blocks or metal supports. Attach concrete block supports to the supported bar with wire cast in the center of each block. Use Class 1 (plastic protected) or Class 2, Type B (stainless steel protected) metal supports in contact with exposed concrete surfaces. Use stainless steel conforming to ASTM A493, Type 430.

Space slab bar supports no more than 48 inches apart transversely or longitudinally. Do not use bar supports either directly or indirectly to support runways for concrete buggies or other similar construction loads. Replace damaged supports.

Place bars no more than 1½ inches from the plan location. Do not cumulate spacing variations. Do not allow the average of any two adjacent spaces to exceed the required spacing. Place reinforcing steel in deck slabs within ¼ inch of the vertical plan location. Using a template, check the clear cover over deck reinforcing steel before placing deck concrete.

Provide 2 inches clear cover for reinforcement. The tolerance on minimum concrete cover is minus ⅜ inch. For concrete surfaces cast against the ground provide at least 3 inches of clear cover over reinforcement.

Tie reinforcing at intersections around the perimeter of each mat and at no more than 24-inch centers or at every intersection, whichever is greater. Tie bridge deck reinforcing bars at no more than 12 inches or every intersection, whichever is greater.

Tie bundle bars together at intervals no more than 6 feet. Do not bundle bars unless the location and splice details are specified.

Do not place concrete in members until the reinforcing steel placement is approved.

554.09 Splices. Do not splice, except as shown in the plans, without approval. Provide lap lengths shown in the plans.

Make lapped splices by placing the reinforcing bars in contact and wiring them together to maintain the alignment and position of the bars.

If welding of reinforcing steel is allowed, use welders with current certifications and weld according to AWS D1.4, *Structural Welding Code – Steel Reinforcing Bars*. Do not weld reinforcing steel conforming to AASHTO M 31 or corrosion-resistant reinforcing steel bars. Do not weld reinforcing steel if its carbon equivalent exceeds 0.55 percent.

Mechanical couplers may be used if approved. Use couplers with a strength that is at least 125 percent of the required yield strength of the reinforcing steel. Do not exceed 0.01 inch total slip of the reinforcing bar within the splice sleeve when loading in tension to 30.0 kips per square inch and relaxing to 3.0 kips per square inch for bar sizes up to No. 14 as measured between gauge points clear of the splice sleeve.

For mechanical couplers used in the superstructure slab, use only butt type splices.

Use only epoxy coated mechanical couplers for joining epoxy coated reinforcing. For corrosion-resistant steel reinforcing bars, use only mechanical butt couplers of the same material as the bars being spliced.

Provide clear coverage at splice sleeves of at least 1.75 inches measured from the surface of the concrete to the outside face of the sleeve. Do not place slab bar mechanical splices adjacent to each other.

Use mechanical splices according to the manufacturer's recommendations.

If welded wire fabric is shipped in rolls, straighten into flat sheets before placing. Splice sheets of mesh or bar mat reinforcement by overlapping at least 1-mesh width plus 2 inches. Securely fasten at the ends and edges.

554.10 Acceptance. Reinforcing steel and epoxy coating material will be evaluated under Subsections 106.02 and 106.03. Provide a production certification with each shipment of reinforcing steel.

Placement of reinforcing steel will be evaluated under Subsections 106.02 and 106.04.

Measurement

554.11 Measure the Section 554 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure reinforcing steel laps added for the Contractor's convenience.

Do not measure reinforcing steel for precast, prestressed concrete structural members.

Payment

554.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 554 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 555. — STEEL STRUCTURES

Description

555.01 This work consists of constructing steel structures and the steel structure portions of composite structures.

Material

555.02 Conform to the following Section:

Structural metal	717

Construction Requirements

555.03 Submittals. Submit the following according to Subsection 104.06:

(a) Steel certifications. Provide copies of mill orders at the time orders are placed with the manufacturer. Provide certified mill test reports and production certifications before the start of fabrication using material covered by these reports.

Include on certified mill test reports the chemical analyses and physical test results for each heat of steel used in the work and for steels with specified impact values, include the results of Charpy V-notch impact tests. Confirm on the test report that the material was so produced when fine-grain practice is specified.

Provide production certifications instead of mill test reports for material that is not normally supplied with mill test reports and for items such as fills, minor gusset plates, and similar material when quantities are small and the material is taken from stock.

(b) Fabrication drawings. Show complete detailed dimensions and sizes of component parts of the structure and details of miscellaneous parts.

Show the direction of plate rolling where specific orientation of plates is required. Show plate girder flanges and webs cut from plates so the long dimension of the girder parallels the rolling direction.

Identify the type and grade of each piece that is to be made of steel other than AASHTO M 270, Grade 36 steel.

Show assembly marks that are cross-referenced to the original pieces of mill steel and their certified mill test reports.

Show shop-welded splice locations. Locate shop-welded splices to avoid points of maximum tensile or fatigue stress. Locate splices in webs at least 12 inches from shop splices, flange butt joints, or stiffeners. Additional nondestructive tests may be required on shop-welded splices.

(c) Erection drawings. Fully illustrate the proposed method of erection. Show details of falsework bents, bracing, guys, dead-men, lifting devices, and bridge member attachments. Show the erection sequence, crane and barge locations, crane capacities, lifting point locations, and bridge member masses. Show complete details for anticipated phases and erection conditions. If required during drawing review, provide calculations showing that allowable stresses are not exceeded and that member capacities and final geometry are correct. Include drawings for temporary works according to Section 562.

(d) Camber diagram. Show the camber at each truss or arch rib panel point, at field splice locations, and at the specified span length fractions of continuous beams and girders or rigid frames. Show calculated cambers to be used in preassembly of the structure according to Subsection 555.14.

(e) Transportation drawings. Show support points, tie-downs, temporary stiffening trusses or beams, and other details needed to support and brace the member. Provide calculation sheets showing self-weight plus dynamic load allowance stresses induced by the loading and transportation procedure. Use dynamic load allowance stresses of at least 100 percent of the self-weight dead load stress. Do not allow fatigue stresses to exceed the constant-amplitude fatigue threshold for the appropriate categories. Verify computed girder stresses satisfy the AASHTO, *LRFD Bridge Design Specifications*.

Ship and store members in the same orientation as the completed structure unless otherwise approved.

555.04 Fabrication Notice. Give written notice at least 21 days before starting fabrication work. Do not manufacture material before notification and drawings are approved.

555.05 Inspection. Ultrasonically inspect girder flanges before fabrication according to ASTM A578 and the following:

(a) Inspect after flanges are stripped from the master plate;

(b) Use ASTM A578, Supplementary Requirement S2.1 for acceptance standards; and

(c) Inspect flanges in the plant or warehouse where the flanges are stripped.

555.06 Storing Material. Store structural material above the ground on platforms, skids, or other supports. Keep material free of dirt, grease, and other foreign matter. Protect from corrosion and stray electrical currents.

555.07 Fabrication. Fabricate structural steel in a fabricating plant that is certified under the AISC, *Quality Certification Program*. Provide and fabricate fracture critical elements according to AASHTO, *LRFD Bridge Design Specifications* and Clause 12 of the AASHTO/AWS D1.5, *Bridge Welding Code*.

Remove mill scale and foreign material from exterior surfaces of exterior girders of uncoated weathering steel by blast cleaning according to SSPC-SP6, *Commercial Blast Cleaning*. Then dry the surface and apply at least three uniform applications of water mist at 24-hour intervals to ensure uniform weathering.

Do not heat curve steel girders.

Do not drill, cut, or weld portions of structural members unless shown in the plans or approved in writing.

Coat structural steel according to Section 563.

Fabricate bearing devices according to Section 564.

(a) Steel identification. Use a system of assembly-marking of individual pieces and cutting instructions (generally by cross referencing of the assembly-marks shown in the drawings with the corresponding item covered on the mill purchase order). Provide information to the shop that maintains the identity of the original piece.

Identify material provided from stock by heat number and mill test report.

During fabrication and before assembling members, show the specification of each piece of steel. Mark steel using steel die stamping or firmly attaching a substantial tag to pieces of steel which will be subject to fabricating operations which might obliterate paint marking before assembling into members. These fabrication operations include blast cleaning, galvanizing, heating for forming, or coating.

Use low-stress type steel die stamps. Avoid impressions near edges of tensile-stressed plate members. Do not use die stamps on fracture-critical members.

Provide an affidavit certifying the identification of steel has been maintained throughout the fabrication operation.

(b) Plates.

(1) Rolling direction. Cut and fabricate steel plates for main members and splice plates for flanges and main tension members, so that the primary direction of rolling is parallel to the direction of the principal tensile and compressive stresses.

(2) Plate cut edges.

(a) Edge planing. Remove sheared edges on plates thicker than ⅝ inch to a depth of ¼ inch beyond the original sheared edge or beyond re-entrant cuts produced by shearing. Fillet re-entrant cuts before cutting.

(1) Oxygen cutting. Perform oxygen cutting according to AASHTO/AWS D1.5, *Bridge Welding Code*.

(2) Visual inspection and repair of plate cut edges. Visually inspect and repair plate cut edges. Conform to AASHTO/AWS D1.5, *Bridge Welding Code*.

(b) Flange plates. Provide flange plates with either oxygen-cut edges that have ground corners chamfered at least 1⁄16 inch or provide universal mill plates.

(c) Web plates. Use oxygen cutting to provide the prescribed camber in web plates of built-up beams and girders, box girders, and box arches. Cut sufficient extra camber into the webs to provide for camber losses due to welding and cutting.

(d) Truss members. Prepare longitudinal edges of plates in welded sections of truss web and chord members by oxygen cutting. Use grinding to chamfer the edges of the corners of plates at least 1⁄16 inch if plates are not joined by welding.

(e) Stiffeners and connection plates. Sheared edges may be used on plate thicknesses up to ¾ inch for stiffeners and connection plates welded transverse to girder webs and flanges.

Universal mill plate may be used for plate thicknesses up to 1 inch. Provide other stiffeners and connection plates with oxygen-cut edges.

(f) Lateral gusset plates. Bolted lateral gusset plates may be provided with sheared edges provided the thickness is less than or equal to ¾ inch. Oxygen cut, parallel to lines of stress, gusset plates and other connections welded parallel to lines of stress in tension members where the plate thickness exceeds ⅜ inch.

(g) Splice plates and gusset plates. Provide with oxygen-cut edges.

(h) Bent plates. Provide un-welded, load-carrying, rolled steel plates.

Bend plates at right angles to the direction of rolling, except cold-bent ribs for orthotropic-deck bridges may be bent in the direction of rolling.

Before bending, round the plate corners to a radius of $\frac{1}{16}$ inch throughout the portion of the plate where the bending occurs.

Cold bend fracture-critical steels and nonfracture-critical plates and bars.

The minimum bending radius for plates bent perpendicular to the direction of rolling is 5 times the plate thickness, except for cross-frame or diaphragm connection plates up to ¾-inch thick, for which the bending radius is 1.5 times the plate thickness.

Orient bend lines perpendicular to the direction of the final rolling of the plate where possible. For plates bent parallel to the direction of rolling, the minimum bending radius is increased to 7.5 times the plate thickness, except for web splice plates, fillers, gusset plates not serving as chord splices, connection plates, and web stiffeners.

Hot bend steel members only if allowed in the plans. Hot bend the plates at a temperature less than 1200 °F, except for Grades HPS 70W and HPS 100W. Do not heat Grades HPS 70W and HPS 100W to a temperature greater than 1100 °F.

(c) Stiffener fit. Fabricate (mill, grind, or weld) girder end bearing stiffeners and concentrated load bearing stiffeners to provide full bearing on the flanges to which the load is transmitted or received. Fabricate intermediate stiffeners to provide a tight fit against the compression flange.

(d) Abutting joints. Mill or saw cut abutting joints in truss and column compression members to obtain a square joint and uniform bearing. Other joints not required to be faced may have openings up to ⅜ inch.

(e) Bearing surface facing. Finish bearing surfaces as shown in Table 555-1 and American Society of Mechanical Engineers (ASME) B46.1, *Surface Texture (Surface Roughness, Waviness and Lay), Part I*.

Table 555-1
ASME Surface Roughness Values

Bearing Surface	Surface Roughness Value, microinch
Steel slabs	2000
Heavy plates in contact in shoes to be welded	1000
Milled ends of compression members, milled or ground ends of stiffeners & fillers	500
Bridge rollers & rockers	250
Pins & pin holes	125
Sliding bearings	125

Machine sliding bearings with a surface roughness greater than 75 microinches so the lay of the cut is parallel to the direction of movement.

Fabricate bearing parts to provide uniform even contact with the adjacent bearing surface. Limit the maximum gap between bearing surfaces to 0.04 inch. Machine the base plate sliding surfaces if the plane and true base and sole plates exceed the surface roughness value shown in Table 555-1.

Machine surfaces of fabricated assemblies only when heat treatment and fabrication on the assembly is complete.

(f) Straightening material. Straighten plates, angles, other shapes, and built-up members using methods that do not fracture or damage the metal when approved.

Use mechanical means or a limited amount of localized heat when approved. Do not exceed the temperatures shown in Table 555-2 and control the heat application with temperature-indicating crayons, liquids, or bimetal thermometers. Remove external forces from the material to be straightened, except for the mechanical stress designed to be used in conjunction with the heat.

Table 555-2
Maximum Straightening and
Stress Relieving Holding Temperatures

Material	Maximum Temperature, °F
Grades HPS 70W & HPS 100W	1100
Other Steels	1200

555.08 Annealing and Stress Relieving. Normalize and anneal (full annealing) according to ASTM A941. Maintain uniform temperatures throughout the furnace during the heating and cooling so the temperature at no two points on the member differs by more than 100 °F.

Record each furnace charge, identify the pieces in the charge, and show the temperatures and schedule used. Provide proper instruments including recording pyrometers for determining member temperatures. Provide records of the treatment operation for approval.

Do not anneal or normalize Grade HPS 100W or HPS 70W steel members without approval. See Table 555-2 for the maximum stress relieving holding temperature for these grades.

Relieve stress from members (such as bridge shoes, pedestals, or other parts that are built-up by welding sections of plate together) according to Subsection 4.4 of the AASHTO/AWS D1.5, *Bridge Welding Code*.

555.09 Bolt Holes. Punch or drill bolt holes. If required below, either subpunch or subdrill holes $^{3}/_{16}$ inch smaller than the nominal bolt diameter and after assembling ream or drill full size.

(a) Punched holes. Unless subpunching and reaming is required by Subsection 555.09(h), punch material forming parts of a member composed of 5 thicknesses or less of metal if the material thickness is no greater than:

(1) ¾ inch for Grade 36 steel;

(2) ⅝ inch for Grade 50, 50W, 50S, and HPS 50W steel; or

(3) ½ inch for Grade HPS 70W and HPS 100W steel.

Punch holes $^{1}/_{16}$ inch larger than the nominal bolt diameter. Ream holes that require enlarging to admit bolts. Produce clean cut holes without torn or ragged edges.

(b) Reamed or drilled holes. Subdrill and ream or drill holes full-size where there are more than five thicknesses or where the main material is thicker than Subsections 555.09(a)(1) through (3).

Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling. Where practical, use twist drills, twist reamers, or roto-broach cutters directed by mechanical means. Ream or drill cylindrical holes $^{1}/_{16}$ inch larger than the nominal bolt diameter that are perpendicular to the member. Remove burrs on the outside surfaces.

(c) Accuracy of holes. Drilled or reamed holes may be up to $^{1}/_{32}$ inch larger than the true decimal equivalent of the nominal diameter of the drill or reamer. Punched holes may be slightly conical. Slotted holes produced by flame-cutting or a combination of drilling or punching and flame cutting, may be up to $^{1}/_{32}$ inch larger than the nominal width. Grind flame cut surfaces smooth to a maximum surface roughness of 1000 microinches.

(d) Accuracy of hole group before reaming. Punch, subpunch, or subdrill holes to allow a cylindrical pin $^{3}/_{16}$ inch smaller in diameter than the nominal size of the punched hole can be inserted in holes after assembling (before reaming). In addition, produce at least 75 percent of the contiguous holes in the same plane such that a cylindrical pin ⅛ inch smaller in diameter than the nominal size of the punched hole can be inserted perpendicular to the face of the member without drifting.

(e) Accuracy of hole group after reaming. Use dimensioned steel templates with hardened steel bushings in the holes. Use connection centerlines when locating templates from the milled or scribed ends of members. Produce at least 85 percent of the holes in a contiguous group of holes with a maximum offset of $^{1}/_{32}$ inch between adjacent thicknesses of metal after reaming or drilling.

(f) Numerically-controlled drilled field connections. Drill or punch full-sized bolt holes in unassembled pieces and connections using numerically-controlled drilling or punching equipment.

(g) Holes for ribbed bolts, turned bolts, or other approved bearing-type bolts. Provide finished holes with a driving fit.

(h) Preparation of field connections. Drill full size holes through all thicknesses of material assembled in proper position for field connections and field splices. Do not punch full-size holes in longitudinal main load-carrying members, transverse floor beams, or components designated as fracture critical members. Other options include the following:

(1) Main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frame connections and splice holes. Subpunch or subdrill and ream while assembled or drill full size to a steel template.

(2) Rolled beam stringers continuous over floor beams or cross frames. Drill full-size holes for field splices unassembled to a steel template.

(3) Floor beam and stringer field end connection holes. Subpunch and ream while assembled or drill full size to a steel template.

(4) Cross frames, lateral bracing components, and the corresponding holes in connection plates between girders and cross frames or lateral components. Punch full-size holes.

Locate, position, and firmly bolt the template in place when reaming or drilling full size field-connection holes through a steel template. Use duplicates of templates used for reaming matching members or the opposite faces of a single member. Locate templates used for connections on like parts or members so that the parts or members are duplicates and require no match-marking.

555.10 Pins and Rollers.

(a) Fabricating pins and rollers. Fabricate straight and smooth pins and rollers without flaws.

Forge and anneal pins and rollers or use cold-finished carbon steel shafting for diameters less than 9 inches. Slowly cool forged pins to a temperature below the critical range to prevent damage from rapid cooling. Bore a hole in the pin at least 2 inches in diameter full-length along the pin axis before annealing.

(b) Boring pin holes. Do not exceed the pin diameter by more than $1/50$ inch for pins 5 inches or less in diameter or exceed by more than $1/32$ inch for larger pins when boring pin holes. Bore pin holes smooth, straight, at right angles with the axis of the member, and parallel with each other. Produce the final surface using a finishing cut.

Produce a maximum variation in the distance outside-to-outside of end holes in tension members and inside-to-inside of end holes in compression members of $1/32$ inch from that specified. Bore pin holes in built-up members after the member is assembled.

(c) Threads for bolts and pins. Conform to the ASME B1.1, *Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms)*, Class 2A for external threads and Class 2B for internal threads. Provide six threads per inch for pin ends with a diameter of $1\frac{3}{8}$ inches or greater.

555.11 Eyebars. Provide eyebars that are straight and without twists. Limit the inclination of bars to the plane of the truss to a 0.5 percent slope.

Locate pin holes on the centerline of the eyebar. Securely clamp eyebars that are to be placed side-by-side in the structure in the order they are to be placed on the pin. Bore the pin holes to the finished diameter from both ends or flame cut the pin holes at least 2 inches smaller than the finished pin diameter.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically operated torches abreast of each other guided by a substantial template to prevent distortion of the plates.

Use low-stress type steel die stamps to match-mark eyebars for shipment and erection. Locate stamps on the visible edge each member when the bars are nested in place on the structure.

555.12 Assembly Bolting. Clean metal contact surfaces. Assemble, securely pin, and draw together member parts. Drill, ream, and bolt the assembly. If necessary, take assembly apart to remove burrs and shavings produced by the operation.

Assemble the members without twists, bends, and other deformation. Drift only enough to bring the parts into position without enlarging holes or distorting metal.

555.13 Welded Connections. Conform to AASHTO/AWS D1.5, *Bridge Welding Code*. Install shear connector studs according to Chapter 9. Perform preproduction testing according to Subsection 9.7.1 and inspect installed studs according to Subsection 9.8.

555.14 Preassembly of Field Connections. Submit method and details of preassembly for approval.

Preassemble field connections of truss, arch, continuous beam, plate girder, bent, tower, and rigid frame main members. Use preassembly methods and details consistent with approved erection procedures and camber diagrams.

Assemble girders and beams in their cambered (no load) condition. When members are assembled with webs vertical, support the members at intervals of 20 feet, or two-tenths of the span length, whichever is less. When the webs are horizontal, support intervals may be increased provided there is no noticeable deflection between points of support.

Assemble trusses in full dead-load position unless the design of the structure provides for secondary stresses created by the fully cambered assembly. Start assembly from a location in the structure and proceed in one or both directions. Support trusses at each panel point. Preassemble at least three contiguous panels. For successive assemblies, include at least one section or panel of the previous assembly plus two or more sections or panels added at the advancing end. For structures longer than 150 feet, make each assembly at least 150 feet long.

Verify the geometry of the completed structure or unit. Verify or prepare field splices.

(a) Bolted connections. Where applicable, assemble major components with milled ends of compression members in full bearing. While assembled, ream subsized holes to the specified size.

(b) Check assembly. Make a check assembly for each major structural type of each project based on proposed order of erection, joints in bearings, special complex points, or similar considerations. Assemble at least three contiguous shop sections. For trusses, assemble members in at least three contiguous panels, but at least the number of panels associated with three contiguous chord lengths (such as the length between field splices). Other shop assemblies are not required.

Obtain approval of each assembly before reaming holes or dismantling the assembly. Inaccurate camber, alignment, hole alignment, milled joint fit, or other problems may require additional check assemblies.

(c) Field-welded connections. Do not field weld connections unless specifically shown in the drawings. Verify the fit of members, including the proper space between abutting flanges, with the segment preassembled.

(d) Match marking. Match mark connecting parts preassembled in the shop to ensure proper fit in the field. Provide a diagram showing match-marks.

555.15 Connections Using Unfinished or Turned Bolts. Use bolts conforming to ASTM A307, Grade A with single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope more than 1:20 with respect to a plane normal to the bolt axis.

For turned bolts, provide hex headed bolts of the nominal size specified with a body surface ANSI roughness less than 125 microinches. Ream holes to provide for a light driving fit. Keep bolt threads outside of the holes. Provide a washer under the hexagonal nut.

555.16 Connections Using High-Strength Bolts.

(a) Bolted parts. Use only steel material within the grip of the bolt with no compressible material (such as gaskets or insulation). Fabricate steel parts to fit solidly together after bolts are stressed. Remove burrs that prevent solid seating. Limit the slope between the bolted surface and the plane normal to the bolt axis to 1:20.

(b) Surface conditions. Clean dirt, foreign material, and scale (except tight mill scale) from joint surfaces at the time of assembly. Remove coating, including inadvertent overspray, from areas within the bolt pattern. In non-coated joints, exclude or remove coating closer than 1 inch or one bolt diameter, whichever is larger, from the edge of holes.

(c) Rotational-capacity tests. If ordered, or if bolt assembly components were relubricated, perform field rotation-capacity tests according to ASTM F3125 Annex A2 for ASTM F3125 bolts, and ASTM F3148 Annex A1 for ASTM F3148 bolts. Rotational-capacity testing are not required for twist-off bolts (ASTM F3125 Grade F1852 or F2280).

(d) Pre-installation verification (PIV) testing. Provide a calibrated bolt tension measuring device with bushings and hardened spacers to test the diameter and lengths of bolt assemblies used in the project. Provide documentation of annual testing by an approved testing agency confirming the accuracy of the bolt tension measuring device.

At the start of work, perform a PIV test in a bolt tension measurement device using a representative sample of at least 3 fastener assemblies of each rotation-capacity lot and assembly orientation to be used in the work. Demonstrate the method used to develop a snug condition. Validate the installation method after snugging develops a tension equal to or greater than shown in Table 555-3. Perform periodic retesting when ordered.

Table 555-3
Minimum PIV Fastener Tension(1)

Nominal Bolt Diameter, inch	Specified Minimum Tensile Strength of 120(2) ksi, pounds	Specified Minimum Tensile Strength of 144(3) or 150(4) ksi, pounds
½	13,000	16,000
⅝	20,000	25,000
¾	29,000	37,000
⅞	41,000	51,000
1	54,000	67,000
1⅛	67,000	84,000
1¼	85,000	107,000
1⅜	102,000	127,000
1½	124,000	155,000

(1) Equal to 1.05 times minimum installation tension.
(2) Includes ASTM F3125 Grade A325 and F1852 bolts.
(3) Includes ASTM F3148 Grade 144 bolt.
(4) Includes ASTM F3125 Grades A490 and F2280 bolts.

Start all verification tests from the same condition. Install the bolting assembly in a calibrated bolt tension measuring device so that at least three and no more than five threads are located between the bearing face of the nut and the bolt head. Install the bolting assembly to the snug tight condition using the tools, bolting components, assembly configuration, and installation methods to be used in the work.

Perform verification tests for bolts too short to be installed in a bolt tension measuring device in solid steel plates with direct tension indicators (DTIs) instead of a tension measuring device. First calibrate the DTI lot with a longer grip surrogate bolt in the bolt tension measuring device. Pretension the assembly to the required verification tension shown in Table 555-3 and measure an average gap to the nearest 0.001 inch. Install the short bolt assembly in the solid steel plate with the DTI from the calibrated lot and perform the prescribed pre-tensioning method. Verify that the average gap in the calibrated DTI is no more than the calibrated gap determined from the surrogate bolt calibration.

Do not use DTIs as a bolt tension measurement device for the turn-of-nut and combined installation methods.

(1) Turn of nut verification. After snugging the bolt assembly in the bolt tension measurement device, apply the rotation shown in Table 555-4 to the bolt assembly. After rotation, confirm the bolt tension exceeds that shown in Table 555-3. If tension is less than shown in Table 555-3, determine the cause and resolve before installing bolt assemblies. Cleaning, lubrication, and retesting of these bolting assemblies is allowed if all assemblies are treated in the same manner.

To verify bolts that are too short to fit in a bolt tension measuring device, install the bolt in a solid steel plate, snug tighten, and apply the prescribed number of turns from Table 555-4. Fracture of the fastener or stripped threads results in failure of the test. After the assembly is removed, run the nut down the bolt by hand. If the nut can be run down the complete thread length of the bolt, excluding thread run-out, the threads are not stripped and the bolt assembly passes the PIV test.

Table 555-4[1]
Nut Rotation from the Snug-Tight Condition[2]

Bolt Length Measured from Underside of Head to End of Bolt	Geometry of Outer Faces of Bolted Parts		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis & Other Face Sloped No More than 1:20 (Bevel Washer Not Used)	Both Faces Sloped No More Than 1:20 from Normal to Bolt Axis (Bevel Washers Not Used)
Up to & including 4 diameters	⅓ turn	½ turn	⅔ turn
Over 4 diameters, but no more than 8 diameters	½ turn	⅔ turn	⅚ turn
Over 8 diameters, but no more than 12 diameters	⅔ turn	⅚ turn	1 turn

(1) Applicable only to connections where all material within the grip of the bolt is steel.
(2) Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned.
The tolerance is minus 0, plus 60°.

(2) Calibrated wrench verification. After snug tightening the bolt assembly in the bolt tension measurement device, determine the torque required for the installation tool to develop a pretension in the bolting assembly to at least the required verification tension shown in Table 555-3. Use the largest torque measured from the three assemblies tested as the minimum installation torque. Use the nut as the turned element in the calibrated wrench method.

When tightening from a snug-tight condition, verify that the wrench adjustment selected by the calibration does not produce a nut rotation greater than shown in Table 555-4. If the rotation is greater than shown in Table 555-4, determine the cause and resolve before bolt assemblies are installed in the work. Cleaning, lubrication, and retesting of these bolting assemblies is allowed if all assemblies are treated in the same manner.

(3) Twist-off tension control bolt verification. After snug tightening the bolt assembly in the bolt tension measurement device, tighten the assembly with the installation tool until the splined end shears off. After the splined end has sheared off, confirm the bolt tension exceeds the required verification tension shown in Table 555-3. If tension is less than shown in Table 555-3, determine the cause and resolve before installing bolt assemblies.

(4) DTI verification. Perform PIV testing for each combination of bolt, nut, and washer rotational-capacity lot; DTI lot; DTI position and orientation; turned element (bolt head or nut) planned in the work, and when the condition of the fasteners or the knowledge or practice of the wrench operator is in question. Position the DTI under the stationary element or place a hardened washer between the DTI and the turned element. Follow the DTI manufacturer's recommendations for placement and type of hardened washers. If the bolt is the turned element, place the DTI on the nut side of the fastener assembly.

Depending on the DTI position and orientation, a flat plate bushing may be needed for bolt tension measurement device. Install the bolt, nut, washer, and DTI assembly in the bolt tension measurement device so that at least three and preferably no more than five threads are located between the bearing face of the nut and the bolt head. Tension the bolt to the load shown in

Table 555-3. If an impact wrench is used, ensure the tension developed using the impact wrench is no more than two-thirds of the required tension. Use a non-impacting method to achieve the required tension. Ensure the number of refusals of the 0.005-inch tapered feeler gauge is no more than shown in Table 555-5.

Table 555-5
DTI 0.005-Inch Feeler Gauge Verification Refusal Requirements

DTI Spaces	Maximum Verification Refusals	
	Coated DTIs under turned element	All other cases
4	3	2
5	4	2
6	5	3
7	6	3
8	7	4
9	8	4

Further tension the bolt until the feeler gauge is refused at all spaces without dead flatting the DTI. Do not exceed 95 percent of the average peak tension from the rotation-capacity test results in the bolt in this condition. Remove the bolt from the bolt tension measurement device and run down the nut by hand for the complete thread length of the bolt excluding thread run-out.

If any of the above three criteria are not met, determine the cause and resolve before installing bolt, nut, washer, and DTI.

(5) Combined method verification. Apply the manufacturer's recommended initial torque and ensure the bolt tension device reads more than the manufacturer's minimum initial tension. Apply the manufacturer's recommended angle and ensure the bolt tension measurement device reads a final tension at least the required verification tension shown in Table 555-3. If final tension is less than shown in Table 555-3, determine the cause and resolve before installing bolt assemblies.

(e) Washers. Conform to ASTM F436. Use a hardened beveled washer where the outer face of the bolted parts has a slope greater than 1V:20H with respect to a plane normal to the bolt axis.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels.

If necessary, clip washers on one side to within seven-eighths times the bolt diameter measured from the washer center.

Under the following conditions use hardened washers for connections using ASTM F3125, Grade A325 and Grade A490 bolts:

(1) Under the turned element if the tensioning is done by the calibrated wrench method;

(2) Under both the head and the nut when Grade A490 bolts are installed in material having a specified yield point less than 40 kips per square inch; and

(3) As shown in Table 555-6.

Table 555-6
Washer Requirements for Oversize or Slotted Holes in Outer Plies

<table>
<tr><th rowspan="2">Bolt Specified Minimum Tensile Strength</th><th rowspan="2">Nominal Bolt Diameter, inch</th><th colspan="2">Hole Type in Outer Ply</th></tr>
<tr><th>Oversized or Short-Slotted</th><th>Long-Slotted</th></tr>
<tr><td>120 ksi</td><td>½ to 1½</td><td rowspan="2">ASTM F436(1)</td><td rowspan="2">Minimum 5/16 in-thick plate washer or continuous bar</td></tr>
<tr><td rowspan="2">144 ksi,
150 ksi</td><td>≤ 1</td></tr>
<tr><td>> 1</td><td>ASTM F436 extra thick or ASTM F436 with minimum ⅜ in-thick plate washer or continuous bar(1)</td><td>ASTM F436 with minimum ⅜ in-thick plate washer or continuous bar</td></tr>
</table>

(1) Not required under the head of ASTM F3125/F3125 Grades F1852 and F2280, or ASTM F3148 Grade 144 bolting assemblies with round heads that meet the requirements of ASME B18.2.6 Fasteners for Use in Structural Applications and have a bearing circle diameter satisfying the requirements of the relevant ASTM Standard.

Do not use multiple stacked washers to satisfy thickness requirements.

Alternate design fasteners that provide a bearing circle on the head or nut of at least the diameter of an ASTM F436 hardened washer may be used without washers.

(f) Installation. Use fasteners of the same rotation-capacity lot number for each connection. Protect fasteners from dirt and moisture. Only remove the fasteners from protected storage that are to be installed and tensioned during a work shift. Return unused fasteners to protected storage at the end of each shift. Do not remove as-delivered lubricant from fasteners. Discard and replace fasteners for slip-critical connections that accumulate rust or dirt before installing.

Snug-tighten all assemblies using the same means and methods as proven in the PIV test. Start snugging with the most rigid part of the connection and proceeding to the free edges. Repeat the snug-tightening sequence until the entire connection is in a snug-tight condition.

Install fasteners with specified washers according to Subsection 555.16(e) in properly aligned holes. Tension according to Subsections 555.16(f)(1) through (5). Tension within 10 days of snugging. If there is longer than 10 days between snugging and tension, remove of representative assemblies from the work and conduct new PIV tests.

When it is impractical to turn the nut, tension the fastener by turning the bolt, except for the calibrated wrench method, while preventing the nut from rotating when approved. Provide adequate capacity and sufficient air to tension each bolt in 10 seconds if impact wrenches are used.

Do not reuse ASTM F3125 Grade A490 fasteners or any fastener which has been galvanized or coated. If approved, non-galvanized ASTM F3125 Grade A325 bolts may be reused once. Touching up or re-torquing previously tensioned bolts (which may have been loosened by the tensioning of adjacent bolts) will not be considered reuse if the tensioning continues from the initial position and does not require greater rotation than shown in Table 555-4.

(1) Turn of nut installation. After snug tightening, apply the applicable rotation shown in Table 555-4 using the same means and methods proven in the PIV test. Apply the rotation starting with bolts in most rigid part of the connection and proceeding to the free edges. Prevent rotation of the part not turned by the wrench during the tensioning operation.

(2) Calibrated wrench installation. After snug tightening, apply the maximum torque as determined in PIV testing to every nut starting with the most rigid part of the connection and proceeding to the free edges. The bolt cannot be the turned element. Return the wrench to touch up previously tensioned bolts which may have been relaxed as a result of the subsequent tensioning of adjacent bolts until all bolts are tensioned to the prescribed amount. Use the calibrated wrench method only when wrenches are calibrated using the PIV test on a shift basis. Recalibrate wrenches when a significant difference is noted in the surface condition of the bolts, threads, nuts, or washers. If manual torque wrenches are used, torque nuts in the tensioning direction when torque is measured.

If tightening from a snug-tight condition, verify that the wrench adjustment selected by the calibration does not produce a nut rotation greater than shown in Table 555-4.

(3) Twist-off tension control bolt installation. After snug tightening, shear off the splined ends using the same installation tool used in the PIV test.

(4) DTI installation. After snug tightening, ensure no DTI has more refusals than shown in Table 555-7. Replace DTIs that fail the requirement. Continue to tighten the assemblies until the number of refusals is equal to or greater than shown in Table 555-7 and the feeler gauge can be partially entered in at least one gap.

Table 555-7
DTI 0.005-Inch Feeler Gauge Installation Refusal Requirements

DTI Spaces	Minimum Verification Refusals	
	Coated DTIs under turned element	All other cases
4	3	3
5	4	3
6	5	4
7	6	4
8	7	5
9	8	5

(5) Combined method installation. Install bolt assemblies in the connection and torque to the initial installation torque provided by the manufacturer. Progress torquing systematically from the most rigid part of the joint to its free edges. Return the wrench to “touch up” previously snugged bolts. After snug tightening, apply the manufacturer’s specified rotation to every turned element.

If the bolt length measured from the underside of the head to the end of the bolt exceeds 12 diameters, determine the required rotation by actual tests in a tension device simulating the actual conditions.

(6) Alternate design bolt installation method. If approved, provide alternate fasteners that meet the material, manufacturing, and chemical composition requirements of ASTM F3125, Grade A325 or A490 and:

(a) Meet the mechanical property requirements of the same specification in full-size tests; and

(b) Have body diameter and bearing areas under the head and nut, or their equivalent, at least those provided by a bolt and nut of the same nominal dimension.

Install alternate design bolts in connection holes according to the manufacturer's recommendations and pull the plies to firm contact throughout the connection. Tighten bolts snug-tight without yielding or fracturing the control or indicator element of the fastener.

Further tension fasteners starting with bolts in most rigid part of the connection and proceeding to the free edges. Proper tensioning of the bolts may require more than a single cycle of systematic partial tensioning. Replace individual fastener assemblies if yielding or fracture occurs before the final tensioning cycle.

Verify the tension according to Subsection 555.16(d).

(7) Inspection. Inspect the tensioned fasteners in the presence of the CO. Replace or re-tension loose or relaxed fasteners. Do not remove fasteners by cutting with a torch.

(a) Non-threaded fasteners. Ping each fastener with a hammer to test for soundness.

(b) Threaded fasteners. Use an inspection torque wrench to verify tensioning unless alternate fasteners or DTI devices are used allowing verification by other methods.

Calibrate the inspection torque wrench at least once each inspection day. Individually place three fastener assemblies of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Use a washer under the part turned in tightening each bolt if washers are used on the structure. Use the same material that abuts the part turned in the tension measuring device as used on the structure if washers are not used on the structure. In the calibration device, tighten each bolt to the specified tension. Apply the inspecting wrench to the tightened bolt to determine the torque required to turn the nut or head 5 degrees, approximately 1 inch at a 12-inch radius, in the tightening direction. Use the average of the torque required for all three bolts as the job-inspection torque.

Randomly select 10 percent (at least two) of the tensioned bolts on the structure in each connection represented by the test bolts. Apply the job-inspection torque to each selected bolt with the inspecting wrench turned in the tensioning direction. If this torque turns no bolt head or nut, the fastener is properly tensioned. If the torque turns one or more bolt heads or nuts, apply the job-inspection torque to all bolts in the connection. Re-torque and re-inspect fasteners whose head or nut turns.

555.17 Welding. Comply with AASHTO/AWS D1.5, *Bridge Welding Code* for welding, welder qualifications, prequalification of weld details, and inspection of welds. For tubular connections, conform to AWS D1.1, *Structural Welding Code – Steel, Section 10, Part D.*

Do not weld or tack brackets, clips, shipping devices, or other non-required material to members unless shown in the drawings.

555.18 Erection. Install falsework and forms according to Section 562. Coat structural steel according to Section 563. Use steel erectors certified under the AISC, *Quality Certification Program*.

(a) Handling and storing material. Place stored material on skids above ground. Keep material clean and properly drained. Place and shore girders and beams upright. Support long members (such as columns and chords) on skids placed close enough together to prevent deflection damage.

(b) Bearings and anchorages. Provide and install bridge bearings according to Section 564.

(c) Erection procedures. Erect according to the approved drawings. Submit revised drawings and verification of stresses and geometry for modifications to or deviations from the approved erection procedure for approval.

(1) Erection stresses. Allow for erection stresses locked in the structure caused by erection methods or equipment that differ from those previously approved. Provide additional material necessary to keep both temporary and final stresses within the allowable limits used in the design.

Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments.

(2) Maintaining alignment and camber. Support structural segments to produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing during erection to provide stability and ensure correct geometry. Provide temporary bracing at any stage of erection.

(d) Field assembly. Clean bearing surfaces and permanent contact surfaces. Assemble material as shown in the approved drawings and match-marks. Do not hammer, damage, or distort members.

For bolted splices and field connections, fill one-quarter of the holes with bolts and one-quarter of the holes with cylindrical erection pins before placing permanent fasteners. For continuous units, pin and bolt all beam and girder splices and bring the splices to the correct elevations before permanently fastening. For bolted connections, use fit-up bolts with the same nominal diameter as the permanent fasteners, and use cylindrical erection pins with a diameter $\frac{1}{32}$ inch larger than the bolts. Evenly space the pins around the connection. Place pins in the corner holes of the splice plates. Systematically remove fitting-up bolts and cylindrical erection pins and replace them with tightened high-strength bolts. Start from the most rigid part of connection and proceed to the free edges.

Release temporary erection supports at a splice or connection only after bolts are installed and tightened. Show special assembly and support situations on the erection drawings.

(e) Pin connections. Use pilot and driving nuts when driving pins. Drive pins so that the members fully bear on the pins. Screw pin nuts tight and burr the threads at the face of the nut with a pointed tool.

(f) Misfits. Correct minor misfits using small amounts of reaming, cutting, grinding, and chipping. Remove and replace members misfit due to shop fabrication error or deformation during handling or transporting.

555.19 Contact with Other Material. Place an unvulcanized virgin polychloroprene rubber (neoprene) waterproofing sheet between the structural steel and timber surfaces. Provide a continuous ⅛-inch thick sheet conforming to AASHTO M 215, with a low temperature Grade 2 and a hardness of 50±5.

555.20 Acceptance. Material for steel structures will be evaluated under Subsections 106.02 and 106.03.

Construction of steel structures will be evaluated under Subsections 106.02 and 106.04.

Bearing devices will be evaluated under Section 564.

Coatings will be evaluated under Section 563.

Temporary works will be evaluated under Section 562.

Measurement

555.21 Measure the Section 555 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring structural steel by the pound, measure structural steel computed according to AASHTO, *LRFD Bridge Construction Specifications*.

When measuring structural steel by the contract quantity, changes in quantities resulting from alternative details proposed by the Contractor and accepted as a part of the drawings are not subject to adjustment according to Subsection 109.06.

Payment

555.22 The accepted quantities will be paid at the contract price per unit of measurement for the Section 555 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 556. — BRIDGE RAILING

Description

556.01 This work consists of providing, erecting, removing, and resetting bridge railings.

Material

556.02 Conform to the following Subsections:

Aluminum alloy for bridge rail	717.10
Aluminum bolt heads and nuts	717.11
Aluminum welding wire	717.12
Box beam rail	724.01(b)

Construction Requirements

556.03 General. Accurately place anchor bolts to provide correct and true alignment of the railing. Set anchor bolts so that they project no more than ⅜ inch beyond the nut when tightened. Chamfer or round by grinding or filing sharp exposed metal edges.

Do not erect railing until centering or falsework for the supporting span is removed. Construct bridge railing so that it does not follow unevenness in the curb, sidewalk, or wall that supports the railing. Install railing to present a smooth and uniform appearance in its final position. Set posts vertical.

556.04 Concrete Railing. Conform to Section 552. Construct reinforcing steel according to Section 554.

556.05 Steel Railing. Conform to Section 555.

556.06 Aluminum Railing. Conform to Section 555, except as modified by the following:

(a) Cutting. Material that is ½ inch thick or less may be cut by shearing, sawing, or milling. Saw or mill material that is over ½ inch thick. Do not flame cut. Make cut edges true, smooth, and without excessive burrs or ragged breaks. Fillet reentrant cuts by drilling before cutting.

(b) Bending. Material may be heated to a maximum 400 °F for no more than 30 minutes to facilitate bending.

(c) Rivet and bolt holes. Drill rivet and bolt holes to finished size or subpunch smaller than the nominal diameter of the fastener and ream to size. Subpunch to a diameter that is smaller than that of the finished hole by at least one-quarter the thickness of the piece. Make the finished diameter of holes no more than 7 percent greater than the nominal diameter of the fastener, except:

(1) Fabricate slotted bolt holes as required; and

(2) Fabricate anchor bolt holes up to 25 percent larger, no more than ½ inch larger than the nominal bolt diameter.

(d) Welding. Weld according to AWS D1.2, *Structural Welding Code - Aluminum*.

(e) Contact with other material. Protect aluminum alloys that contact other material as follows:

(1) Aluminum alloys in contact with other metals. Coat the contacting surfaces with dielectric aluminum-impregnated caulking compound or place a synthetic rubber gasket between the surfaces.

(2) Aluminum alloys in contact with stone or concrete.

(a) If a bond is not required, coat the contacting surfaces with aluminum-impregnated caulking compound or with heavy bituminous coating pigmented with aluminum powder or paste.

(b) If a bond is required, coat the contacting aluminum surface with zinc-chromate coating. Allow coating to dry before installation.

(3) Aluminum alloys in contact with wood. Coat the contacting wood surface with three coats of coating material according to Section 563 and coat the contacting aluminum surface with aluminum-impregnated caulking compound.

556.07 Timber Railing. Conform to Section 557.

556.08 Remove and Reset Bridge Railing. Salvage the existing bridge railings and appurtenances according to Subsection 203.04. Reset bridge railings as shown in the plans. Replace railings, supports, and hardware damaged during removal, storage, or resetting.

556.09 Coating. Conform to Section 563.

556.10 Acceptance. Material (except concrete, coating, reinforcing steel, structural steel, and timber) for bridge railings will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of bridge railing.

Construction of bridge railings will be evaluated under Subsections 106.02 and 106.04.

Coatings will be evaluated under Section 563.

Concrete will be evaluated under Section 552, except compressive strength will be evaluated under Subsection 106.04.

Reinforcing steel will be evaluated under Section 554.

Steel structures will be evaluated under Section 555.

Timber structures will be evaluated under Section 557.

Measurement

556.11 Measure the Section 556 pay items listed in the bid schedule according to Subsection 109.02.

Payment

556.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 556 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 557. — TIMBER STRUCTURES

Description

557.01 This work consists of fabricating, treating, erecting, and coating structural timber.

Material

557.02 Conform to the following Section and Subsections:

Galvanized coatings	717.07
Gray iron castings	717.04(c)
Malleable iron castings	717.04(d)
Material for timber structures	716
Structural carbon steel	717.01(a)

Construction Requirements

557.03 General. Excavate and backfill according to Section 208.

Use slings or other devices to protect the corners of heavy timbers and banded packages of lighter timber.

Cut and form lumber and timber so joints have even bearing over their entire contact surface. Do not use shims in making joints. Close all joints. Drive nail and spike heads flush with the wood surface.

Use the same end, face, and edge of the timber member for all layout dimensions. Bore holes from mating faces.

557.04 Storing Material. Store material in an area cleared of weeds, rubbish, or other deleterious material. Elevate material at least 8 inches above the ground. Provide sufficient support to prevent sagging.

Open-stack untreated material to shed water. Allow for free air circulation by stacking material in layers on stickers that extend across the full width of the stack. Align stickers vertically and space them at regular intervals.

Close-stack treated material to shed water.

Protect material from the elements. Use water-resistant paper or opaque polyethylene film if material is be covered. Do not use impervious membranes (such as polyethylene film) during dry weather. Slit or puncture individual wrappings full length on the lower side to allow water drainage.

Store and protect glued laminated timber according to AITC 111, *Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage and Erection*.

557.05 Holes for Drift Pins, Dowels, Bolts, and Lag Screws. Bore holes before preservative treatment.

Bore holes for round drift pins and dowels to a diameter $\frac{1}{16}$ inch less than the diameter of the pin or dowel. Bore holes for square drift pins and dowels to a diameter equal to the side dimension of the pin or dowel.

Bore holes for galvanized bolts to a diameter $\frac{1}{16}$ inch larger than the diameter of the bolt.

Bore holes for lag screws to a bit not larger than the body of the screw at the base of the thread.

557.06 Treating Timber. Indicate the preservative used, penetration in inches, and the retention in pounds per cubic foot (assay method).

Cut, frame, and bore timbers before treatment. Do not cut or bore timber below the high-water mark in coastal waters.

Handle treated timber according to AWPA M4, *Standard for the Handling, Storage, Field Fabrication, and Field Treatment of Preservative-Treated Wood Products*. Do not drip or spill preservative into an aquatic environment or onto the ground. Handle treated timbers to prevent damage to their surfaces. Do not use cant hooks or pike poles.

Field treat cuts or abrasions with preservative. Dip, soak, spray, or apply three brush coats of the same preservative according to AWPA M4.

Impregnate holes bored after treatment with the same preservative using tools suitable for proper application. Plug unused holes with the same treated timber.

557.07 Hardware. Galvanize hardware and fasteners, including nails, spikes, bolts, washers, and timber connectors according to AASHTO M 232.

Use washers under bolt heads and nuts in contact with wood. Fabricate washers from gray iron or malleable iron castings. Use malleable iron washers with a diameter approximately three times the bolt diameter. Use steel washers only when specified.

Use cut or round wire nails of standard form. Use cut, round, or boat spikes as specified.

Cut off excess bolt lengths of more than 1 inch. After final tightening, check or burr bolts with a pointing tool to prevent loosening of the nuts.

Use split-ring or shear-plate timber connectors conforming to Section 16.2.6 of AASHTO, *LRFD Bridge Construction Specifications.*

For fasteners in contact with wood treated with copper-based preservatives, use Type 316 stainless steel or hot-dipped galvanized steel that conforms to ASTM A153 or A653, Class G185. For wood structures immersed in or within one mile of salt or brackish water, use Type 316 stainless steel fasteners and hardware.

557.08 Countersinking. Countersink screws, bolts, and nuts where required. Treat countersunk recesses with an approved preservative before filling, except in railings. Fill the recess with hot pitch or other approved filler after bolts, screws, and nuts are in place.

557.09 Framing. Do not slab or trim treated piles when fitting sway or sash braces. Securely fasten braces to smaller piles using treated blocks to fill the gaps.

557.10 Framed Bents. For mud sills, firmly and evenly bed mud blocks to solid bearing. Tamp in place.

Finish concrete pedestals supporting framed bents so that sills or posts bear evenly on the pedestals. When concrete is cast, set dowels for anchoring sills and posts to project at least 6 inches above the tops of the pedestals.

Make sills bear evenly and true on mud blocks, piles, or pedestals. Bolt sills into place with drift bolts that extend into the mud blocks or piles for at least 6 inches. Where possible, remove material in contact with sills for circulation of air around the sills.

557.11 Bent Caps. Make timber caps bear evenly and uniformly over the tops of aligned supporting posts or piles. Secure caps with drift bolts extending at least 9 inches into the approximate center of each post or pile.

557.12 Bracing. Bolt the ends of bracing through the pile, post, cap, or sill. Bolt intermediate intersections and spike with wire or boat spikes. Use galvanized spikes in addition to bolts.

Make bracing bear firmly against the pile or cap to which it is bolted. Provide and place shims as necessary to prevent bending of the bracing more than 1 inch out of true when bracing bolts are tightened.

Shim based on the spacing between the bracing and cap or pile as follows:

(a) Less than 1 inch, shims are not needed;

(b) From 1 to 2 inches, place two ogee washers with their narrow faces together or other approved washers on each bolt that passes through the space; or

(c) Over 2 inches, use wooden shims of the proper thickness.

Fabricate the wooden shims from the same treated wood used in the structure. Do not use built-up wooden shims. Make wooden shims from a single piece of lumber with the width at least 4 inches and the length at least the width of the bracing measured along the cap or pile. Do not adze, trim, or cut treated members to avoid the use of shims.

557.13 Stringers. Size stringers at bearings. Position stringers so knots near edges are in the top portion of the stringer.

Outside stringers may have butt joints with ends cut on a taper. Lap interior stringers so both stringer ends have full length bearing on a floor beam or cap. Stagger joints where stringers are two panels in length. Separate lapped ends of untreated stringers by at least ½ inch for air circulation. Use drift bolts to securely fasten the lapped ends.

Place cross-bridging at the center of each span. Cut cross-bridging members to provide full bearing on the stinger sides at each end. Securely toenail the cross-bridging with at least two nails in each end. If blocking is used, make it fit snugly and securely.

557.14 Plank Decks. Use planks that are surfaced on four sides (S4S).

Grade plank thickness so no two adjacent planks vary in thickness by more than ⅛ inch. Lay the planks heart side down with ¼ inch space between them for dry, seasoned material and with no joint space for unseasoned material. Spike each plank securely to each stringer.

For two-layer timber plank decks, treat the lower layer according to Subsection 557.06. Lay the top layer either diagonally or parallel to the roadway centerline. Stagger joints at least 36 inches. Securely fasten each top layer member to the lower layer. Where the top layer is placed parallel to the centerline of the roadway, use special care to securely fasten the ends of the flooring. Bevel the ends of top layer members at each end of the structure.

557.15 Transversely Nail Laminated Decks. Use 2-inch nominal thickness laminations, surfaced on one side and one edge.

Place the laminations on edge parallel to the skew as shown in plans with the surfaced edge facing downwards. Attach each piece to the preceding piece using spikes of sufficient length to pass through two pieces and at least halfway through the third piece. Drive spikes at each end and at approximately 18-inch intervals alternately driving near the top and bottom edges.

Securely attach the deck to stringers using approved galvanized metal clips.

Use pieces of sufficient length to bear on at least four stringers. Do not splice pieces between stringers. Space end joints on a stringer no closer than every third piece. Space end joints in adjoining pieces no closer than every second stringer.

557.16 Glue Laminated Panel Decks. When handling and transporting, avoid bending panels, especially transverse to the laminated pieces. When lifting a panel, support it at a sufficient number of points to prevent damage and distortion. Do not drag or skid panels. Protect the panel edges from damage.

When dowels are used between panels, use a template or drilling jig to properly space dowel holes. Drill holes the same diameter as the dowel and ¼ inch deeper than one-half of the dowel length. Slightly taper or round dowel tips and lubricate dowels to facilitate the connection process.

Start the tips of the dowels partially and equally in the holes of the panels to be joined. Draw the panels together, keeping the edges parallel, until the panels abut tightly. Securely fasten each panel to each stringer.

557.17 Wheel Guards and Railings. Use S4S timber for wheel guards, rails, and posts. Place wheel guards in at least 12-foot lengths. Squarely butt-joint rails at posts.

557.18 Trusses. Avoid irregularities in alignment. In horizontal projection, fabricate chords straight and true from end-to-end. In vertical projection, fabricate chords to a smooth, corded curve through panel points conforming to the correct camber. Make bearing surfaces fit accurately. Do not make uneven or rough cuts at the points of bearing.

557.19 Coating. If required, coat according to Section 563.

557.20 Acceptance Material for timber structures will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of structural timber and lumber. If treated, indicate the preservative used, penetration inches, retention in pounds per cubic foot (assay method), and the BMP used in treating timber members.

Construction of timber structures will be evaluated under Subsections 106.02 and 106.04.

Coatings will be evaluated under Section 563.

Excavation and backfill will be evaluated under Section 208.

Measurement

557.21 Measure the Section 557 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring untreated and treated structural timber and lumber by the thousand board feet measure, measure in the structure.

Compute the quantities from nominal dimensions and actual lengths, except for transversely nail laminated decks and glue laminated panel decks. Measure transversely nail laminated decks and glue laminated panel decks in place after dressing.

Payment

557.22 The accepted quantities will be paid at the contract price per unit of measurement for the Section 557 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 558. — DAMPPROOFING

Description

558.01 This work consists of dampproofing concrete and masonry surfaces.

Material

558.02 Conform to the following Subsection:

Dampproofing material	723.01

Construction Requirements

558.03 Dampproofing. Cure the concrete or masonry surface according to Subsection 552.13, except do not use liquid membrane curing compound. Allow concrete surface to dry at least 10 days after completion of curing.

Apply dampproofing to a dry, clean, and reasonably smooth surface that is free of dust and loose material. Apply dampproofing in dry weather when the air and surface temperatures are 45 °F or higher.

Apply primer to the surface and allow it to dry. Apply two coats of asphalt at the rate of approximately 25 pounds per 100 square feet of surface per coat. Apply prime coat and asphalt coats uniformly, covering the surface, and work them into the surface. Allow first coat to dry before second coat is applied. Make the total of the final two asphalt coats approximately $\frac{3}{32}$ inch thick. Allow asphalt coats to harden before allowing contact with water or backfill material.

558.04 Acceptance. Material for dampproofing will be evaluated under Subsections 106.02 and 106.03.

Applying dampproofing will be evaluated under Subsections 106.02 and 106.04.

Measurement

558.05 Measure the Section 558 pay items listed in the bid schedule according to Subsection 109.02.

Payment

558.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 558 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 559. — WATERPROOFING AND SEALING

Description

559.01 This work consists of providing and installing waterproofing systems on concrete surfaces and sealing concrete surfaces.

Material

559.02 Conform to the following Subsections:

Blotter	703.12
Penetrating sealant	725.20
Sealants, fillers, and seals	712.01
Waterproofing material	723.02

Construction Requirements

559.03 Qualifications. At least 30 days before starting waterproofing work, submit the following for approval:

(a) Waterproofing systems. Provide an on-site supervisor, waterproofing system provider, on-site technical representative, and membrane applicator with experience installing waterproofing systems on concrete surfaces.

(1) On-site supervisor. A résumé describing experience on at least three concrete bridge waterproofing projects within the past 5 years. Include project names, a brief description of each project, construction dates and quantities, locations, and contact information for project owners;

(2) Waterproofing system provider. Documentation from the waterproofing system provider describing experience on at least five concrete bridge waterproofing projects within the past 5 years. Include project names, a brief description of each project, construction dates and quantities, locations, and contact information for project owners;

(3) On-site technical representative. A résumé describing experience on at least three bridge deck waterproofing projects within the past 3 years. Include project names, a brief description of each project, construction dates and quantities, locations, and contact information for project owners; and

(4) Membrane applicator. Manufacturer certification documenting that the membrane applicator is an approved applicator with the required training.

(b) Concrete sealer. A résumé describing experience on at least three concrete bridge sealing operations within the past 5 years. Include project names, a brief description of each project, construction dates and quantities, locations, and contact information for project owners.

559.04 General. Conduct a preapplication preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of operations. Review QCP procedures with personnel performing the work before start of installation.

Store sealers and waterproofing materials in a dry, protected, climate-controlled location, and according to the manufacturer's recommendations. Do not store rolls standing on end. Protect materials from sparks or flames.

Provide accessory materials that are compatible with membrane according to the membrane manufacturer's recommendations.

Protect surfaces, including scuppers, drains, dams, and headers, that will not be waterproofed by masking with oil-resistant, adhesive-backed construction paper. Prevent materials from coating surfaces not receiving or immediately receiving the waterproofing. Upon completion, remove the adhesive-backed construction paper from all surfaces.

Provide certification from the waterproofing system provider's on-site technical representative that the membrane installation complies with the manufacturer's recommendations.

559.05 Substrate Preparation.

(a) Waterproofing membrane. Before waterproofing installation, sound the entire bridge deck in the presence of the CO according to ASTM D4580 to identify unsound substrate concrete. Submit repair areas, method, and materials for approval. Repair concrete according to Section 572.

Ensure the concrete surface is free of projections or depressions that might cause puncture of the membrane. Provide a substrate surface profile with less than ¼-inch projections or depressions or according to the manufacturer's recommendations. Provide a clean concrete surface free of contaminants that could interfere with the proper function of the waterproofing system. Do not place membranes on damp or wet concrete. Do not place membranes on new concrete until at least 10 days after completion of the concrete curing process according to Subsection 552.13. Apply waterproofing in dry weather when the concrete substrate and ambient temperatures are at least 40 °F and are expected to remain above 40 °F during application.

Do not expose cleaned surfaces to vehicles or equipment other than required by the waterproofing operation. If the deck becomes contaminated before installation, clean the contaminated areas.

Before waterproofing placement, ensure that the substrate concrete is clean and dry with a moisture content in the deck substrate less than 5.0 percent as determined by an approved electronic moisture meter. Ensure that the concrete substrate is 5 °F above the dew point according to ASTM D4230 before applying the waterproofing system.

(b) Sealers. Clean concrete surface according to manufacturer's recommendations before application. Do not place sealer on damp or wet concrete. Do not place sealer on new concrete until at least 10 days after completion of the concrete curing process according to Subsection 552.13. Apply sealer in dry weather when the concrete substrate and ambient temperatures are at least 40 °F and are expected to remain above 40 °F during application. Ensure that the concrete substrate is 5 °F above the dew point according to ASTM D4230 before applying the sealer.

559.06 Primer Application for Waterproofing Membrane Systems. Review QCP procedures with personnel performing the work before starting the primer application. Prevent primer from coating surfaces not receiving or immediately receiving the waterproofing.

Monitor ambient temperature, surface temperature, moisture content of concrete, and dew point during primer application according to Subsection 559.05.

Mix and apply primer according to the manufacturer's recommendations. Continuously agitate the primer during application. Apply primer starting at the lowest point on bridge deck and work upwards. Work primer up the grade and up the cross slope during application. Overlap start of new day of primer installation over previous day's primer according to the manufacturer's recommendations.

Apply primer to ensure complete coverage. Prevent and remove puddling and excess buildup. If the primed surface becomes contaminated, clean and reapply primer.

Cure primer according to the manufacturer's recommendations. Break bubbles in the primer according to the manufacturer's recommendations before testing primer bond strength.

559.07 Waterproofing Systems. Provide one of the following waterproofing systems:

(a) Seamless spray-applied system. A seamless spray-applied waterproofing system consists of a seamless, cold liquid applied multi-component polymer. The seamless spray-applied system includes primer, elastomeric spray-applied membrane, and an elastomeric membrane topcoat containing broadcast aggregate for the placement of an asphalt concrete pavement wearing course.

Monitor ambient temperature, surface temperature, moisture content of concrete, and dew point during spray membrane application according to Subsection 559.05. Provide wind breaks to minimize overspray. Do not apply spray membrane when wind speeds measured 2 feet above the deck exceed 10 miles per hour with windbreaks in place.

(1) Primer bond strength test. Verify bond strength of primer to concrete substrate by attaching a metal dolly to the primed area of concrete. Test for bond strength according to ASTM D7234. Perform at least one test per 2500 square feet of primed deck or one per day. Consider the bond strength of primer sufficient if the bond pull-off test exceeds 150 pounds per square inch. If the bond pull-off fails, establish adequate bond according to the manufacturer's representative recommendations. Repair test areas according to the manufacturer's recommendations.

(2) Membrane installation. When the primer has been accepted, start membrane installation.

Mix and apply spray membrane according to the manufacturer's recommendations. Continuously agitate the liquid spray membrane during application. Apply spray membrane starting at the lowest point on bridge deck and work up the grade and up the cross slope during application. Lap spray membrane up curb 2 inches or the thickness of the asphalt pavement overlay. At the start of each day's operations, overlap the previously applied spray membrane according to the manufacturer's recommendations.

Apply membrane at a thickness of 80 mils.

Prevent and remove puddling and excess buildup. If the spray membrane becomes contaminated, clean and reapply the membrane.

Cure spray membrane according to the manufacturer's recommendations. Break bubbles in the spray membrane according to the manufacturer's recommendations before testing the bond strength of the membrane.

Verify bond strength of spray membrane to primed concrete by attaching a metal dolly to the waterproofed area. Test for bond strength according to ASTM D7234. Perform at least one test per 2500 square feet of waterproofed deck or one per day. Consider the bond strength of the membrane sufficient if the bond pull-off test exceeds 150 pounds per square inch. If bond pull-off fails, establish adequate bond according to the manufacturer’s representative recommendations. Repair test areas according to the manufacturer’s recommendations.

(3) Elastomeric membrane topcoat with broadcast aggregate. Review QCP procedures with personnel performing the work before start of elastomer membrane topcoat installation.

When the waterproofing membrane has been accepted, start elastomeric membrane topcoat installation.

Apply elastomeric membrane topcoat according to the manufacturer’s recommendations. Apply elastomeric membrane topcoat at a thickness of 40 mils. Use approved aggregate source and gradation to broadcast into elastomeric topcoat. Broadcast aggregate uniformly according to the manufacturer’s recommendations. Apply elastomer aggregate broadcast topcoat starting at the lowest point on bridge deck and work up the grade and up the cross slope during application. Overlap start of a new day of elastomer aggregate broadcast topcoat construction over previous day’s work according to the manufacturer’s recommendations.

Cure topcoat according to the manufacturer’s recommendations.

Lightly vacuum sweep excess aggregate from cured topcoat. Dispose of excess aggregate according to Subsection 203.07.

(b) Preformed membrane system. A preformed membrane system consists of a primer applied to the prepared surface and a single layer of adhering preformed membrane sheet. The preformed membrane system includes primer, bituminous polymer or asphalt rubberized preformed membrane sheet with self-adhering backing, and materials for sealing of joints and around inlets, curbs, or other features.

Place the waterproofing membrane continuously within the masked areas within the time frame recommended by the manufacturer. If this time is exceeded, reapply the primer. Do not apply waterproofing membrane over wet primer.

Lap membrane sheets in the direction of water flow. Stagger membrane overlaps in the transverse direction so that transverse seams do not line up.

(1) Bridge decks.

(a) Install a 12-inch minimum width strip along the juncture of deck and base of barrier railing or curb face at the low side of the deck with the sheet extending up the face 3 inches;

(b) Starting at the gutter line, lay sheets longitudinally and side lapped with adjacent sheets by at least 2½ inches and end lapped by at least 6 inches;

(c) Place a 12-inch minimum width strip at the juncture of deck and base of curb or railing at the high side of the deck extending up the face 3 inches;

(d) Cut the membrane sheet and turn into the joint or bleeder as the sheet is being laid at open joints, deck bleeder pipes, and other locations as needed;

(e) For rubberized asphalt sheets and modified bitumen sheets, apply mastic as a bead along the exposed edge of the membrane sheet that extends up the barrier railing or curb face and that ends in the high-side gutter. Seal terminations with mastic compatible with waterproofing system according to the manufacturer's recommendations; and

(f) Leave 12 inches of membrane to tie into if waterproofing one side of a deck at a time.

(2) Surfaces other than bridge decks. Install according to Subsection 559.07(b)(1) and the following:

(a) Place membrane vertically. Lap successive sheets at least 3 inches over the previous sheet;

(b) Lap horizontal splices by at least 6 inches;

(c) Place a troweled bead of manufacturer's recommended mastic or sealing tape along exposed edges of the installed membrane;

(d) Flash projecting pipe, conduits, sleeves, or other facilities passing through the preformed membrane waterproofing;

(e) Use prefabricated or field-fabricated boots, fitted coverings, or other devices as necessary to provide watertight construction; and

(f) Make a seal with the curb up to the depth of the overlay.

Roll the surface with hand rollers or other apparatus as necessary to develop a firm and uniform bond to the primer and minimize wrinkles and air bubbles.

Patch tears, cuts, or narrow overlaps by placing sections of membrane sheet over the defective area so that the patch extends at least 6 inches beyond the defect. Seal edges of patches with a mastic recommended by the manufacturer. On modified bitumen sheets with a permanent polyester film, use a propane torch to melt the polyester film on the section to be patched, then place the patch over the heated surface. Press or roll patches firmly onto the surface.

559.08 Concrete Sealers. Protect all surfaces, including scuppers, drains, dams, and headers, that will not be sealed by masking with materials that are non-reactive to the sealer. Remove the masking material from all surfaces after completion of sealer application.

Monitor ambient temperature, surface temperature, moisture content of concrete, and dew point during sealer application according to Subsection 559.05. Provide wind breaks to minimize overspray if using a sprayer system to apply sealer. Do not apply sealer with sprayer systems when wind speeds measured 2 feet above the deck exceed 10 miles per hour with windbreaks in place.

Apply sealer according to manufacturer's recommendations. Do not allow puddles to occur on low spots for horizontal surface applications. Do not allow puddling at curb lines on bridge deck applications. Do not allow excessive dripping to occur during application on vertical surfaces.

Do not allow any pedestrian or vehicular traffic until sealer has sufficiently cured. Provide blotter for newly cured sealed horizontal surfaces subject to traffic. Remove blotter 72 hours after opening to traffic and dispose of blotter according to Subsection 203.07.

559.09 Protective Covering. Install a protective covering immediately after waterproofing that prevents damage to the membrane from sunlight, weather, traffic, and construction operations.

If backfill will be placed against waterproofed surfaces, cover the membrane with ⅛-inch thick hardboard or other approved material.

559.10 Asphalt Concrete Pavement Overlay Placement. Do not place the overlay until the CO has accepted the waterproofing. Protect the waterproofing from damage. Limit traffic on the waterproofing system to necessary construction equipment and emergency vehicles before overlay placement. Do not turn vehicles or equipment on the membrane. Avoid abrupt starts and stops.

Sweep the membrane surface before placing the overlay. Repair damaged areas on the membrane before starting overlay placement. If recommended by the manufacturer, apply an asphalt tack coat according to Section 412 before placing the overlay.

Place the overlay continuously over waterproofed and masked areas according to the applicable asphalt concrete pavement Section, as soon as possible and within 48 hours after placing the membrane. Limit the lay-down temperature of the asphalt concrete mix according to the manufacturer's recommendations. Do not windrow asphalt concrete on the waterproofing membrane ahead of the paving machine. Do not use an asphalt concrete pickup machine. Make subsequently asphalt pavement cuts at or near the expansion joint after the overlay is in place.

559.11 Acceptance. Material for waterproofing systems and sealing concrete surfaces will be evaluated under Subsections 106.02 and 106.03.

Installation of waterproofing systems will be evaluated under Subsections 106.02, 106.03, and 106.04.

Sealing concrete surfaces will be evaluated under Subsections 106.02, 106.03, and 106.04.

Asphalt tack coat will be evaluated under Section 412.

Concrete repairs will be evaluated under Section 572.

Measurement

559.12 Measure the Section 559 pay items listed in the bid schedule according to Subsection 109.02.

Payment

559.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 559 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 560. — REMOVAL OF CONCRETE BY HYDRODEMOLITION

Description

560.01 This work consists of removing concrete with high-pressure water jets.

Material

560.02 Conform to the following Subsection:

Water for construction	725.01(c)

Construction Requirements

560.03 Submittals. At least 30 days before starting hydrodemolition work, submit the following according to Subsection 104.06:

(a) Sequence and schedule of work;

(b) Concrete removal procedures; and

(c) List of equipment to be used.

560.04 General. Provide water required to operate the hydrodemolition equipment.

Protect adjacent property from dislodged concrete during operations. Construct debris shields to prevent debris and wastewater from entering waterways, travel lanes open to public traffic, or areas designated not to be disturbed.

Dispose of wastewater and debris according to Subsection 203.07.

560.05 Equipment.

(a) Hydrodemolition system. Provide a self-propelled and completely programmable hydrodemolition system designed for concrete removal.

(b) Vacuum system. Provide a vacuum system equipped with:

(1) Fugitive dust control devices that can remove wet debris and water in the same pass; and

(2) A pressurized washing system that can clean the concrete surface during the vacuum operation to dislodge debris and slurry.

560.06 Calibration. Calibrate equipment to remove concrete to the required dimensions before starting hydrodemolition production work. If hydrodemolition equipment cannot remove concrete to the required dimensions, remove equipment and provide another hydrodemolition system. Verify operation of equipment at the start of each day on an area of representative concrete designated by the CO before starting operations. Recalibrate during the work if concrete conditions, including degree of deterioration and strength, or dimensions change.

Record the following settings at each calibration and notify the CO:

(a) Water pressure gauge;

(b) Water usage in gallons per minute;

(c) Machine staging control (step) – feet per minute forward travel;

(d) Nozzle size;

(e) Nozzle speed (revolutions per minute);

(f) Transverse nozzle travel speed. Only applicable if hydrodemolition nozzle is not fixed and moves transversely on a track between stops before staging to the next step. Report transverse nozzle travel speed in feet per second; and

(g) Effective pass width of hydrodemolition unit. Effective pass width is defined as the width of hydrodemolition that has uniform pressure, water, and dwell time per machine staging control (step). Report effective width in feet.

560.07 Concrete Removal. Remove concrete as follows:

(a) Concrete scarification. Scarify to the depth shown in the plans. If no depth is shown, remove at least ¼ inch of material. Clean the surface by an approved method of water blasting with 7000 pounds per square inch minimum pressure until sound concrete is exposed.

(b) Concrete removal. Remove concrete to the depth shown in the plans or down to sound concrete. Provide at least 1 inch below the bottom of the exposed reinforcing steel. Do not damage remaining sound concrete or reinforcing steel. If the bond between existing concrete and reinforcing steel is destroyed, remove the concrete adjacent to the reinforcing steel to a depth that allows new concrete to bond to the reinforcing steel.

Remove loose and unsound concrete resulting from the hydrodemolition operations below the minimum depth.

Verify depth of concrete removal at least every 30 feet along the cutting path.

In areas inaccessible to the hydrodemolition equipment, use approved hand-held water blasting equipment or power-driven hand tools such as jackhammers, mechanical chipping tools, or chipping hammers. Do not use jackhammers heavier than nominal 30-pound class or chipping hammers heavier than 15-pound class. Operate mechanically driven tools at a maximum angle of 45 degrees from the concrete surface.

If necessary, use hand tools such as hammers and chisels to remove the final particles of concrete to achieve the required depth. Leave a rough surface after the concrete is removed. Immediately remove residue, water, dust, and concrete to prevent rebonding to the surface or reinforcing steel.

560.08 Reinforcing Steel. Do not cut or damage reinforcing steel designated to remain.

Inspect the reinforcing steel with the CO after the concrete has been removed. Clean exposed reinforcing steel of rust, loose and rebounded material, and other contaminants that may inhibit bonding to new concrete. Tie new reinforcing steel to the existing reinforcing steel if more than 10 percent of its section is lost. If the deteriorated portion of the reinforcing steel is closer to the edge of the patch than the overlap distance designated in the plans, extend the limits of the patch to provide the required overlap distance with acceptable reinforcing steel. Provide a minimum 2-inch clearance between the ends of new reinforcing steel and the existing slab face. Match the number, type, and spacing of the new reinforcing steel to the existing reinforcing steel.

560.09 Acceptance. Removal of concrete by hydrodemolition will be evaluated under Subsections 106.02 and 106.04.

Measurement

560.10 Measure the Section 560 pay items listed in the bid schedule according to Subsection 109.02.

Payment

560.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 560 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 561. — CONCRETE CRACK REPAIR BY EPOXY INJECTION

Description

561.01 This work consists of repairing cracks in concrete by injecting epoxy into the cracks.

Material

561.02 Conform to the following Subsections:

Epoxy resin adhesives	725.12
Latex-modified mortar	701.05(c)

Construction Requirements

561.03 General. At least 14 days before starting concrete crack repair work, submit the following according to Subsection 104.06:

(a) Personnel qualifications;

(b) Manufacturer's SDS and product data sheets;

(c) Manufacturer's installation recommendations; and

(d) Work plan for performing the work.

Conduct a pre-injection preparatory phase meeting at least 7 days before the start of injection operations according to Subsection 153.06(a).

561.04 Crack Preparation. Identify work areas and mark the cracks to be repaired for approval. Prepare cracks according to the manufacturer's recommendations. Remove dirt, laitance, and other debris from the exterior and interior of the crack. Apply a temporary surface seal material with sufficient strength and adhesion to confine the injected epoxy resin adhesive within the crack until cured.

Provide openings (entry ports) in the surface seal along the crack. Make the distance between entry ports at least the thickness of the concrete member being repaired.

561.05 Injection Procedure. Maintain the epoxy resin adhesive component mix ratio within 5 percent by volume as recommended by the manufacturer. Do not use solvents to thin the epoxy.

Use positive inline displacement type equipment to meter, mix, and inject the epoxy at pressures no more than 200 pounds per square inch. Inject epoxy into cracks according to the manufacturer's recommendations until the entire crack is filled.

Perform the following tests for each injection unit at the start and at the end of each day.

(a) Ratio check test. Disconnect the mixing head of the injection equipment. Pump the two adhesive components through a ratio check device having two independent valved nozzles that can control the flow rate and back pressure by opening or closing the valves. Use a pressure gauge that can sense back pressure behind each valve. Adjust the discharge pressure to 200 pounds per square inch for both epoxy components. Simultaneously discharge both epoxy components into separate calibrated containers. Compare the discharged quantities to determine the mix ratio.

After the test is completed at 200 pounds per square inch discharge pressure, repeat the procedures for 0 pounds per square inch discharge pressure.

(b) Pressure check test. Disconnect the mixing head of the injection equipment. Attach the two adhesive component delivery lines to a pressure check device having two independent valved nozzles that can control the flow rate and pressure by opening or closing the valves. Use a pressure gauge that can sense the pressure build-up behind each valve. Close the valves on the pressure-check device and operate the equipment until the gauge pressure on each line reads 200 pounds per square inch. Stop the pumps and check that the gauge pressure does not drop below 190 pounds per square inch within 3 minutes.

(c) Records. Maintain and make available complete and accurate records of the ratio and pressure check tests. Additional ratio and pressure check tests may be required.

561.06 Coring. Take one 2-inch diameter test core according to AASHTO T 24 for every 50 feet of repaired crack at designated locations. The crack repair is acceptable when the epoxy bonding has penetrated at least 90 percent of the crack volume within the core sample.

If a test core is unacceptable, redo that 50-foot crack segment or the segment that the core represents and resample. Repeat this procedure until acceptable crack repair is achieved.

561.07 Finishing. Remove the surface seal and fill sample core holes with polymer concrete and mortar according to the manufacturer's recommendations. Finish the face of the crack, the entry ports, and the core holes flush with the adjacent surface and finish the surface to match the adjacent concrete.

561.08 Opening to Traffic. Do not allow traffic on crack injection work for 6 hours after completion of the crack injection work or until the injected epoxy resin has attained a compressive strength of at least 1450 pounds per square inch, whichever is less. For bridge deck repairs, stage traffic so that the edge of the nearest travel lane to the repair area is no closer than the center of the adjacent girder.

561.09 Acceptance. See Table 561-1 for sampling, testing, and acceptance requirements.

Material for concrete crack repair will be evaluated under Subsections 106.02 and 106.03.

Concrete crack repair work will be evaluated under Subsections 106.02 and 106.04.

Measurement

561.10 Measure the Section 561 pay items listed in the bid schedule according to Subsection 109.02.

Payment

561.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 561 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 561-1
Sampling, Testing, and Acceptance Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Daily Start-up & Shutdown Testing									
Epoxy resin adhesive	Process control (153.03)	Ratio check (Mix)	–	Subsection 561.05(a)	Daily before starting work & after ending work	Injection unit	No	Subsection 561.05	
		Pressure check	–	Subsection 561.05(b)	"	"	"	"	
Production									
Epoxy resin adhesive	Measured & tested for conformance (106.04)	Penetration of material into crack	–	Subsection 561.06	1 core for every 50 ft of repaired crack length	In-place after epoxy resin injection completed	No	Upon completion of test	

Section 562. — TEMPORARY WORKS

Description

562.01 This work consists of the design, construction, inspection, maintenance, and removal of temporary works (such as shoring, bracing, cofferdams, falsework, forms, and formwork) for the construction and repair of permanent structures. This work also includes temporary facilities used in construction that do not become part of the permanent structure.

Material

562.02 Select material consistent with the safety and quality required by the design assumptions.

Provide factory fabricated components of vertical shoring towers according to FHWA-RD-93-033, *Certification Program for Bridge Temporary Works*.

Design Requirements

562.03 Design. Design temporary works that will support loads imposed and provide the necessary rigidity to produce the lines and grades shown in the plans for the final structure. Design temporary works according to the AASHTO, *LRFD Bridge Design Specifications* or AASHTO, *Guide Design Specifications for Bridge Temporary Works*. Ensure the design load on manufactured devices is within the load rating recommended by the manufacturer.

Design falsework and forms that support deck slabs and overhangs on girder bridges to ensure no differential settlement between the girders and the deck forms during placement of deck concrete.

Limit the calculated deflections of falsework and formwork members for cast-in-place concrete structures as follows:

(a) Falsework member vertical deflection. $\frac{1}{360}$ of the span under the dead load of the concrete only, regardless of the fact that deflection may be compensated for by camber strips;

(b) Formwork (other than sheathing). $\frac{1}{360}$ of the span under the dead load of the concrete only or the lateral pressure of fluid concrete only; and

(c) Formwork (sheathing). $\frac{1}{8}$ inch or $\frac{1}{270}$ of the center-to-center distance between studs, joists, form stiffeners, form fasteners, or wales.

Design falsework and forms for concrete supported on steel structures to ensure loads are applied to girder webs within 6 inches of a flange or stiffener. Distribute the loads to avoid producing local distortion of the web. Brace or tie exterior girders, upon which overhanging bridge deck falsework brackets are hung, to the adjacent interior girders as necessary to prevent rotation of exterior girders or overstressing the exterior girder web.

Do not use deck overhang form brackets that require holes to be cast or drilled into the bridge girders.

Do not apply loads to existing, new, or partially completed structures more than the load carrying capacity of any part of the structure as determined according to AASHTO, *LRFD Bridge Design Specifications*.

Do not use permanent or stay-in-place deck forms.

562.04 Drawings. Submit drawings according to Subsection 104.06. Provide design calculations and supporting data in sufficient detail to allow a structural and safety review of the proposed design. Show information to allow the design of components to be checked independently. Provide catalog or equivalent data indicating a manufactured device's recommended safe load capacity.

Indicate the proposed sequence, rate of placement, direction of placement, and location of construction joints when concrete placement is involved. Show anticipated total settlements and deflections of the falsework and forms. Include falsework footing settlements, joint take-up, and deflection of beams or girders.

Submit the erection procedure and temporary support system for girder erection. Include calculations in sufficient detail to substantiate that the girder geometry is correct. Provide supporting calculations showing the falsework design accommodates the erection procedure without overstressing the girder and produces the required final structural geometry, intended continuity, and structural action.

Submit foundation design calculations and other relevant foundation design data for approval.

Construction Requirements

562.05 Foundations. Determine the allowable bearing capacity of the foundation material that supports the temporary works. Perform load tests to verify proposed bearing capacity values that are in doubt, marginal or in other high-risk situations.

Specified foundation support values for the permanent structure may be used in the design of falsework foundations if foundations are at the same elevation and on the same soil as those of the permanent structure. If temporary works are to be supported on temporary fill, construct the fill according to Section 204 and verify the bearing capacity of the placed material.

Locate the edge of footings at least 12 inches from the intersection of the bench and the top of the slope. Locate the edge of the footings at least 48 inches or the depth of excavation, whichever is greater from the edge of excavation, unless shoring adequately supports the footing excavation.

Provide adequate site drainage and erosion control protection.

If piles are used, capacities may be estimated and later confirmed during construction using standard procedures based on the driving characteristics of the pile. Determine ultimate pile capacity according to Section 551. The Contractor may use load tests to confirm the estimated capacities. Perform load tests to verify proposed bearing capacity values that are in doubt, marginal, or in other high-risk situations.

562.06 Construction. Construct temporary works according to the approved drawings and the AASHTO, *Construction Handbook for Bridge Temporary Works*. Use material and workmanship consistent with that assumed in the approved drawings.

Do not weld or use driven devices to fasten temporary works to portions of the permanent structure unless shown in the approved drawings.

Place form panels for exposed surfaces in uniform widths of at least 36 inches and in uniform lengths of at least 6 feet, except where the width of the member formed is at least 36 inches. Arrange panels in symmetrical patterns conforming to the general lines of the structure. Place panels for vertical surfaces with the long dimension horizontal and with horizontal joints level and continuous. Place panels with the long dimension parallel to the footing for walls with sloping footings and that do not abut other walls. Align form panels on each side of the panel joint by supports or fasteners common to both panels.

Devices may be cast into the concrete for later use in supporting forms or for lifting precast members. Do not use driven devices for fastening forms or form supports to concrete. Use form ties consisting of form bolts, clamps, or other devices necessary to prevent spreading of the forms during concrete placement. Do not use form ties consisting of twisted wire loops.

Make the angle points for chords in wall stems fall at vertical rustication joints when architectural treatment is required. Form exposed curved surfaces to follow the shape of the curve, except on retaining walls that follow a horizontal curve. The wall stems may be a series of short chords if the following apply:

(a) Chords within the panel are the same length;

(b) Chords do not vary from a true curve by more than ½ inch at any point; and

(c) All panel points are on the true curve.

Provide tell-tales with surveyed measurements, or other acceptable means, for accurate measurement of falsework settlement. Do not use the ground surface near falsework supports as a reference elevation. Record settlement to the nearest ⅛ inch during concrete placement.

Discontinue concrete placement and take corrective action if settlement or deflections occur that deviate more than ⅜ inch from those shown on the approved drawings. If satisfactory corrective action is not taken before initial set, remove unacceptable concrete.

562.07 Maintenance and Inspection. Inspect and maintain temporary works in an acceptable condition. Clearly mark the capacity on each manufactured component according to FHWA-RD-93-033.

Perform an in-depth inspection of the temporary works in the presence of the CO no more than 24 hours before starting each concrete placement, or before allowing people to enter a cofferdam or excavation support structure. Perform inspections and provide certifications according to FHWA-RD-93-033. Submit written results of the inspections before:

(a) Placing concrete;

(b) Allowing people to enter a cofferdam or excavation support structure; or

(c) Loading temporary works.

Inspect other temporary works at least once a month to ensure they are functioning properly. Use a professional engineer to inspect cofferdams, shoring, support of excavation structures, and support systems for load tests before loading.

For structures that qualify as bridges, perform an initial safety inspection for the temporary bridge structure according to the National Bridge Inspection Standards (NBIS) before opening the bridge to public traffic. Submit the initial bridge inspection report before opening the bridge to public traffic.

Perform other safety inspections according to the NBIS. Maintain the in-service temporary bridge structure throughout its service life. Submit bridge inspection reports within 7 days after completing the inspection.

562.08 Removal. Remove temporary works, except as follows:

(a) Portions of driven falsework piles that are at least 36 inches below subgrade within roadbeds, 24 inches below the original ground or finished grade outside of roadbeds, or 24 inches below the established limits of a navigation channel;

(b) Footing forms where their removal would damage the structural integrity of the cofferdams or other work; or

(c) Forms from enclosed cells where access is not provided.

Remove temporary works to allow the structure to take the stresses of its own dead load uniformly and gradually.

Remove temporary works upon completion of the work unless approved to remain. Do not disturb or damage the finished work. Remove debris and restore the area to its original or planned condition. The removed temporary works remain the property of the Contractor.

After the concrete has been in place for 24 hours, removal of railing and barrier forms and forms that do not support the dead load of concrete members is allowed. Do not remove forms until the concrete has attained at least 500 pounds per square inch strength. Do not damage the surface when removing forms. Cure concrete according to Subsection 552.13 when forms are removed less than 7 days after concrete placement.

Do not remove forms supporting the dead load of concrete members until the concrete has attained 90 percent of the design compressive strength and has been in place for at least 7 days.

Do not remove falsework supporting any span of a simple span bridge until the concrete, excluding concrete above the bridge deck, has attained 90 percent of the design compressive strength and has been in-place at least 10 days.

Do not remove falsework supporting any span of a continuous or rigid frame bridge until the concrete in that span and in the adjacent portions of each adjoining span for a length equal to at least one-half of the length of the span where the falsework is to be released meets the requirements for simple span bridges.

Do not release falsework for post-tensioned portions of structures until the prestressing steel has been tensioned.

Remove falsework for arch bridges uniformly and gradually. Start at the crown and work toward the springing points. Remove falsework for adjacent arch spans simultaneously.

Install a reshoring system if falsework supporting the sides of girder stems with slopes steeper than 1V:1H are removed before placing deck slab concrete. Design the reshoring system with lateral supports, which resist rotational forces acting on the stem, including those caused by the placement of deck slab concrete. Install the lateral supports immediately after each form panel is removed and before release of supports for the adjacent form panel.

562.09 Acceptance. Temporary works will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of temporary fill will be evaluated under Section 204.

Measurement and Payment

562.10 Do not measure temporary works for payment. See Subsection 109.05.

Section 563. — COATING

Description

563.01 This work consists of removing and applying coatings.

Material

563.02 Conform to the following Section and Subsection:

Coating material	719
Water for cementitious materials	725.01(a)

Construction Requirements

563.03 Qualifications. At least 30 days before starting coating work, submit the following for approval:

(a) Coating contractors. Coating contractors certified according to the following, as appropriate for the work:

(1) SSPC-QP1, Certification (Field Application to Complex Industrial and Marine Structures);

(2) SSPC-QP2, Certification Program (Field Removal of Hazardous Coatings); or

(3) SSPC-QP3, Certification Program (Shop Painting Certification Program).

(b) Personnel. Personnel with the following qualifications:

(1) SSPC Competent Person Certificate;

(2) Certificate of completion of lead exposure training according to 29 CFR 1926.62;

(3) Minimum of 2 years' industrial field coating experience; and

(4) Minimum of 1 year's field supervisory or management experience in coating removal projects.

563.04 Submittals. At least 30 days before starting coating work, submit the following according to Subsection 104.06:

(a) A coating plan conforming to Subsection 563.05. Indicate which products will be used, methods of application, and schedule of application, including hold points.

(b) SDS and product data sheets (PDS) for cleaning and coating products.

(c) A containment system, coating removal, and waste disposal plan conforming to Subsection 563.07.

(d) A worker protection plan conforming to Subsection 563.08.

(e) Specific safety measures to comply with 29 CFR 1926.62, 40 CFR 50.6, 40 CFR 50.12, and 40 CFR Parts 260-268, if coating being removed is a hazardous material.

(f) Emergency spill procedures.

(g) Site-specific plan for maintenance and protection of traffic.

(h) A topcoat coating sample at least 1 foot by 1 foot, using the same coating system to be used on the surface to be coated.

563.05 General. Perform work according to the approved Coating Plan. Stop work and take corrective action if the measures fail to perform as intended.

(a) Hold points. Specific inspection items are designated as hold points. Notify the CO at least four hours before reaching a hold point. If the four-hour notification is provided and the work is ready for inspection at that time, the CO will conduct the necessary inspection, testing, and validation. If the work is not ready at the appointed time and unless other arrangements are made, an additional four-hour notification is required. Do not proceed beyond a hold point until approved.

(b) QC. Provide equipment to perform the QC inspections. At a minimum, provide the following:

(1) Psychrometer or comparable equipment for the measurement of dew point and relative humidity, together with weather bureau tables or psychrometric charts;

(2) Surface temperature thermometer;

(3) Bresle Kits or equivalent for chloride determinations;

(4) Wet film thickness gauge;

(5) Blotter paper for compressed air cleanliness checks;

(6) Type 2 magnetic dry film thickness gauge according to SSPC-PA 2, *Procedure for Determining Conformance to Dry Coating Thickness Requirements*;

(7) Calibration standards for dry film thickness gauge;

(8) Light meter for measuring light intensity during cleaning, coating, and inspection activities;

(9) Applicable ASTM and SSPC Standards used for the work;

(10) Putty knife of a minimum thickness of 40 mils and a width from 1 to 3 inches if there are touch-up areas where the coating is being feathered and tested with a dull putty knife; and

(11) Procedures for chloride remediation and frequency of testing.

Calibrate instruments according to the QC process and the equipment manufacturer's recommendations. Make inspection equipment and calibration charts available to the CO for inspection and testing.

(c) Lighting. Inspection of lighting is designated as a hold point defined in Subsection 563.05(a).

Provide artificial lighting both inside and outside the containment system where natural light is inadequate, as determined by the CO, to allow proper cleaning, inspection, and coating. Provide illumination for inspection of at least 30 foot-candles. Provide illumination for cleaning and coating, including the working platforms, access, and entryways, of at least 20 foot-candles. Provide general work area illumination outside the containment of at least 5 foot-candles. Design and operate the lighting system to avoid glare that interferes with traffic, workers, and inspection personnel.

(d) Inspection access. Facilitate the CO’s inspections as needed, including allowing ample time to view the work. Provide and erect equipment to allow close observation of surfaces to be cleaned and coated. Provide this equipment during all phases of the work.

(e) Protection of the work. Use tarps, screens, paper, cloth, or other suitable means to protect adjacent surfaces that are not to be coated. Prevent contamination of freshly coated surfaces by dust, oil, grease, or other harmful or deleterious material.

Repair damage caused to the bridge structure during construction.

(f) Coating material. Provide new coating material applied to a single structural component from the same coating manufacturer and coating system. Include both shop and field coating applications and components.

Use safe handling practices conforming to the manufacturer’s SDS and PDS. Store coating material in original unopened containers with labels intact and in weather-tight spaces where temperature is maintained between 40 and 100 °F. Do not open coating material containers until required for application that day. Do not use coating material from a punctured container or from a container with its lid seal broken. Do not use coating material with an expired shelf life.

Mix coating material according to the manufacturer’s recommendations. Mix coating material with mechanical mixers for sufficient time to thoroughly blend the pigment and solvent together. Continue the mixing during application. Do not thin coating material that is formulated ready for application. Strain coating material after mixing, except where application equipment is provided with strainers. Use strainers of a size to remove only skins and undesirable matter, but not to remove the pigment. Where a skin has formed in the container, cut the skin loose from the sides of the container and discard it. If the volume of the skin is visually estimated to be more than 2 percent of the remaining coating material, discard the coating material.

(g) Surface preparation and weather limitations. Remove dirt, dust, and other contaminants from the surface according to the coating manufacturer’s recommendations. Clean the surface to the specified cleanliness level. Thoroughly dry the surface to be coated.

Apply coating when the following conditions are met or according to the manufacturer’s recommendations, whichever is more restrictive:

(1) The surface temperature is between 50 and 100 ºF;

(2) The surface temperature is 5 ºF or more above the dew point measured according to ASTM D4230; and

(3) The humidity is 85 percent or less, unless otherwise specified on the manufacturer’s PDS.

Continuously monitor, record, and provide temperatures and humidity at least every 15 minutes while coating. Check the dew point immediately before each coating, at least every 4 hours during coating, and as conditions change.

Provide a controlled environment to meet weather limitations if necessary.

(h) Application. Apply coating material according to the manufacturer's recommendations. Apply coating material by brush, sprayer, roller, or combination of methods recommended by the manufacturer's PDS.

(1) Brushes. Use brushes with sufficient bristle body and length to spread the coating material in a uniform film. Use round, oval shaped brushes, or flat brushes no wider than 4½ inches. Evenly spread and thoroughly brush out the coating material as it is applied.

(2) Sprayers. Use airless or conventional spray equipment with suitable traps, filters, or separators to exclude oil and water from the compressed air. Use compressed air that does not show black or wet spots when tested according to ASTM D4285. Use the spray gun tip sizes and pressures recommended by the manufacturer.

(3) Rollers. Select rollers and covers suitable for the surface and coating material to be applied. Use rollers only on flat, even surfaces. Do not use rollers that leave a stippled texture in the coating film.

Use sheepskin daubers, bottle brushes, or other coating methods recommended by the manufacturer to coat surfaces that are inaccessible for coating by regular means.

Coat surfaces in a manner that does not produce excessive coating build-up, runs, sags, skips, holidays, or thin areas in the coating film. Correct thin areas, skips, holidays, and other deficiencies before the next application of coating material.

Tint succeeding applications of coating material to contrast with the coating being covered. Obtain color approval for the finish coat before application.

Coat surfaces that will be inaccessible after erection with the full number of undercoats required before erection. After erection, clean areas where the undercoating is damaged or deteriorated, and spot coat with the specified undercoats to the required thickness before applying the final coat.

Measure the wet film thickness during application and adjust the application rate to obtain the required dry film thickness.

(i) Curing. Cure each coat according to the manufacturer's recommendations, increasing cure times as needed for changes in surface and ambient temperatures, and humidity. Maintain a surface temperature of at least 5 ºF above the dew point measured according to ASTM D4230 for at least 12 hours after coating is finished.

Continuously monitor, record, and provide temperatures and humidity at least every 15 minutes while curing. Maintain the coating manufacturer's curing requirements for each coating application for the entire curing duration.

Protect coated surfaces from direct exposure to rain for the time interval recommended by the coating manufacturer for proper cure.

563.06 Protection of Public, Property, and Workers. Comply with SSPC-PA, Guide 10, *Guide to Safety and Health Requirements for Industrial Painting Projects* and OSHA standards.

Handle all waste as hazardous material until tested and proven to be non-hazardous. If a hazardous material is removed, comply with the following:

(a) SSPC Guide 6, *Guide for Containing Surface Preparation Debris Generated During Paint Removal Operations*;

(b) SSPC Guide 7, *Guide to the Disposal of Lead-Contaminated Surface Preparation Debris*;

(c) 29 CFR 1926.62, Lead (Safety and Health Regulations for Construction);

(d) 40 CFR 50.6, National Primary and Secondary Ambient Air Quality Standards for PM_{10};

(e) 40 CFR 50.12, National Primary and Secondary Ambient Air Quality Standards for Lead; and

(f) 42 U.S.C. §6901, Resource Conservation and Recovery Act.

Collect and dispose of material including wastewater that is used in preparing, cleaning, or coating.

563.07 Containment System, Coating Removal, and Waste Disposal. Design and construct safe containment systems to support the loads imposed. Do not apply loads to the existing structure more than the load carrying capacity of any part of the structure. Include details of attachment. Include connections with clamps or other approved devices that do not require welding or drilling holes in the existing structure. Include working drawings and construction details.

Provide design calculations, manufacturer’s specifications, and certifications for the containment system’s working platform. Provide a platform that is firm and stable, designed to support workers, authorized persons, spent abrasive material, and equipment during all phases of construction. Provide calculations and specifications stating the proposed containment system’s load bearing capacity and show that the system will support imposed loads. Maintain minimum vertical and horizontal clearances for construction operations as approved.

Fully enclose surface preparation and coating application operations to eliminate the emission of airborne blast debris, dust, and coatings from the containment, and ensure that no dust, debris, or coatings enter the water below. Comply with SSPC Guide 6, Class 2. Provide a containment system with air impenetrable walls, a negative air pressure environment within the containment, and fresh air flow through the containment. Maintain an average negative pressure of 0.03-inch water column inside the enclosure (as measured by manometer or differential pressure gauge) during blasting and blow down operations. Maintain a safe and uncluttered passageway for foot traffic in the containment system, and between staging and work areas.

Design air flow inside the enclosure to meet OSHA standards. Provide containment design and ventilation to allow for the maximum practical reduction in exposure of workers to airborne contaminants inside the containment system. Submit a list of the equipment, including operating capacities and manufacturer’s instructions.

Prevent release of accumulated debris into the environment. Protect workers from exposure to hazardous materials. Immediately correct visible emissions from the containment enclosure. Ensure emissions from the containment enclosure conform to Federal and state air quality standards.

Take at least eight representative soil samples, including at least one at each corner of the work site according to SSPC Guide 6. Take samples and perform test analysis for toxic metals on samples before work start-up, during surface preparation and coating application operations, and after work operations are completed. If elevated levels of toxic heavy metals are found in baseline soil samples, obtain additional samples and retain for future analysis.

Take water samples and perform test analysis for toxic metal content downstream before work start-up, every two weeks during work, and after work operations are completed, to demonstrate water purity.

Clean up spilled waste materials immediately and take necessary actions to remedy resulting soil and water contamination.

Comply with SSPC Guide 7. Seal collected waste materials in leak-proof drums. Place only spent abrasives, coating particles, and blast debris in the drums. Provide drums that are in new condition and approved for use. Clearly identify each drum according to EPA and state rules and regulations, with the bridge number, contract number, Contractor’s name, contents, and the date waste material accumulation started.

Obtain necessary permits for storage, transport, characterization, and disposal of waste.

Store contaminated debris according to Federal and state rules and regulations. Store drums containing contaminated debris in a locked sea cargo trailer within a secured staging area.

Remove the contaminated debris from the site within 30 days of collection. Obtain approval before storing drums in the trailer. Prevent the entry of unauthorized persons, livestock, or wildlife into the staging area and the lead work area. Post warning signs with clearly visible legends, "DANGER - AUTHORIZED PERSONNEL ONLY", easily visible from routinely used approaches to the staging area and the work area.

Sample and test the waste material according to EPA, *SW-846 Test Method 1311, Toxicity Characteristic Leaching Procedure*. Test waste for lead and other elements shown in SSPC Guide 7, Table 1.

If waste material is determined to be hazardous, obtain an EPA Identification Number and prepare a manifest of hazardous waste to be transported to an approved waste storage site. Prepare the manifest according to Federal and state rules and regulations. Provide a certificate or manifest indicating the weight and the number of drums of waste to be disposed. Provide a testing manifest for hazardous waste and EPA Identification Number to the bridge owner before the material is transported. Provide proof of acceptance from an approved disposal site, including information required by state and local rules and regulations.

Ensure that the hazardous waste hauler is licensed and has an EPA Identification Number. Conform to Federal and state rules and regulations regarding the maximum volume of hazardous waste which may be stored on the site. Do not store the waste materials on the site for more than 90 days. Do not treat hazardous waste on site.

If lead or any element shown in SSPC Guide 7, Table 1 does not meet or exceed the permissible level of concentration as measured by the Toxicity Characteristic Leaching Procedure (TCLP), dispose of the waste material as an industrial solid waste according to Federal and state rules and regulations. Dispose of waste at an approved facility. Provide the CO with an authorization before disposal.

If waste material is transported outside the state for disposal, comply with Federal, state, and local rules and regulations.

563.08 Worker Protection Plan.

(a) Submit a worker health and protection plan that has been prepared by a Certified Industrial Hygienist who is certified by the American Industrial Hygienist Association, and according to Federal rules and state regulations. Include the following:

(1) Work practices;

(2) Engineering controls;

(3) Administrative controls;

(4) Training;

(5) Medical surveillance;

(6) Hazard identification;

(7) Protective clothing and respirator selection;

(8) Handling containers;

(9) Emergency responses;

(10) Decontamination;

(11) Illumination;

(12) Sanitation; and

(13) Site control.

(b) Train workers and persons exposed to coating or cleaning operations according to the approved worker protection plan.

Provide documentation of workers' safety training and education that requires instruction in recognizing and avoiding unsafe conditions and hazards, complying with OSHA 29 CFR 1910 and OSHA 29 CFR 1926, with emphasis on beryllium, cadmium, chromium, lead, and respirable crystalline silica.

(c) Require workers scheduled to receive lead exposure at or above the action level on any day during the project duration to have the following:

(1) An initial medical surveillance consisting of blood sampling and analysis for lead and zinc protoporphyrin levels (an indicator of lead levels in the blood).

(2) Follow-up blood tests for any worker whose initial medical surveillance results were at the permissible exposure limit or more.

(3) Thorough medical examinations for workers who are or may be exposed at or above the action level for 30 or more days in any 12-month period.

Use OSHA-approved laboratories to perform blood analyses. Provide initial and follow-up medical surveillance to workers and the CO within 48 hours of a worker's exposure. Do not use prophylactic or preventive chelation to keep blood lead levels down while workers are on the job.

(d) Designate a competent person who is knowledgeable about protection of workers from the hazards of lead exposure to be the Worker Health and Safety Officer and responsible for ensuring worker safety and remedying any hazardous situation. Submit certification signed by the Worker Health and Safety Officer at completion of the project that the worker health and protection plan complied with all regulations and was fully implemented.

563.09 Structural Iron and Steel. Provide the topcoat of coating material to match existing coating on structural iron and steel or as directed. Conform to SAE-AMS-STD-595.

Comply with SSPC-VIS Standards or NACE Comparators for surface conditions and finished surface profile visual standards.

(a) Test blast. This Subsection is designated as a hold point defined in Subsection 563.05(a).

Perform a test blast on a portable steel plate, measuring approximately 1 foot by 1 foot, representative of those steel surfaces cleaned throughout the structure, and according to Subsection 563.09(c). Produce an anchor profile height within the range recommended by the coating system manufacturer's PDS. Measure anchor profile according to Subsection 563.09(c).

Start blast cleaning only after the CO has inspected and approved the test blast plate. Preserve and protect the test blast plate as a job standard with a clear sealer, and photograph for documentation and project QC.

(b) Compatibility test. This Subsection is designated as a hold point defined in Subsection 563.05(a).

Select a test area of at least 30 square feet in a condition representative of the condition of the structure. Perform surface preparation according to Subsection 563.09(c) and apply the proposed system according to Subsection 563.09(f). Perform tests according to ASTM D5064. Observe for lifting, bleeding, blistering, wrinkling, cracking, flaking, or other evidence of incompatibility.

Verify that no indication of incompatibility exists at least 14 days after the application of each product. Perform adhesion tests according to ASTM D4541, Methods C through F.

Notify the CO if failure is due to adhesion (between coating and substrate or between applied coats) or cohesion (failure within a coating layer). If failure occurs, provide a compatible coating system and repeat the compatibility process.

Remove dirt, dust, and other debris from the surface by vacuuming or other approved methods.

(c) Surface preparation. Prepare surfaces by removing the existing coating, which may contain lead and other contaminants, according to Subsection 563.07.

Remove dirt, mill scale, rust, and other foreign material from exposed surfaces by blast cleaning to near-white metal according to SSPC-SP 10/NACE No. 2, *Near-White Blast Cleaning*. Prepare surfaces inaccessible to near-white metal blast cleaning according to SSPC-SP 11, *Power Tool Cleaning to Bare Metal*.

Blast clean with clean dry slag, mineral grit, steel shot, angular steel grit, or chilled iron grit abrasives. Use a suitable gradation to produce a dense, uniform anchor pattern. Produce an anchor profile within the range recommended by the coating system manufacturer's PDS. Measure anchor profile height according to ASTM D4417, Method C or Method D, or ASTM D7127. Follow SSPC-PA 17, *Procedure for Determining Conformance to Steel Profile/Surface Roughness/Peak Count Requirements*.

(d) Chloride testing. This Subsection is designated as a hold point defined in Subsection 563.05(a).

Test bare metal surfaces for the presence of chlorides. If chlorides are present, clean surfaces to remove chlorides. Methods of chloride removal may include, but are not limited to, steam cleaning, pressure washing (with or without the addition of a chemical soluble salt remover according to the coating manufacturer), and scrubbing.

After completing the chloride remediation steps, use approved cell methods of field chloride extraction and test procedures to test representative surfaces for the presence of remaining chlorides. Test at frequencies shown in the approved QCP. Maintain remaining chloride levels less than 5 μg/sq cm as read directly from the surface without any multiplier applied to the results.

Repeat solvent and surface cleaning if surfaces rust or become contaminated before coating. Repeat blast cleaning if surface cannot be made free of rust or contamination by other methods. Repeat blast cleaning on areas that have flash rusted from the chloride testing.

(e) Primer application. Apply primer to bare metal surfaces within 3 days of cleaning, and before the steel flash rusts. Repeat blast cleaning on areas that have flash rusted before applying primer.

(f) Application. Use sheepskin daubers, bottle brushes, or other acceptable methods to coat surfaces that are inaccessible for coating by regular means. Coat in a manner that does not produce excessive coating build-up, runs, sags, skips, holidays, or thin areas in the coating film. Correct thin areas, skips, holidays, and other deficiencies before the next application of coating material.

Apply coating material in the following order: primer, primer stripe, intermediate, intermediate stripe, and finish coat. Extend stripe coats at least 1 inch beyond welds, rivets, bolts, nuts, edges of plates and structural members, angles, bearings, lattice pieces or other shapes, corners, crevices, and any area in which full coverage and film thickness are difficult to achieve.

Provide a different color for each coat with substantial contrast to the underlying substrate and previous coats to verify complete coverage. Submit colors for the primer, stripe coat, and intermediate coat to the CO for approval.

Apply according to the manufacturer's recommendations.

Do not use accelerator additives.

Apply subsequent coats of coating material only when the receiving surface is dry and fully cured according to the manufacturer's recommendations.

Determine the dry coating thickness on steel structures using a Type 2 (electronic) film thickness gauge according to SSPC-PA 2.

Repair minor coating defects, handling damage, and other occasional non-conformances, according to SSPC-PA 1, *Shop, Field, and Maintenance Coating of Metals* and the manufacturer's recommendations. Submit repair procedures for substantial damage, significant defects, or widespread (gross) non-conformances in the coated surface. Ensure that repairs to the topcoat of coating material result in an acceptable, uniform color, gloss, and texture on visible surfaces.

(g) Curing. Cure according to Subsection 563.05(i).

563.10 Lumber and Timber. Dry timber to a moisture content of 15 percent or less.

Remove cracked or peeled coating, loose chalky coating, dirt, and other foreign material on previously coated timber. Use wire brushing, scraping, or other approved methods.

If timber is treated with a waterborne preservative, wash and brush away visible salt crystals on the wood surface. Allow wood to dry before coating.

Remove dust and other foreign material from the surface fed before coating.

The primer may be applied before erection. After the primer dries and the timber is in place, fill cracks, checks, nail holes, and other depressions flush with the surface using an approved putty. After the putty has dried, evenly spread and thoroughly work the coating material into corners and recesses. Allow the full thickness of the applied coating material to dry before applying the next coat.

563.11 Masonry Block and Concrete Structures. Remove laitance, dust, and other deleterious material from the concrete surface. Give the cleaned surface a light abrasive sweep blast to remove mortar wash and other contaminants. Remove residue and dust by vacuuming or other approved methods.

Evenly spread and thoroughly work the coating material into corners and recesses. Allow the full thickness of the applied coating material to dry before applying the next coat.

563.12 Other Metals.

(a) Aluminum. Prepare aluminum surfaces to be coated according to ASTM D1730. Use the type of treatment and method of preparation appropriate to the condition of the surface and coating to be applied.

(b) Galvanized surfaces. Prepare galvanized surfaces to be coated according to ASTM D6386. Use the type of treatment and method of preparation appropriate to the condition of the surface and coating to be applied. Use zinc-rich coating material conforming to SSPC Paint 20 to treat galvanized steel field cuts and damaged galvanizing according to the applicable requirements of ASTM A780.

563.13 Acceptance. Coating material will be evaluated under Subsections 106.02 and 106.03. Sample coating material according to ASTM D3925. Test coating properties according to FED-STD-141D, *Paint, Varnish, Lacquer and Related Materials: Methods of Inspection, Sampling and Testing*, if required.

Coatings will be evaluated under Subsections 106.02 and 106.04.

Containment systems will be evaluated under Subsections 106.02 and 106.03.

Surface preparation will be evaluated under Subsection 106.02.

Treating galvanized steel field cuts and repairing damaged galvanizing will be evaluated under Subsection 106.02.

Measurement

563.14 Measure the Section 563 pay items listed in the bid schedule according to Subsection 109.02.

Payment

563.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 563 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 564. — BEARING DEVICES

Description

564.01 This work consists of providing and installing bridge bearing devices.

Material

564.02 Conform to the following Subsections:

Bearings	717.09
Bolts and nuts	717.01(d)
Galvanized coatings	717.07
Non-shrink grout	701.04(b)(1)

Construction Requirements

564.03 General. Provide elastomeric, rocker, roller, sliding plate, and disc bearing devices.

(a) Drawings. Submit drawings according to Subsection 104.06 and Section 18 of the AASHTO, *LRFD Bridge Construction Specifications*. Show details of bearings including material proposed for use. Do not start fabrication until drawings are approved.

(b) Fabrication. Fabricate bearings according to Section 18 of AASHTO, *LRFD Bridge Construction Specifications*. Finish bearing components surfaces in contact with each other or in contact with concrete according to Subsection 555.07(e).

Preassemble bearing assemblies and check for proper completeness and geometry. Galvanize steel bearing components and anchor bolts. Do not galvanize stainless steel bearing components or anchor bolts.

Packaging, handling, and storing material.

Clearly identify each bearing component and mark on its top the location and orientation in the structure before shipping. Securely bolt, strap, or otherwise fasten bearings to prevent relative movement.

Package bearings to prevent damage during shipping, handling, or storing.

Do not dismantle bearing assemblies on site unless necessary for inspection or installation. Dismantle under the direct supervision or approval of the manufacturer.

Provide a listing of individual bearing numbers.

Store bearing devices to prevent damage from weather or other hazards.

(c) Construction and installation. Clean bearings of deleterious material. Install and set bearings to the dimensions shown in the plans or according to the manufacturer's recommendations. Adjust bearings according to the manufacturer's recommendations to compensate for installation temperature and future movements.

Set bearings level, at the elevation, and position shown in the plans. Provide full and even bearing on external bearing contact surfaces. Notify the CO if bearing surfaces are at improper elevations, not level, or if bearings cannot be set properly. Submit a written proposal to modify the installation.

Bed metallic bearing assemblies on concrete with an approved filler or fabric material when not embedded in concrete.

Set elastomeric bearing pads directly on properly prepared concrete surfaces without bedding material.

Machine bearing surfaces seated directly on steel to provide a level and planar bearing surface.

564.04 Elastomeric Bearings. Fabricate, comply with testing and acceptance criteria, and mark elastomeric bearings according to AASHTO M 251. Test and accept bearings specified by hardness and designed according to Method A of AASHTO, *LRFD Bridge Design Specifications* according to Section 8.8.4 of AASHTO M 251.

Place bearings on a level surface. Correct misalignments in the support to form a level surface. Do not weld steel girders or base plates to the exterior plates of the bearing unless there is more than 1½ inches of steel between the weld and elastomer. Do not expose the elastomer or elastomer bond to instantaneous temperatures greater than 400 °F. Do not design or fabricate elastomeric bearings with holes.

564.05 Rocker, Roller, and Sliding Plate Bearings. Fabricate pins, rollers, and rockers according to Subsection 555.10. Remove burrs, rough and sharp edges, and other flaws. Stress relieve rocker, roller, and other bearings that are built up by welding sections of plate together before boring, straightening, or final machining.

Thoroughly coat contact surfaces with oil and graphite before placing roller bearings. Install rocker, roller, and sliding bearings vertically at the specified mean temperature after release of falsework and after shortening due to prestressing forces. Account for variations from mean temperature of the supported span at time of installation and other anticipated changes in length of the supported span.

Ensure the superstructure has full and free movement at movable bearings. Position roller bearings so their axes of rotation align and coincide with the axis of rotation of the superstructure.

564.06 Disc Bearings. Use structural steel plates conforming to AASHTO M 270, Grade 50. Equip disc bearings with a shear restriction mechanism to prevent movement of the disc. Use disc bearings produced by the same manufacturer.

For guided bearings, use either a guide bar or keyway system to restrict transverse movement. Face the sliding surfaces of the guide bar or keyway systems with either PTFE sheets or stainless steel.

Provide polyether urethane rotational elements molded as a single piece.

Design the disc bearings for the loads and movements shown in the plans according to AASHTO, *LRFD Bridge Design Specifications*. Install according to the manufacturer’s recommendations.

Submit manufacturer’s test results to the CO certifying that the completed bearings and their components comply with the proof load test and sliding coefficient of friction test, according to Subsection 18.3.4 of AASHTO, *LRFD Bridge Construction Specifications*.

Bearings represented by test specimens passing the requirements are approved for use in the structure subject to on-site inspection for visible defects. Bearing devices showing visual defects will be rejected. Visual defects include extruded or deformed elastomer or PTFE, damaged seals or rings, and cracked steel.

564.07 Masonry, Sole, and Shim Plates for Bearings. Provide metal plates conforming to AASHTO M 270, Grade 36.

Fabricate and finish steel according to Subsection 555.07. Form holes in bearing plates by drilling, punching, or controlled oxygen cutting. Remove burrs by grinding.

Set bearing plates in a level position and provide a uniform bearing over the bearing contact area. If plates are embedded in concrete, make provisions to keep them in correct position as the concrete is placed.

564.08 Polytetrafluoroethylene Surfaces for Bearings. Provide PTFE material that is factory-bonded, mechanically connected, or recessed into the backup material.

Bond or mechanically attach the fabric containing PTFE fibers to a rigid substrate. Use a fabric that can carry unit loads of 10,000 pounds per square inch without cold flow. Use a fabric-substrate bond that can withstand a shear force equal to 10 percent of the perpendicular or normal application loading plus other bearing shear forces without delamination.

Use approved test methods and procedures according to Section 18 of AASHTO, *LRFD Bridge Construction Specifications*. Perform at least one material test on the material used in the sliding surface for each lot of bearings. If required by the contract, test complete bearings for complete bearing friction. If the test facility does not allow testing of completed bearings, manufacture extra bearings and prepare samples of at least 100-kip capacity at normal working stresses by sectioning the bearing.

Measure the coefficient of friction between two mating surfaces. Submit test results showing the static and dynamic coefficients of friction meet the requirements for the design coefficient of friction specified in the contract or by the manufacturer for approved material.

564.09 Anchor Bolts. Provide threaded anchor bolts.

Adjust bolt locations for superstructure temperature and anticipated lengthening of bottom chord or bottom flange due to dead load after setting as required. Do not restrict free movement of the superstructure at movable bearings.

Preset anchor bolts before concrete placement or install anchor bolts in drilled holes after concrete placement. Drill holes 1 inch in diameter greater than the bolt if non-shrink cement grout is used to secure the bolts. Follow the adhesive manufacturer’s recommendations for hole diameter if an approved chemical adhesive is used to secure the bolts.

564.10 Bedding of Masonry Plates. Clean the contact surfaces of the concrete and steel before placing the bedding material and installing bearings or masonry plates. If bedding is specified, place filler or fabric as bedding material under masonry plates and install it to provide full bearing on contact areas. If bedding material is not specified, comply with Subsection 18.10.2 of AASHTO, *LRFD Bridge Construction Specifications* as directed.

564.11 Acceptance. Material for bearing devices will be evaluated under Subsections 106.02 and 106.03.

Submit a production certification with each shipment of bearing devices.

Bearing device installation will be evaluated under Subsections 106.02 and 106.04.

Measurement

564.12 Measure the Section 564 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure bearing devices for prefabricated steel bridges and fiber-reinforced polymer bridges.

Payment

564.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 564 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 565. — DRILLED SHAFTS

Description

565.01 This work consists of providing and constructing reinforced concrete drilled shafts.

Material

565.02 Conform to the following Subsections:

Neat hydraulic cement grout	701.04(a)(2)
Reinforcing steel	709.01
Slurry (drilling fluids)	725.13
Steel pipes	717.06
Structural carbon steel	717.01(a)
Water for cementitious materials	725.01(a)

Construction Requirements

565.03 Qualifications. At least 30 days before starting drilled shaft work, submit the following for approval:

(a) On-site supervisor. A résumé for the on-site supervisor describing at least 5 years' experience supervising construction of drilled shafts of similar lengths and scope to those shown in the plans and in similar geotechnical conditions described in the geotechnical report. Include experience as the direct supervisor responsible for on-site construction operations;

(b) Drill operator. A résumé for each drill operator describing at least 2 years' experience in the construction of drilled shafts;

(c) Professional engineer or geologist. A résumé for a professional engineer or professional geologist with at least 5 years' experience in the design and construction of drilled shafts and logging shaft excavations;

(d) Geotechnical engineer or geologist. If applicable, a résumé for a geotechnical engineer or engineering geologist working under the direct supervision of the professional engineer or professional geologist described in Subsection 565.03(c), to maintain the boring log. Show at least 2 years' experience in the design and construction of drilled shafts and logging shaft excavations; and

(e) Crosshole sonic logging (CSL) engineer. A résumé for a CSL engineer describing at least 5 years' experience in the testing of drilled shafts.

565.04 Construction Plan. At least 30 days before starting drilled shaft work, submit the following according to Subsection 104.06:

(a) Proposed drilled shaft construction schedule and sequence. Schedule shaft installation to avoid interconnection or damage to shafts in which placed concrete has not attained final set.

(b) Proposed drilling, hole cleaning, hole preparation, and bottom inspection method; and reinforcement and concrete placement equipment and procedures for the ground conditions expected to be encountered. Provide specific shaft drilling and concreting procedures to mitigate problems associated with ground water, surface water bodies, or both. Demonstrate an understanding of the subsurface conditions at the site by referencing available subsurface data shown in the boring logs. Indicate procedures to minimize disturbance to the construction site or overlaying or adjacent structure or services. Discuss potential drilling difficulties and indicate means and methods that will be used to remove obstructions from the excavation.

(c) Proposed drilled shaft excavation and construction methods used to ensure shaft stability during construction and reinforcement and concrete placement. Include proposed shaft drilling procedures for maintaining required horizontal and vertical shaft alignment. Include disposal plan for excavated material. If shaft casing is required, provide casing dimensions and detailed procedures for permanent casing installation or temporary casing installation and removal.

(d) Proposed methods for mixing, testing, circulating, using, maintaining, and disposing of slurry, if used. Provide a detailed slurry mix design and its suitability to the subsurface conditions. Include the name and telephone number of the slurry manufacturer's representative.

(e) Details of reinforcement placement. Include bracing, centering, centralizers, and lifting and support methods.

(f) Proposed structural concrete mix design conforming to Section 552, except as shown in Table 565-4.

(g) Concrete placement methods. Include proposed operational procedures for free-fall, tremie, or pumping methods.

(h) The method used to form an emergency horizontal construction joint during concrete placement.

(i) Inspection forms and charts for logging subsurface conditions during excavation and concrete volume placement. Include examples of populated forms.

Conform to the installation and construction plan requirements for drilled shafts in FHWA-NHI-18-024, *Drilled Shafts: Construction Procedures and LRFD Design Methods*.

565.05 Trial Drilled Shafts. If trial drilled shafts are required, perform the work according to the applicable requirements of Subsection 565.06.

Before drilling holes for production shafts, demonstrate that the proposed methods and equipment are adequate by drilling a trial drilled shaft adjacent to the production shafts at an approved location. Make the center-to-center spacing between the trial shaft and production shafts at least three shaft diameters or two bell diameters, whichever is larger.

Construct the trial drilled shaft to the same size and to the tip elevation of the deepest production shaft shown in the plans. When bells are specified for production shafts, include a bell in the final trial shaft to verify the feasibility of belling in the specified bearing stratum.

Install casing if caving occurs or the hole deforms sufficient to encroach upon the planned placement of the reinforcement cage with specified minimum concrete cover. Seat the casing to prevent caving and to allow dewatering of the hole when required. Remove material from inside the hole. Keep casing in place at least 4 hours while attempting to remove water in the hole. Record the rate of groundwater seepage into the hole. After this 4-hour period, fill the hole with saturated sand while the casing is removed to simulate the concreting operation and casing removal for the production drilled shafts.

Concrete or reinforcing steel is not required in the trial drilled shaft.

Modify methods and equipment if the trial drilled shaft does not meet performance requirements. Submit a new installation plan and drill a new trial shaft for approval.

565.06 Shaft Drilling.

(a) Drilling. Drill holes according to the approved construction plan. Excavate structural footings supported on drilled shafts and construct fills before initiating shaft drilling.

Provide equipment and tooling able to drill shafts of the specified diameter and lengths 20 percent longer than those specified. Comply with tolerances shown in Table 565-1.

(1) Boring log. Provide a geologist or an engineer to maintain a boring log of material excavated from the drilled shaft. Include the following information:

(a) Description and approximate top and bottom elevation of each type of soil or rock material encountered and the date and time the soil or rock material was encountered;

(b) Elevation and approximate rate of seepage or groundwater encountered;

(c) Equipment used to drill the shaft, time required to complete the shaft, bit changes, breakdowns, and other drilling difficulties encountered; and

(d) Remarks.

(2) Drilling methods. Use the uncased dry construction method where groundwater level and soil conditions are suitable to construct the shaft in a relatively dry-stable excavation and may be visually inspected before placing concrete. Use casing construction method, wet construction method, or both for shafts that do not meet the requirements for the dry construction method.

(a) Dry construction method. Drill the shaft, remove accumulated water and loose material from the excavation, place the reinforcing cage, and concrete the shaft in a relatively dry excavation.

The dry construction method may be used when the excavation meets the following:

(1) Less than 12 inches of water accumulates above the base of the hole during a 1-hour period without pumping;

(2) The sides and bottom of the hole remain stable without caving, sloughing, or swelling for 4 hours after excavation or over-reaming; and

(3) Loose material and water can be satisfactorily removed before inspection and before reinforcement and concrete placement.

(b) Wet construction method. Use water or slurry to maintain shaft stability with a fluid head inside the shaft excavation higher than the on-site static water elevation while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft. Perform the following:

(1) Desand and clean drilling slurry;

(2) Final cleaning of the excavation using a bailing bucket, submersible pump, or other approved devices;

(3) Place shaft concrete with a tremie or concrete pump, starting at the shaft bottom; and

(4) Maintain pressure inside the shaft higher than outside at all times. Maintain inside fluid head elevation at least 5 feet higher than outside water head elevation.

Table 565-1
Drilled Shaft Construction Tolerances

Drilled Shaft Attribute	Allowable Variance
Top elevation	1 in above to 3 in below the elevation shown in the plans
Axial alignment	Within 1.5% of plumb in soil Within 2.0% of plumb in rock
Rebar stick-up	6 in above to 3 in below the elevation shown in the plans
Diameter	At least the diameter shown in the plans
Horizontal location at top-of-shaft elevation	
Shaft diameter less than or equal to 2.0 ft	3 in
Shaft diameter greater than 2.0 ft and less than 5.0 ft	4 in
Shaft diameter 5.0 ft or larger	6 in

If drilled shaft excavations and completed drilled shafts are out of tolerance or defective, submit correction procedures for approval before correcting the deficiencies. Correct unacceptable shaft excavations and completed shafts to the satisfaction of the CO.

Maintain the drilled hole to the specified nominal diameter before placing reinforcement elements and concrete. Increase the hole diameter at least ½ inch to a maximum of 3 inches when approved if ground softening, swelling or slurry cake buildup occurs. Case the hole, use a slurry during drilling, or both if the drilled hole continues to degrade and encroach upon the planned placement of the reinforcement cage with specified minimum concrete cover.

Extend exterior casings from above the waterline to a subsurface elevation to protect against water action during placement and curing of the concrete when drilled shafts are located in open waters. Install the exterior casing to provide a positive seal at the bottom of the casing and prevent piping of water or entry of other material from the shaft excavation behind the casing.

Remove drill cuttings and other loose debris from the bottom of the hole upon completion of drilling. Clean the drilled hole leaving no more than 2 inches of sediment on the bottom of the hole. Reduce the depth of accumulated water to less than 3 inches before placing concrete in shafts constructed using the dry method. Use a Shaft Inspection Device (SID) to visually verify that the magnitude of sediment is within tolerance unless otherwise specified. Provide a SID for the inspection that is equipped with a high-resolution video camera with recording capability. Use the SID to measure the amount of sediment in the bottom of the drill hole in multiple locations totaling no less than 1 location per foot of drilled shaft diameter. Provide 3 days' notice before performing the SID camera work and provide live video feed. Provide video recordings within 1 week.

Do not drill additional shafts, allow wheel loads, vibration-inducing equipment, or other construction activities within 15 feet or 3 shaft diameters, whichever is greater, of a newly constructed shaft for at least 20 hours.

Fill rejected drill holes with flowable backfill.

(b) Slurry. Premix slurry with potable water according to the slurry manufacturer's instructions to allow for hydration before introduction into the shaft excavation. Use slurry tanks of adequate capacity for slurry circulation, storage, and treatment. Do not use excavated slurry pits or the shaft excavation to mix the slurry. Do not add slurry component directly into the shaft excavation.

Provide desanding equipment to limit slurry sand content as shown in Tables 565-2 and 565-3, at any point within the shaft. Verify sand content immediately before placing concrete. Desanding is not required for setting temporary casings, sign posts, or lighting mast foundations.

Maintain the level of slurry in the excavation at least 5 feet above the highest expected adjacent piezometric water pressure head for mineral slurry, or 10 feet above the highest expected piezometric water pressure head for polymer or water slurry.

Stop drilling and take corrective measures when there is a sudden loss of slurry from the hole. Prevent the slurry from setting up in the shaft. Discontinue the use of slurry and use an approved alternative method if the slurry construction method fails to produce the desired results.

Maintain density, viscosity, and pH of the mineral or polymer slurry throughout shaft excavation and concrete placement according to Tables 565-2 and 565-3. Take slurry samples using an approved sampling tool. Extract slurry samples from the base of the shaft and 10 feet up from the base of the shaft. Perform 4 sets of tests during the first 8 hours of slurry use. The testing frequency may be decreased to one test set for every 4 hours of slurry use when results are acceptable and consistent.

Comply with the manufacturer's recommendations and Table 565-3 for polymer slurry.

Table 565-2
Acceptable Range of Values for Mineral Slurry

Property	In Hole at Time of Test Concreting	Method
Density, pounds per cubic foot(1)	64 to 72	Density balance API 13B-1, Section 1(2)
Viscosity, seconds per quart	28 to 50	Marsh Funnel AP 13B-1, Section 2.2(2)
pH	8 to 11	pH paper or meter
Sand content, %	4.0 maximum	API 13B-1, Section 5(2)

(1) Density values shown are for fresh water. Increase density values 2 pounds per cubic foot for saltwater. Perform tests when slurry temperature is above 40 °F.
(2) American Petroleum Institute, API 13B-1, *Recommended Practice for Field Testing Water-based Drilling Fluids*.

Table 565-3
Acceptable Range of Values for Polymer Slurry

Property	In Hole at Time of Test Concreting	Method
Density, pounds per cubic foot(1)	64 maximum	Density balance API 13B-1, Section 1(2)
Viscosity, seconds per quart	32 to 135	Marsh Funnel AP 13B-1, Section 2.2(2)
pH	8 to 11	pH paper or meter
Sand content, %	1.0 maximum	API 13B-1, Section 5(2)

(1) Density values shown are for fresh water. Increase density values 2 pounds per cubic foot for saltwater. Perform tests when slurry temperature is above 40 °F.
(2) American Petroleum Institute, API 13B-1, *Recommended Practice for Field Testing Water-based Drilling Fluids*.

Correct slurry if sample does not meet the requirements shown in Table 565-2 or 565-3. Do not place concrete until the results of the resampling and retesting are approved.

(c) Casings. Install temporary casing to prevent sloughing of the top of the shaft excavation, unless it can be satisfactorily demonstrated to the CO that surface casing is not required. Install temporary casing regardless of excavation method when sidewall conditions warrant additional stabilization or mitigation of excessive groundwater infiltration.

Use smooth, clean, watertight, steel casings of sufficient strength to withstand handling, installation stresses, concrete placement, and surrounding earth pressures. Casing diameters are outside diameters when shown in the plans. Comply with American Petroleum Institute tolerances applicable to regular steel pipe for permanent casing diameter. Provide casings with the outside diameter at least the specified size of the shaft.

Install casings to produce a positive seal at the bottom of the shaft to prevent piping of water or other material into or out of the excavated hole. Stabilize the excavation with slurry, backfill, or other approved methods if it becomes necessary to remove a casing. Maintain an adequate head of water or slurry inside the casing to prevent piping or sloughing of material at the bottom of the hole when drilling below the water table.

Subsurface casings are to be considered temporary unless designated as permanent casing. Remove temporary casing concurrent with concrete placement. Maintain the concrete within the casing so fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete.

Temporary casings that have become bound or fouled during shaft construction and cannot be practically removed are considered to be a defect in the drilled shaft. Correct defective shafts using approved methods. Corrective action may consist of, but is not limited to, the following:

(1) Removing the shaft concrete and extending the shaft deeper to compensate for loss of frictional capacity in the cased zone;

(2) Providing straddle shafts to compensate for capacity loss; or

(3) Providing a replacement shaft.

Cut permanent casing off at the required elevation and leave in place.

(d) Obstructions. If obstructions, such as boulders, logs, or man-made objects are encountered during shaft excavation, notify the CO. Remove, bypass, or break-up obstructions according to the approved construction plan and Section 203. If methods in the approved construction plan are not effective, submit alternative plans for approval.

Drilling tools and other construction material and equipment lost in the excavation will not be considered as obstructions. Promptly remove tools, material, or equipment from the excavation and repair degradation of the shaft.

565.07 Reinforcing Steel and Crosshole Sonic Logging Access Tubes Placement. Perform reinforcing steel work according to Section 554. Securely wire together contact reinforcing steel lap splices. Tie and support the reinforcing steel so it remains within the required tolerances. Securely tie concrete spacers or other approved spacing devices at fifth points around the cage perimeter and space at intervals no more than 10 feet along the length of the cage. Use spacers of approved material at least equal in quality and durability to the shaft concrete.

Install steel CSL access tubes for each drilled shaft at locations specified and according to ASTM D6760. Extend access tubes at least 24 inches above shaft top and no more than 3 inches above shaft bottom. Use 1½-inch nominal diameter, Schedule 40, standard black pipe conforming to ASTM A53 for CSL access tubes. Provide a watertight end plug at the lower end of the pipe and make joints watertight. Fill the CSL access tubes with potable water before placing concrete in the drilled shaft. Temporarily cap the top of the tubes to prevent debris or concrete from entering the tubes.

Place the reinforcing steel cage as a unit immediately after the drilled hole is inspected, accepted, and before concrete placement. Remove cage when directed for re-inspection if concrete is not placed immediately. Avoid distortion or racking of the steel when handling reinforcing cages.

Provide positive support at the top for the reinforcing steel cage during concrete placement.

Do not proceed with installation of subsequent shafts until CSL testing has been completed on the first drilled shaft and the results have been approved in writing. Approval to proceed with the construction of subsequent shafts, before receiving approval of the first shaft will be based on observations of workmanship during construction of the first shaft and the following:

(a) Compliance with the approved shaft installation plan;

(b) Contractor's daily reports and inspector's daily logs of excavation, reinforcement, and concrete placement; and

(c) Concrete placement logs and volume curves.

The CO will furnish written notification to proceed with subsequent shaft construction within 24 hours after completion of the first shaft. If the CO determines the first shaft to be of questionable quality, discontinue all shaft construction until the CSL test results of the first shaft are received and reviewed and the shaft accepted in writing.

After the first drilled shaft has been accepted, do not change construction methods, equipment, or material used to construct subsequent shafts, unless otherwise approved.

565.08 Concrete for Drilled Shafts. Use a removable form or other approved means to form the shaft to at least 24 inches below finished ground when the top of shaft is above ground. Forms may be removed according to Subsection 562.08 if the shaft concrete has not been exposed to saltwater or moving water for 7 days. Strip the forms without damaging the concrete.

Remove the top portion of the drilled shaft concrete before continuing with column construction when it is determined the concrete has been affected by underwater placement.

Place concrete immediately after excavation is complete and the reinforcing steel cage with CSL access tubes is in place. Provide concrete conforming to Section 552, except as shown in Table 565-4.

Table 565-4
Concrete for Drilled Shafts

Method	Class	Slump
Shafts constructed without drilling fluid	A(1)	7±1 inches
Shafts constructed with drilling fluid	A(1)	8±1 inches
Shafts for underwater placement	S	–

(1) Use Class A(AE) concrete on portions of the drilled shaft above the finished ground-line unless otherwise noted.

Do not use seal concrete above the freeze-thaw or wet-dry zone of the hole. Place underwater concrete according to Subsection 552.08(d), except as modified in this Section and as approved.

Adjust approved admixtures for project conditions to ensure that the concrete has the minimum required slump for at least 2 hours. Submit trial mix and slump loss test results for concrete at ambient temperatures appropriate for site conditions.

Place each load of concrete within 2 hours of batching. Longer placement time may be allowed if the concrete mix maintains the minimum required slump for longer than 2 hours. Do not retemper concrete that has developed its initial set.

Place concrete in one continuous operation from bottom to top of the shaft.

Continue placing concrete after the shaft excavation is full and until acceptable quality concrete is evident at the top of shaft. Consolidate the top 10 feet of the shaft concrete using acceptable vibratory equipment before initial concrete set. Finish the top of the shaft to the required elevation shown in Table 565-1. Consolidate shaft concrete only when water or slurry above the finish concrete level has been removed.

Place concrete using the following methods:

(a) Free-fall. Use free-fall placement only in dry holes. Ensure the concrete falls directly to the shaft base without contacting either the rebar cage or shaft sidewall.

Drop chutes may be used to direct placement of free-fall concrete. Drop chutes consist of a smooth tube of either one-piece construction or sections that can be added and removed. Support the drop chute so that the maximum height of free-fall of the concrete measured from the bottom of the chute is 25 feet. Reduce the height of free-fall or rate of concrete flow into the excavation if concrete placement causes the shaft excavation to cave or slough or strikes the rebar cage or sidewall. Use tremie or pumping to place the concrete if placement cannot be satisfactorily accomplished by free-fall placement.

(b) Tremies. Use tremies for concrete placement in either wet or dry holes. A tremie consists of a hopper and tube of sufficient length, mass, and diameter to discharge concrete at the shaft base. Do not use tremies that contain aluminum parts that will come in contact with the concrete. Provide a tremie tube with clean and smooth inside and outside surfaces and sufficient wall thickness to prevent crimping or sharp bends. Provide tubes with an inside diameter at least six times the maximum size of aggregate used in the concrete mix, but at least 10 inches. Use a watertight tremie according to Subsection 552.08(d) for wet holes. Construct the discharge end of the tremie to allow free radial flow of concrete during placement. Place the tremie discharge at the shaft base elevation. Place the concrete in a continuous flow. Keep the tremie discharge immersed at least 10 feet below the surface of the fluid concrete. Maintain a positive head of concrete in the tremie at all times. If the tremie discharge is removed from the fluid concrete column and discharges concrete above the rising concrete surface into displaced water; remove the reinforcing cage and concrete, complete necessary sidewall removal as directed, and reconstruct the shaft.

(c) Pumps. Use pumped concrete placement in either wet or dry holes. Use a 4-inch minimum diameter discharge tube with watertight joints. Place the discharge tube at the shaft base elevation.

Use a sealed discharge tube according to Subsection 552.08(d) for wet holes. If a plug is used, remove it from the hole or use a plug made from approved material that will prevent a defect in the shaft if not removed.

Place the concrete in a continuous flow. Keep the pump discharge tube immersed at least 10 feet below the surface of the fluid concrete. Remove the reinforcing cage and concrete if the discharge tube is removed from the fluid concrete column and discharges concrete into displaced water. Complete necessary sidewall removal as directed and reconstruct the shaft.

565.09 Crosshole Sonic Logging Integrity Testing. Provide an on-site CSL engineer during testing.

(a) Testing. Perform integrity testing on production drilled shafts according to ASTM D6760. Test drilled shafts between 4 and 14 days after concrete placement. Submit drilled shaft bottom and tip elevations, access tube lengths, surveyed tube positions, and date of concrete placement before testing to the CO. Perform tests between all tube pairings in the shaft, including adjacent perimeter access tubes and diagonally between tubes.

If an access tube is unacceptable for testing, drill a plumb core hole to the appropriate depth and install a fully-grouted replacement tube or propose an alternative integrity test method that is acceptable to the CO.

Tremie fill access tubes with neat hydraulic cement grout after integrity testing, inspection and data analysis are completed and accepted.

(b) Test results and reporting. Submit preliminary results for each shaft tested before CSL test personnel leave the site. Submit a detailed CSL report within 5 days of testing. Allow 5 days for review of the data before continuing construction on the tested shaft. Include the following in the CSL report:

(1) Project identification and dates of CSL testing;

(2) Table and a schematic showing shafts tested with identification of tube coordinates and collar elevation;

(3) Names and affiliations of personnel who performed the CSL tests and interpretations;

(4) Type of equipment used for testing;

(5) Data logs and waterfall diagrams;

(6) X-Y plots of first arrival times, amplitude, and velocity versus shaft depth; and

(7) Interpretations, analyses, and results.

Identify and provide detailed discussion of each anomalous zone detected by the CSL. Anomalous zones are zones where velocity reduction exceeds 15 percent of the average velocity of properly placed and cured shaft concrete at the time of testing or reductions in measured relative energy are greater than 9 dB of the local average value of relative energy. Collect and process additional data sufficient to construct 3D color-coded tomographic images with two-dimensional cross-sections between tubes within identified anomalous zones.

565.10 Acceptance. Material for drilled shafts will be evaluated under Subsections 106.02 and 106.03.

Construction of drilled shafts will be evaluated under Subsections 106.02, 106.03, and 106.04 as follows:

(a) Drilled shafts exhibiting velocity reductions less than or equal to 15 percent of the average velocity of properly placed and cured shaft concrete at the time of testing and reductions in measured relative energy less than 9 dB of the local average value of relative energy are acceptable.

(b) Where velocity reductions exceed 15 percent of the average velocity of properly placed and cured shaft concrete at the time of testing or reductions in measured relative energy are greater than 9 dB of the local average value of relative energy, provide additional imaging and other data required in Subsection 565.09(b) to enable further evaluation of the shaft. Drill at least two core holes to intercept the anomalous zone and obtain core samples from the suspect area when required. The CO will evaluate the crosshole sonic logging data, the tomographic imaging data, and the retrieved core data and determine if substantive defects are present.

(c) Removal of obstructions will be evaluated under Subsection 106.02.

Concrete will be evaluated under Section 552, except concrete will be sampled at the point of discharge from the truck.

Reinforcing steel will be evaluated under Section 554.

Measurement

565.11 Measure the Section 565 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring drilled shafts by the linear foot, measure from the plan top elevation to the approved tip. Do not measure portions of shafts extending deeper than approved.

When measuring trial drilled shafts by the linear foot, measure from the approved tip elevation to the ground surface at the center of the shaft.

Payment

565.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 565 pay items listed in the bid schedule, except the drilled shaft contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for drilled shafts will be made at a price determined by multiplying the contract price by the structural concrete compressive strength pay factor.

Section 566. — SHOTCRETE

Description

566.01 This work consists of constructing shotcrete on a prepared surface. This work also consists of installing shotcrete drainage systems.

Material

566.02 Conform to the following Section and Subsections:

Concrete curing material and additives	711
Geocomposite drain	714.02
Hydraulic cement	701.01
Pozzolans	701.03
Reinforcing steel	709.01
Shotcrete aggregate	703.16
Water for cementitious materials	725.01(a)

Construction Requirements

566.03 Qualifications. Provide an on-site supervisor and nozzle operators with experience placing shotcrete. At least 30 days before starting shotcrete work, submit the following for approval:

(a) On-site supervisor. A résumé describing experience on at least five shotcrete projects of similar complexity within the past 5 years. Include project names, locations, and contact information for project owners; and

(b) Nozzle operator. A résumé describing experience in shotcrete construction on at least three projects with similar complexity within the past 3 years. Include an ACI nozzle operator certification in the processes and orientations in which shotcrete will be applied.

566.04 Composition (Shotcrete Mix Design). Design and produce shotcrete mixtures that conform to Table 566-1 and ACI 506.2, *Specification for Shotcrete*.

Submit the following for approval at least 30 days before preconstruction testing:

(a) Proposed shotcrete mix design with mix proportions and aggregate grading;

(b) Dosage of admixtures. Do not mix chemical admixtures together in a mix unless they are compatible. Provide supporting documentation of compatibility from the manufacturers;

(1) Air-entraining admixtures. Entrained air may be obtained with either air-entraining hydraulic cement or air-entraining admixture.

(2) Set accelerating admixtures. Do not use chloride accelerators. Do not use set accelerating admixtures in prestressed concrete applications.

(3) Hydration stabilizing admixtures. Hydration stabilizing admixtures may be used to extend the allowable delivery time for concrete. Determine dosage required to stabilize shotcrete using job site material, field trial mixtures, and admixture manufacturer's recommendations. Changes to dosage rates to meet changing job site conditions is allowed. Include the design discharge time limit. The maximum allowable design discharge time is 3½ hours;

(c) Representative samples of shotcrete material, if requested;

(d) Test results conforming with Table 566-1;

(e) Material certifications;

(f) Fiber samples and method for adding the fibers to the shotcrete, if used;

(g) When an integral color admixture is specified, prepare five 2- by 2-foot test panels. Construct the test panels using the proposed mix design. Determine coloring agent batch amounts by weight. Provide color charts representing available color selections for shotcrete material in a range of dark, earth-tone colors representative of natural features found in the local landscape. Provide additional mixing time according to the manufacturer's recommendations. Cure the test panels similar to the structure. Transport the panels to an approved location. Provide at least 2 weeks outside exposure. The CO will select the acceptable test panel. Use the same rate of integral color admixture for the item of work;

(h) Proposed equipment and method for applying shotcrete. Conform to the equipment requirements in ACI 506R, *Guide to Shotcrete*;

(i) Proposed methods of shotcrete placement, installing depth gauges for maintaining shotcrete thickness, and for properly curing the applied shotcrete layers;

(j) If applicable, the proposed construction method, sequence, and schedule for shotcrete drainage system elements. Include the following:

(1) Proposed weep hole drilling methods and equipment. Include drill rod sizes and bit diameters;

(2) Catalog cuts, brochures, or other descriptive literature describing the materials and equipment to be used in the installation of shotcrete drainage system elements;

(3) Proposed method to access the weep hole locations with the drill equipment; and

(4) Proposed methods for cleaning weep holes, protecting them during shotcrete applications, and reopening them after shotcrete has set.

(k) Other information necessary to verify compliance with ACI 506.2, including steel reinforcement plan for each area, when applicable.

Table 566-1
Composition and Property Requirements of Shotcrete Mixtures

Type of Shotcrete Mixture	Maximum Water-Cementitious Material Ratio	Air Content AASHTO T 152	Minimum 28-Day Compressive Strength, f'_c, ASTM C1604, pounds per square inch,[1]	Maximum Boiling Absorption, ASTM C642, percent	Maximum Permeable Void Volume, ASTM C642, percent	Minimum Core Quality Evaluation ACI 506.6T[2]	Maximum Water-Soluble Chloride Ion Content, ASTM C1218, percent by mass of cement
Wet	0.50	–	4000	9	17	Satisfactory	0.15
Wet (AE)	0.45	Grading A 7±1.5% Grading B 6±1.5%	4000	9	17	Satisfactory	0.15
Dry	0.40	–	4000	9	17	Satisfactory	0.15

(1) Calculate mean compressive core strength as the average strength of at least three individual cores taken from the same nonreinforced test panel. Provide a minimum mean core strength of 0.85 f'_c for the arithmetic average of any three consecutive cores with no individual core less than 0.75 f'_c.
(2) Use a group of at least three cores taken from the same reinforced test panel to complete evaluation.

566.05 Production Start-Up Procedures. Conduct preconstruction shotcrete field trials before starting shotcrete production. Preconstruction test panels are required for each production nozzle operator.

Prepare and cure test panels according to ASTM C1140. Construct steel or wood test panel forms containing no reinforcement with a width and length of at least 24 inches and a depth matching the design shotcrete thickness with either square or sloped sides.

When shotcrete is to be applied over reinforcement or on natural ground and rock, construct additional steel or wood test panel forms containing reinforcement with a width and length of at least 30 inches and a depth of at least 3 inches with either square or sloped sides. Use reinforcement of the same size and spacing or include the fiber reinforcement required for the project.

Demonstrate the procedure for adding fibers with uniform distribution to the shotcrete in the field for approval during preconstruction testing.

Shoot test panels using the personnel, material, equipment, operating pressures, and mix designs approved for the project. Produce test panels for each approved mix proportion, each anticipated shooting orientation, and each proposed nozzle operator.

When shotcrete is applied over reinforcement, or with reinforcing fibers, evaluate at least three cores from each reinforced test panel according to ACI 506.6T, *Visual Shotcrete Core Quality Evaluation*, between 14 and 28 days after shooting.

Repeat the preconstruction testing process until an acceptable test panel is produced. If a nozzle operator's test panel is rejected due to quality evaluation, a second panel may be shot. If the nozzle operator's second test panel is rejected due to quality evaluation, that nozzle operator is not allowed to shoot shotcrete on the project.

Sample material and test according to ACI 506.2 and Table 566-2.

Submit reports with the test data and results. Include the following information in the reports:

(a) Date and time of test panel shooting. Include panel dimensions, size and spacing of reinforcement, when used, and type of curing;

(b) Test panel identification. Include panel number, shooting orientation, mix proportions, and nozzle operator;

(c) Date, time, method of panel coring, number of test samples obtained from each panel and sample preparation methods;

(d) Test sample identification by panel number, sample number, and sample dimensions; and

(e) Date, time, and types of tests performed.

Approval of the nozzle operator and placement operations will be based on preconstruction field trials and test results. Start production only after the test panel is approved.

566.06 Shotcrete Construction. Produce shotcrete according to ACI 506.2 and the following:

(a) Surface preparation. If shotcrete is to be placed over existing concrete or rock, remove loose or deteriorated material from the existing surface by chipping with pneumatic or hand tools. Cut shoulders approximately 1 inch deep along the perimeter of repair areas on existing concrete.

Remove curing compound on previously placed shotcrete surfaces by sandblasting or other approved method. Maintain prepared surfaces in a clean condition. Install approved depth gauges to indicate the thickness of the shotcrete layers. Install depth gauges on 3-foot centers longitudinally and transversely.

When applying shotcrete to soil, thoroughly clean the area of loose material with compressed air and compact the soil to provide a firm face for application. Apply water to surfaces 2 to 24 hours before application to provide a saturated surface dry condition. Remove surface water before placing shotcrete.

(b) Reinforcing. Install reinforcing steel as shown in the plans. Support the reinforcing steel by installing anchor studs or bolts in the existing surface. Do not displace reinforcing steel during shotcrete application. Space supports at no more than 12 inches on overhead surfaces, 18 inches on vertical surfaces, and 36 inches on top of horizontal surfaces. Use at least three supports in each area.

Reinforce areas where the planned shotcrete thickness exceeds 1½ inches. Place reinforcement parallel to the proposed finished surface. Support reinforcement at least ½ inch from the existing surface. Provide at least 1 inch cover over steel items including anchors and reinforcement.

(c) Temperature and weather conditions. Conform to Subsection 552.07. Limit expected evaporation rate to less than 0.2 pound per square foot per hour as determined by Figure 552-1. If the ambient conditions (relative humidity, wind speed, air temperature and direct exposure to sunlight) cause the shotcrete to develop plastic shrinkage or early drying shrinkage cracking, suspend shotcrete application. Reschedule the work to a time when more favorable ambient conditions prevail; or adopt corrective measures as required by Subsection 552.07(c).

Do not place shotcrete against frozen surfaces. Place shotcrete when the surface and ambient temperature is at least 40 °F and rising.

(d) Shotcrete application. Apply shotcrete according to ACI 506.2 and the following:

(1) Use the same nozzle operator that produced approved test panels.

(2) Apply shotcrete within 45 minutes of adding cement to the mixture unless an approved hydration stabilizer is used. If a hydration stabilizer is approved, deliver and place the shotcrete within the approved design discharge time limit, up to 3½ hours maximum.

(3) If fibers are added at the nozzle, uniformly distribute the fibers throughout the shotcrete without isolated concentrations. If fibers are added to the dry or wet mix process, use a screen having a mesh of 1½ inches to 2½ inches to prevent any fiber balls from entering the shotcrete line unless it is demonstrated that fiber balls are not being formed without a screen. Do not add fibers to the dry or wet mix at a rate faster than can be blended with the other ingredients without forming balls or clumps. Pass bulk fibers that tend to tangle together through a vibrating screen or sift them into the mix, so they enter as individual elements and not as clumps.

(4) Limit the thickness of each shotcrete layer to no more than 2 inches. Thicker layers may be approved if no sloughing or sagging is occurring. If additional thickness is required, broom or scarify the applied surface and allow the layer to harden. Provide a saturated surface dry condition before applying an additional layer.

(5) Remove laitance, loose material, and rebound. Promptly remove rebound from the work area. Do not incorporate rebound or slumped shotcrete into final shotcrete.

(6) Taper construction joints to a thin edge over a distance of at least 12 inches. Wet the joint surface before placing additional shotcrete on the joint. Do not use square construction joints.

(7) Construct nonreinforced test panels for each mixture, each workday conforming to Table 566-2. Cure test panels according to ASTM C1140 for mixture properties testing. Construct steel or wood test panel forms to a minimum width and length of 24 inches and a depth matching the design shotcrete thickness with either square or sloped sides.

(8) Finish shotcrete as shown in the plans. If no method is specified, finish according to ACI 506.2. If penetrating stain is required, apply according to the manufacturer's recommendations.

566.07 Curing Shotcrete. Cure shotcrete for at least 7 days. Do not use liquid membrane curing compounds for intermediate shotcrete surfaces or if a stained or finished final surface is required. Cure by one of the following methods:

(a) Ponding or continuous sprinkling;

(b) Covering with an absorptive mat or sand that is kept continuously wet;

(c) Covering with impervious sheeting material; or

(d) Liquid membrane curing compound. Apply twice the rate for formed surfaces as recommended by manufacturer if the surface is a gun finish.

566.08 Production Report. Submit a written report within 24 hours of shotcrete work for each shift. Include the following information:

(a) Quantity and location of shotcrete applied. Include photos of areas before and after the shotcrete was placed;

(b) Observations of success or problems of equipment operation, application, final product condition, and other relevant issues during production and application;

(c) Batch tickets if applicable;

(d) Name of nozzle operator; and

(e) Name and signature of person performing the observation.

566.09 Defective Shotcrete. Repair shotcrete surface defects as soon as possible after placement. Remove and replace shotcrete that exhibits segregation, honeycombing, lamination, voids, or sand pockets.

Make changes to the mix, crew, equipment, or procedures, as needed to obtain satisfactory results, before resuming work. Shoot additional test panels and demonstrate that the shotcrete in the panels satisfies the specified requirements.

566.10 Shotcrete Drainage Systems. Install strip drains, collector systems, and weep holes as shown in the plans.

Provide equipment that can drill straight, uniform-diameter weep holes to the diameter and length shown in the plans. Holes may be advanced by rotary, percussion, down-the-hole hammer, or using other drilling methods suitable for advancing the drill tools to the depth and at the alignment specified. Do not use water or drilling slurry. Drill weep holes to the minimum depths shown in the plans, and within 6 inches of the required location. Adjust weep hole lengths and locations as directed. Drill weep holes perpendicular to rock faces with a minimum inclination of 5 degrees upward unless otherwise shown in the plans, or as directed.

Do not drill weep holes within 15 feet (horizontal and vertical) of any grouted rock reinforcement elements until the grout has set at least 12 hours.

Upon completion of drilling, clean drill holes of cuttings, sludge, and debris using compressed air.

Drill weep holes after rock reinforcements are installed, if applicable, and before shotcrete is applied. Protect weep holes during application of shotcrete and reopen them after the shotcrete has set. Do not drill weep holes through shotcrete.

Provide equipment that can install collector systems, including strip drains, as shown in the plans.

Install strip drains after installation of rock reinforcement and weep holes and before the application of shotcrete.

Provide additional drainage measures, as needed, in addition to the described pattern or adjust the spacing of the weep holes as directed to allow proper drainage of any observed springs or seeps exposed as surface preparation proceeds.

566.11 Acceptance. See Table 566-2 for sampling, testing, and acceptance requirements.

Material for shotcrete will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of hydraulic cement.

The shotcrete mixture's air content, density, boiling absorption, and permeable void volume will be evaluated under Subsections 106.02 and 106.04.

Compressive strength will be evaluated under Subsection 106.05.

Construction of shotcrete will be evaluated under Subsections 106.02 and 106.04.

Shotcrete drainage system elements will be evaluated under Subsection 106.02.

Measurement

566.12 Measure the Section 566 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring shotcrete by the cubic yard, measure in place.

When measuring shotcrete by the square yard, measure the plane parallel to the finished shotcrete surface.

Payment

566.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 566 pay items listed in the bid schedule, except the shotcrete contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for shotcrete will be made at a price determined by multiplying the contract price by the compressive strength pay factor.

Table 566-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sample Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate quality (703.16)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 703.16	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Shotcrete composition	Measured & tested for conformance (106.04)	All	–	Subsection 566.04	1 per mix design	Source of material	No	Before producing	–
Production Start-up (Test Panels)									
Shotcrete composition	Measured & tested for conformance (106.04)	Boiling absorption & permeable void volume(2)	–	ASTM C642(1),(2)	1 set per test panel (unreinforced)	Test panels	No	Before producing	–
		Density	–	AASHTO T 121	1 per load	Shotcrete machine(5)	"	"	–
		Compressive strength	–	ASTM C1604(1),(3)	1 set per test panel (unreinforced)	Test panels	Yes	28 days	–
		Core quality evaluation	–	ACI 506.6T	1 set per test panel(4) (reinforced)	Test panels	No	14 to 28 days after shooting	–

Table 566-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sample Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Aggregate (fine & coarse)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes, If requested	Before batching	–
		Moisture test	–	AASHTO T 255	"	"	"	"	–
Shotcrete	Measured & tested for conformance (106.04)	Boiling absorption & permeable void volume(2)	–	ASTM C642(1),(2)	1 set per 50 yd^3 but not less than 1 per job	Production test panels		Upon completing tests	–
		Density	–	AASHTO T 121	1 per load	Per Shotcrete machine(5)	–	"	–
		Air content (wet mix only)	–	AASHTO T 152	"	"	–	"	–
	Statistical (106.05)	Compressive strength	II	ASTM C1604(1),(3)	1 set per 30 yd^3 but not less than 1 per day	Production test panels	Yes	28 days	–

(1) Core 3-inch diameter samples at least 14 days after the field trial and moisture condition in sealed plastic bags or nonabsorbent containers according to ASTM C1604. As directed, deliver Government cores to the designated laboratory for testing.
(2) Test at least three samples from each nonreinforced test panel between 14 and 28 days after shooting. Samples may consist of cores or pieces of cores.
(3) Test at least three 3-inch diameter moisture conditioned cores from each nonreinforced test panel 28 days after shooting.
(4) Use a group of least three 3-inch diameter cores, taken from the same reinforced test panel at least 14 days after shooting, to complete evaluation.
(5) Obtain samples of shotcrete material according to ASTM C1385.

Section 567. — MICROPILES

Description

567.01 This work consists of providing and installing micropiles.

Material

567.02 Conform to the following Subsections:

Centralizers and spacers	722.02(e)
Chemical admixtures	711.03
Portland cement	701.01(a)
Neat hydraulic cement grout	701.04(a)(1)
Reinforcing bars	709.01(a)
Steel pipes	715.03
Micropile materials	722.06
Water for cementitious materials	725.01(a)

Construction Requirements

567.03 Qualifications. Provide a professional engineer, an on-site supervisor, and installation personnel with experience installing and testing micropiles. At least 30 days before starting micropile work, submit a résumé for each individual describing their experience on at least five micropile projects of similar complexity within the past 5 years for approval. Include project names, locations, and contact information for project owners.

567.04 Submittals. At least 30 days before starting micropile work, submit the following according to Subsection 104.06:

(a) Start date;

(b) Micropile construction sequence;

(c) Micropile types, sizes, spacings, depths, installation angles, and ultimate strengths for range of material to be encountered;

(d) Tendons, full moment splices, permanent casing, and additional hardware with the manufacturer’s product data sheets, specifications, catalog cuts, and mill certificates;

(e) Manufacturer’s recommendations for tendon and hardware handling, storing, assembly, and working temperature ranges. Hollow bar micropiles are unacceptable unless shown in the plans or approved;

(f) Grout type, mix design, mixing equipment, placement procedures, and 7- and 28-day grout compressive strengths test results;

(g) Grouting pressure, volume, and location, if post grouting system is used;

(h) Procedures and material for repairing corrosion protection coatings in the field;

(i) Drilling methods and equipment;

(j) Alternative drilling and grouting methods including grout additives;

(k) Additional material needed to achieve required bond capacities such as grout socks;

(l) Methods to ensure borehole stability during excavation and grout placement;

(m) Micropile testing methods and equipment. Include type and capacity of reaction load system, drawings, and supporting calculations for structural components of the micropile load test apparatus. Include locations for sacrificial micropiles for verification tests; and

(n) Identification number and calibration test certification for each jack, pressure gauge, and electronic load cell. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Submit results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

567.05 Installation. Stage micropile installation to avoid interconnection or damage to piles with uncured grout.

Before drilling holes for constructing production micropiles, install verification micropiles for verification load tests. Install verification and production micropiles as follows:

(a) Drilling. Provide equipment that can drill soil, boulder colluvium and alluvium, and bedrock to anticipated depths. Drill micropile holes to the required diameter and length shown in Table 567-1 and the construction schedule and sequence.

If an obstruction prevents the advancement of the pile, abandon the hole and fill the hole with grout. Drill a new hole at an approved location.

Remove drill cuttings and other loose debris from the hole.

(b) Casing, reinforcing bar, and splicing. Place reinforcing bars with centralizers shown in Table 567-1. Use centralizers sized to within ½ inch of the drill hole diameter.

Construct micropile splices to the required design strength. Align casing joints and reinforcing bar splices to avoid eccentricity or angles at splices. Locate threaded pipe casing joints at least two casing outer diameters from bar splices. When multiple bars are used, stagger the bar splices by at least 12 inches. If shown in the plans or approved, weld according to Subsection 551.11(a).

(c) Grouting. Use a positive displacement grout pump according to Subsection 256.07(b)(1). Place a neat hydraulic cement grout in one continuous operation. Mix admixtures according to the manufacturer's recommendations. Do not use compressed air to directly pressurize the grout.

Grout the micropile the same day the micropile hole is drilled. Inject grout from the lowest point of the drill hole until clean, pure grout flows from the top of the micropile. Grout may be pumped through tremie tubes, hollow stem augers, or drill rods. Ensure complete continuity of the grout column during all phases of grouting and casing extraction. Control the grout pressures and grout takes to prevent excessive heave in cohesive soils or fractured formations. Grout the entire pile to the design cut-off level.

After grouting is complete, fill the grout tube with grout if the tube will remain in the hole. Ensure grout within the micropiles attains the minimum design strength before loading.

Observe site conditions in the vicinity of the micropile construction daily. Stop operations and notify the CO if:

(1) Ground heave, subsidence, or grout leakage is observed;

(2) Micropile structure is adversely affected; or

(3) Adjacent structures are damaged from drilling or grouting.

Table 567-1
Micropile Construction Tolerances

Micropile Attribute	Allowable Variance
Center of micropile	< 3 in from indicated plan location or pile spacing
Pile-hole alignment	±2% of design alignment
Top elevation	0 to 1 in above the design vertical elevation
Center of reinforcing bar	< 0.75 in from pile center

567.06 Testing and Stressing.

(a) Testing equipment. Conform to Subsection 256.08(a).

(b) Stressing. Place testing equipment over the micropile so that the jack, bearing plates, load cells, and stressing assembly are axially aligned with the micropile and the micropile is centered within the equipment. Do not apply loads greater 80 percent of the structural capacity of the micropile.

Place the reference pressure gauge in series with the pressure gauge and jack so they need not be unloaded and repositioned during a test. Raise the load from one increment to another. Hold the load just long enough to measure and record the micropile top movement to the nearest 0.001 inch with respect to an independent fixed reference point. Repump the jack as necessary to maintain a constant load. Monitor the load with a pressure gauge. If the load measured by the pressure gauge and the load measured by the reference pressure gauge differ by more than 10 percent, recalibrate the jack, pressure gauge, and reference pressure gauge.

(1) Verification tests. Perform verification tests at the approved locations. Test under tension according to Tables 567-2 and 567-4 consistent with AASHTO, *LRFD Bridge Design Specifications*.

Table 567-2
Verification Test Load Schedule

Cycle	Load	Hold Time (Minutes)
1	AL(1)	–
	0.075 Factored Design Load (FDL)	4
	0.15 FDL	4
	0.225 FDL	4
	0.30 FDL	4
	0.375 FDL	4
2	AL(1)	1
	0.15 FDL	1
	0.30 FDL	1
	0.375 FDL	1
	0.45 FDL	4
	0.525 FDL	4
	0.60 FDL	4
	0.675 FDL	4
	0.75 FDL	4
3	AL(1)	1
	0.30 FDL	1
	0.60 FDL	1
	0.675 FDL	1
	0.75 FDL	1
	0.825 FDL	4
	0.90 FDL	4
	0.975 FDL	60(2)
4	AL(1)	1
	0.30 FDL	1
	0.60 FDL	1
	0.90 FDL	1
	0.975 FDL	1
	1.05 FDL	4
	1.125 FDL	4
	1.20 FDL	4
	1.275 FDL	4
	1.35 FDL	4
	1.425 FDL	4
	1.50 FDL (Maximum test load)	4
	1.20 FDL	4
	0.90 FDL	4
	0.60 FDL	4
	0.30 FDL	4
	AL(1)	15

(1) No greater than 4 percent of FDL (0.04 FDL) applied to the pile before setting the movement recording devices. Zero dial gauges after the first setting of AL.
(2) Hold the load to within 2 percent and measure and record pile top movement at 1, 2, 3, 4, 5, 6, 10, 20, 30, 50, and 60 minutes.

A verification test is acceptable based on one of the following results:

(a) Total vertical movement does not exceed ⅜ inch under 0.75 FDL. If an AL is used, reduce the allowable movement by multiplying by a factor of (0.75 FDL-AL)/0.75 FDL;

(b) Deflection rate is linear or decreasing and does not exceed 0.040 inch per log cycle time from 1 to 10 minutes or 0.080 inch per log cycle time from 6 to 60 minutes under 0.975 times the FDL; or

(c) Slope of the load versus deflection (at end of increment) curve does not exceed 0.025 inch per kip at each test load increment.

If the micropile verification is unacceptable, perform another verification test to establish the cause and make design or construction modifications. These modifications may include installing replacement test micropiles, modifying the installation methods, increasing the bond length, regrouting with pre-placed re-grout tubes, or changing the micropile type. Submit structure modifications requiring changes and retest the new system as directed.

Submit micropile geometry, construction, testing details, and verification test results for approval before installing production micropiles.

Remove verification test micropiles to an elevation 24 inches below finished ground level.

If construction methods or foundation material change, perform additional verification tests.

(2) Proof tests. The CO will designate production micropiles for proof testing. Test according to Tables 567-3 and 567-4.

A proof test is acceptable based on one of the following results:

(a) Total vertical movement does not exceed ½ inch under 0.75 FDL. If an AL is used, reduce the allowable movement by multiplying by a factor of (0.75 FDL-AL)/0.75 FDL;

(b) Deflection rate is linear or decreasing and does not exceed 0.040 inch per log cycle time from 1 to 10 minutes or 0.080 inch per log cycle time from 6 to 60 minutes under 1.00 times the FDL; or

(c) Slope of the load versus deflection (at end of increment) curve does not exceed 0.025 inch per kip under the maximum test load (1.00 FDL.)

If a proof-tested micropile is unacceptable, proof test another micropile in the immediate vicinity. Establish the cause and make design or construction modifications for future piles. Submit structure modifications requiring changes for approval.

Table 567-3
Proof Test Load Schedule

Load	Minimum Hold Time (Minutes)
AL(1)	–
0.10 Factored design load (FDL)	4
0.20 FDL	4
0.30 FDL	4
0.40 FDL	4
0.50 FDL	4
0.60 FDL	4
0.70 FDL	4
0.80 FDL	4
0.90 FDL	4
1.00 FDL (Load-hold test)	10(2)
0.75 FDL	4
0.50 FDL	4
0.25 FDL	4
AL(1)	4

(1) No greater than 4 percent of FDL (0.04 FDL) applied to the pile before setting the movement recording devices. Zero dial gauges after the first setting of AL.
(2) Hold the load to within 2 percent and measure and record pile top movement at 1, 2, 3, 4, 5, 6, and 10 minutes. If the movement measured between 1 and 10 minutes exceeds 0.04 inch, continue holding the load and measure and record pile movement at 20, 30, 50, and 60 minutes.

567.07 Test Results and Reporting. Submit preliminary results to the CO for each micropile tested before testing personnel leave the site at the end of each testing day. Submit detailed verification and proof test load and deflection data in a tabular format within 5 days. Submit a graph that plots total micropile top movement versus load, the A-line, and the B-line. The A-line is defined as 0.8 multiplied by the theoretical free test length elastic elongation. The B-line is defined as the theoretical free test length elastic elongation plus 0.50 multiplied by the theoretical bond length elastic elongation. Allow 5 days for the CO to conduct a review of the data and approve micropile installation.

567.08 Acceptance. See Table 567-4 for sampling, testing, and acceptance requirements.

Material for micropiles will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of structural steel and casing.

Construction of micropiles will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Measurement

567.09 Measure the Section 567 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring production micropiles by the linear foot, measure from the plan top elevation to the approved tip elevation. Do not measure linear footage for verification test piles. Do not measure failed verification or proof tests or additional tests to verify alternative micropile installation methods proposed by the Contractor.

Payment

567.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 567 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 567-4
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
Neat hydraulic cement grout (701.04(a)(1))	Measured & tested for conformance (106.04)	All	–	Subsection 567.04(f)	1 per mix design	Source of material	If requested	Before producing	–
Production									
Neat hydraulic cement grout (701.04(a)(1))	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per 5 piles	Mixer	No	Upon completion of test	–
		Flow	–	ASTM C939	"	Point of discharge	"	"	–
		Compressive strength	–	ASTM C109	1 set of 3 sample(1)	Grout plant	"	"	–
Verification test micropile	"	Performance	–	Subsection 567.06(b)(1)	All	Installation	No	5 days	–
Proof test micropile	"	Performance	–	Subsection 567.06(b)(2)	1 in 20 & 1 min per substructure unit	"	"	"	–

(1) From each grout plant per day of operation or per five micropiles, whichever occurs more frequently.

Section 568. — SERVICE LIFE DESIGN CONCRETE

Description

568.01 This work consists of constructing Service Life Design Concrete (SLDC) for structural elements to meet the requirements of a stated service life in conditions subject to exposure to chloride ions.

Material

568.02 Conform to the following Section and Subsections:

Coarse aggregate for concrete	703.02
Concrete curing material and additives	711
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Pozzolans	701.03
Structural steel	717.01
Water for cementitious materials	725.01(a)

Construction Requirements

568.03 Service Life Analysis to Determine Adequacy of Submitted Concrete Mixture. Provide concrete for service life design that is free of repairs from chloride intrusion and damage caused by corrosion of reinforcing steel for the stated service life of the structure. Use approved service life modelling software that models the ingress of chlorides into the structure. Use software that indicates the initiation of corrosion based on inputs of estimated chloride exposure, environmental conditions, steel type used, concrete cover depth, and element geometry, and provides the years from corrosion initiation to concrete damage caused by steel corrosion that requires repair to the structure. Provide results of modelling and the life cycle cost to meet the stated service life requirement for the structure.

Fabricate trial batches of concrete to verify that the mixture proposed for SLDC meets the requirements of the model. Fabricate and test specimens according to ASTM C1556 to determine apparent D28 chloride diffusion rate for the mixture. Input the D28 value into the model to confirm service life performance.

If a corrosion inhibitor is selected to meet service life requirements use a calcium nitrite based Corrosion Inhibiting (CI) admixture. Report addition rate required to meet service life requirements.

For prestressed concrete elements that contain 270 kilopound per square inch low relaxation carbon steel strand provide a concrete mixture with minimum addition rate of 3 gallons per cubic yard of CI admixture regardless of level of chloride exposure. If necessary, increase the addition rate of CI to meet the service life requirements of the prestressed element based on exposure risk to chlorides. Provide documentation that calcium nitrite addition rates have been evaluated for the exposure risk for the concrete element with the use of the approved service life modeling software. If a proposed design alternative uses stainless steel secondary reinforcement and stainless steel prestressing strand, the inclusion of CI is not required unless warranted by the service life analysis.

568.04 Composition (Concrete Mix Design). Design and produce concrete mixtures that conform to Tables 568-1 and 568-2.

Table 568-1
Performance Characteristics and Plastic Properties of Service Life Design Concrete

Property	Specification
Concrete resistivity, no corrosion inhibitor in mixture, AASHTO T 358, except as modified in Subsection 568.04(c)	25 kΩ -cm minimum
Concrete resistivity, corrosion inhibitor in mixture, AASHTO T 358, except as modified in Subsection 568.04(c)	18 kΩ -cm minimum
Drying shrinkage, ASTM C157, except as modified in Subsection 568.04(g)	400 microstrains maximum
Apparent chloride diffusion Rate D28, as determined according to ASTM C1556	Subsection 568.03
Compressive strength, AASHTO T 22	4500 psi minimum at 56 days
Approved shrinkage reducing admixture	1.5 gal/yd^3 addition rate
Water to cementitious material ratio	0.45 maximum
Plastic air content AASHTO T 152	5.5% to 8%
Super air meter (SAM) value AASHTO TP 118	0.20 minimum
Aggregate size[7]	1.5 in maximum
Total cementitious content[1]	750 lb/yd^3 maximum
Slump,[2] AASHTO T 119	2 to 8 in
Sulfate resistance	AASHTO M 240, Type IP(MS) or Type IS(< 70)(MS) (use Type II cement per AASHTO M 85)[4,5]
Water-soluble chloride ion content, ASTM C1218[6]	0.15% by mass of cement maximum for reinforced concrete
	0.06% by mass of cement maximum for prestressed concrete

(1) The total cementitious content includes portland cement and all pozzolans added to the concrete mixture (such as ground granulated blast furnace slag, fly ash, and silica fume).
(2) Slump can be adjusted using a high-range water reducer (superplasticizer) if the maximum water to cementitious material ratio is not exceeded. Include the water contained in the aggregates above the amount of absorbed water in the calculation of the water to cementitious material ratio.
(3) If the plastic air content is low when the concrete arrives on site, additional air-entraining agent may be added to the concrete and mixed provided that 300 revolutions of the mixer has not been exceeded.
(4) For seawater exposure, other portland cement types are allowed if the tricalcium aluminate (C_3A) content is 10 percent or less and the water to cementitious material ratio is 0.40 or less.
(5) Other cement types are allowed if the C_3A content is less than 8 percent.
(6) Determine the water-soluble chloride ion content contributed from the ingredients including water, aggregates, cementitious material, and admixtures between ages 28 and 42 days.
(7) Meet size number gradation and requirements from AASHTO M 43 for coarse aggregates. Blending of standard sizes to optimize gradation is allowed.

Table 568-2
Cementitious Material Requirements for Concrete

Cementitious Material	Maximum Percent of Total Cementitious Material by Mass
Fly ash or other pozzolans, AASHTO M 295	25
Slag, AASHTO M 302	50
Silica fume, AASHTO M 307	10
Total fly ash or other pozzolans, slag, and silica fume	50(1)
Total fly ash or other pozzolans and silica fume	35(1)

(1) Limit fly ash or other pozzolans to no more than 25 percent of the total mass of cementitious material and limit silica fume to no more than 10 percent of the total mass of cementitious material.

Determine design strength values according to Section 4 of ACI 301, *Specifications for Concrete Construction*.

Verify mixture design with trial mixes prepared according to Section 4 of ACI 301 from proposed sources or with previous concrete production data for the mixture design submitted from proposed sources. Verify the performance characteristics and plastic properties in Table 568-1. Submit written concrete mix designs for approval at least 36 days before production.

Submit SLDC mix designs on Form FHWA 1608, *552 Structural Concrete Mix Design Submittal*.

Include the following in each mix design submittal:

(a) Mix design information. Information listed in Subsections 552.03(a) except for Subsections 552.03(a)(23) and 552.03(a)(24).

(b) Shrinkage reducing admixture. Provide a shrinkage reducing admixture that conforms to the requirements of ASTM C494 Type S.

(c) Corrosion inhibiting admixture. If required for meeting service life requirements, provide a calcium nitrite corrosion inhibiting admixture that conforms to ASTM C494 Type S.

(d) Design strength. Specified design strength (f'_c) and required average strength (f'_{cr}) for the concrete mixture at 56 days as determined by the process described in Section 4 of ACI 301. This process and associated calculations are outlined on Form FHWA 1608, pages 4 and 5. Pending 56-day strength results, a mix design may be approved on the basis that 14-day compressive strength results meet or exceed 85 percent of the required average strength (f'_{cr}) at 56 days.

(e) Compressive strength. Compressive strengths test results at 1, 3, 7, 14, 28, and 56 days according to Table 552-10, Note (3).

(f) Concrete resistivity. Report concrete resistivity according to AASHTO T 358 at 56 days of curing.

(g) Drying shrinkage of concrete. Initial lime water curing is according to ASTM C157 for 14 days. Report Drying Shrinkage of Concrete after 28 days of air drying, that is 42 days from fabrication of test samples.

(h) Internally cured concrete (ICC). If used as part of the SLDC design, produce concrete mixtures that conform to Tables 568-1 and 552-2. Provide aggregate for the class specified, except substitute a portion of the normal weight fine aggregate (on a cubic yard basis) for Lightweight Fine Aggregate (LWFA) conforming to AASHTO M 195.

Determine the quantity of LWFA (pounds per cubic yard) by the following calculations:

Cementitious Factor = Cementitious Content (lb/yd^3)/100

where:

Cementitious Content is the inclusion of portland cement and any supplementary cementitious materials in the submitted concrete mixture;

$$LWFA\ quantity\ = \frac{cementitious\ factor \times 7.0}{\left(\frac{\frac{percent\ absorption\ of\ LWFA}{100}}{\left(1+\left(\frac{percent\ absorption\ of\ LWFA}{100}\right)\right)}\right)}$$; and

Round calculated LWFA quantity to nearest pound per cubic yard.

Adjust the concrete mix design normal weight fine aggregate quantity after determining the saturated surface dry (SSD) volume of the LWFA. Subtract the SSD LWFA volume from the original volume of normal weight fine aggregate. Calculate new adjusted SSD weight of normal weight fine aggregate on a pound per cubic yard basis.

Start production only after the mix design is approved.

Provide a new mix design for approval if there is a change in a source of material source or when the fineness modulus of the fine aggregate changes by more than 0.20.

568.05 Test Section for Cast-in-Place Bridge Deck and Cast-in-Place Structural Elements. For bridge decks, approach slabs, and other flatwork, construct a 9-foot by 9-foot by 8-inch test section. For other structural elements, construct a 3- by 3- by 3-foot test section. Use the approved concrete mix design and the same methods of handling, placing, monitoring, finishing, curing, and cleaning as intended for production placement. Sample and test according to Table 568-1. Monitor temperatures of the test placements according to Subsection 552.07.Start production only after the test section is approved.

568.06 Delivery. Conform to Subsection 552.05.

568.07 Quality Control of Mix. Conform to Subsection 552.06.

568.08 Temperature, Weather, and Mass Concrete Conditions. Conform to Subsection 552.07.

568.09 Handling and Placing Concrete. Conform to Subsection 552.08. Remove and replace concrete represented by cylinders having a compressive strength less than 90 percent of the minimum 56-day compressive strength (f'_c).

568.10 Construction Joints. Conform to Subsection 552.09.

568.11 Expansion and Contraction Joints. Conform to Subsections 552.10 and 552.11.

568.12 Finishing Plastic Concrete. Conform to Subsection 552.12.

568.13 Concrete Curing. For cast-in-place structural elements, start curing immediately after the free surface water has evaporated and the finishing is complete. If the surface of the concrete starts to dry before the selected cure method can be implemented, keep concrete surface moist using a fog spray without damaging the surface. As soon as possible after completion of finishing operations, start selected curing method.

Keep surfaces to be rubbed moist after forms are removed. Cure immediately following the first rub.

Cure cast-in-place elements at least 14 days and until the summation of the product of concrete temperature (°F) and curing time (hours) for all the temperature sensors placed in the structural element meets a minimum value of 7000 degree-hours, as calculated using the Nurse Saul Method of ASTM C1074, with a datum temperature of 32 °F.

(a) Flatwork and bridge decks. Cure the top surfaces of bridge decks using the water method. Apply the water cure as soon as all finishing operations have been completed. Use water method for flatwork placements.

Keep the concrete surface continuously wet by ponding, spraying, or covering with material that is kept continuously and thoroughly wet. Covering material may consist of cotton mats, multiple layers of burlap, or other approved material that does not discolor or otherwise damage the concrete.

Cover the covering material with a waterproof sheet material that prevents moisture loss from the concrete. Use the widest sheets practical. Lap adjacent sheets at least 6 inches, and tightly seal seams with pressure sensitive tape, mastic, glue, or other approved methods. Secure material so that wind does not displace it. Immediately repair sheets that are broken or damaged.

(b) Cast-in-place structural elements. Use a combination of the forms in-place method according to Subsection 552.13(a) and the water method according to Subsection 552.13(b). If forms are stripped or loosened before the end of the curing period, complete the remainder of the curing using the water method.

(c) Prestressed elements. Cure according to Subsection 553.06.

If directed after curing, clean staining or efflorescence to provide a uniform color to the concrete surface.

568.14 Finishing Cured Formed Structural Elements and Concrete Bridge Decks. Finish according to Subsection 552.14.

568.15 Acceptance. See Table 568-4 for sampling, testing, and acceptance requirements.

Material for SLDC will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of cementitious material.

The concrete mixture's slump, air content, density, and temperature will be evaluated under Subsections 106.02 and 106.04.

Concrete compressive strength will be evaluated under Subsection 106.05. The lower specification limit is the minimum required compressive strength (f'_c) at 56 days shown in Table 568-1.

Concrete resistivity will be evaluated under Subsection 106.04. Refer to Table 568-1 for Resistivity Lower Specification Limits.

Drying shrinkage will be evaluated under Subsection 106.04.

Construction of SLDC structures will be evaluated under Subsections 106.02 and 106.04.

Measurement

568.16 Measure the Section 568 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring SLDC by the cubic yard, measure in the structure.

Payment

568.17 The accepted quantities will be paid at the contract price per unit of measurement for the Section 568 pay items listed in the bid schedule, except the SLDC contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for SLDC will be made at a price determined by multiplying the contract price by the lower of the two pay factors determined for compressive strength or chloride permeability.

Table 568-4
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (fine & coarse)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsections 703.01 & 703.02 including ASR requirements	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Concrete composition	Measured & tested for conformance (106.04)	All	–	Subsection 568.04	1 per mix design	"	Yes	"	–
Production Start-up (Test Section)									
SLDC	Measured & tested for conformance (106.04)(1)	Concrete resistivity(2)	–	AASHTO T 358	1 set per test sextion	Discharge stream at point of placement	Yes	Upon completing tests	–
	"	Compressive strength(3)		AASHTO T 23 & 22	"	"	"	"	–
	"	Plastic air content	–	AASHTO T 152	"	"	No	"	–
	For Informational Purposes	SAM value	–	AASHTO TP 118	"	"	No	"	–

Table 568-4 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Produced aggregate (fine & coarse)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes	Before batching	–
		Fineness modulus	–	AASHTO T 27	"	"	"	"	–
		Moisture test	–	AASHTO T255	"	"	"	"	–
SLDC	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load	Point of discharge	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump(5)	–	AASHTO T 119	"	"	No	"	–
		Temperature	–	ASTM C1064	"	"	No	"	–
		Drying shrinkage(4)	–	ASTM C157	As directed	"	No	"	–
		Concrete resistivity	–	AASHTO T 358	1 set per 30 yd^3 but not less than 1 per day	"	Yes	"	

Table 568-4 (continued)
Sampling and Testing Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
SLDC	Statistical (106.05)	Compressive strength(6)	II	AASHTO T 23 & T 22	1 set per 30 yd^3, but not less than 1 per day	Discharge stream at point of placement	Yes	Upon completing tests	–
SLDC	For informational purposes	SAM value	–	AASHTO TP 118	1 test per 30 yd^3, but not less than 1 per day	Discharge stream at point of placement	No	Upon completing tests	–

(1) Sample according to AASHTO R 60, except composite samples are not required.
(2) Cast at least three 4- by 8-inch for AASHTO T 358 testing cylinders per set and carefully transport the cylinders to the job site curing facility. Have the testing done at 56 days in an independent laboratory that is qualified to perform the testing and is approved. The set test result is the average of the measurements on three cylinders cast from the same load.
(3) Cast at least eighteen 4- by 8-inch compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Have the testing done at 1, 7, 14, 28, and 56 days in an independent laboratory that is qualified to perform the testing and is approved. A single compressive strength test result is the average result from three cylinders cast from the same load.
(4) If testing is directed, use 3- by 3- by 11-inch prisms for drying shrinkage specimens. Cast at least three drying shrinkage prisms per set and carefully transport the prisms to the job site curing facility. Moist the prisms for the duration of the specified moist curing period for SLDC elements. Have the testing done in an independent laboratory that is qualified to perform the testing and is approved. The zero measurement for percent drying shrinkage is the initial measurement taken at demolding of the specimens at 23½±½ hours after introduction of mixing water to the concrete mixture. Measure percent drying shrinkage at the end of specified moist curing period for the structural elements, 1, 4, 7, 14, 28, and 56 days after the end of the specified field moist curing period.
(5) If reinforcing fibers are used at an addition rate greater than 0.3 percent by volume, measure slump at the batch plant before the addition of fibers.
(6) Cast at least six 4- by 8-inch compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders at 56 days. Use the remainder of cylinders as designated by the CO.

Section 569. — CONCRETE OVERLAYS FOR BRIDGE DECKS

Description

569.01 This work consists of providing, placing, finishing, and curing concrete for bridge deck overlays.

Material

569.02 Conform to the following Section and Subsections:

Coarse aggregate for concrete	703.02
Concrete curing material and additives	711
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Pozzolans	701.03
Water for cementitious materials	725.01(a)

Construction Requirements

569.03 Qualifications. Provide an on-site supervisor with experience placing concrete overlays on bridge decks. At least 30 days before starting concrete overlay work, submit a résumé for the on-site supervisor describing experience on at least two overlay projects with the specified overlay class within the past 3 years for approval. Include project names, locations, and contact information for project owners.

569.04 Composition (Concrete Mix Design). Design and produce concrete overlay mixtures that conform to following:

(a) Table 569-1 for the class specified; and

(b) Section 4 of ACI 301, *Specifications for Concrete Construction* for determining required average compressive strength (f'_{cr}).

Table 569-1
Composition of Concrete

Concrete Overlay Class	Property					Performance Characteristics		
	Total Cementitious Material Content, pounds per cubic yard(1)	Maximum Water/ Cementitious Material Ratio(4)	Slump, inches	Air Content, percent	Coarse Aggregate Size Number AASHTO M 43(5)	Maximum Chloride Permeability, AASHTO T 277, coulombs	Average Bond Strength at 14 Days, ASTM C1583, pounds per square inch	Minimum Compressive Strength, AASHTO T 22, pounds per square inch
HPC(O)(2)	564 to 750	0.45	2 to 8	Table 552-1	7, 78, 8	1500	150	4500
LMC(3)	564 to 750	0.45	2 to 8	3.0 to 10.0	7, 78, 8	1500	150	4000

(1) The total cementitious material content includes portland cement and pozzolans added to the concrete mixture (such as ground granulated blast furnace slag, fly ash, and silica fume). Meet the requirements shown in Table 552-2.
(2) Add 1.5 gallons per cubic yard of concrete of an approved Shrinkage Reducing Admixture (SRA).
(3) Add 3.5 gallons of latex emulsion admixture per 94 pounds of cement.
(4) Include the water contained in the aggregate above the amount of absorbed water in the calculation of the water-to-cementitious material ratio.
(5) Meet the processing requirements of AASHTO M 43, Table 1 – Standard Sizes of Processed Aggregate. Do not use gravel or alkali-silica reactive aggregates.

Submit concrete overlay mix designs on Form FHWA 1608, *552 Structural Concrete Mix Design Submittal*.

Verify the mix designs with trial mixes prepared according to Section 4 of ACI 301 from proposed sources or with previous concrete production data for the mixture submitted from proposed sources. Verify the performance characteristics in Table 569-1. Submit written concrete mix designs for approval at least 36 days before production. Include the items listed in Subsections 552.03(a)(1) through (28) in each mix design submittal.

Provide a new mix design for approval if a source of material changes or if the fine aggregate fineness modulus changes by more than 0.20.

569.05 Strength-Maturity Relationship. If used, submit strength-maturity relationships according to AASHTO T 325.

569.06 Surface Preparation. Remove asphalt, asphalt membranes, and concrete overlays without damaging the concrete bridge deck. Micro mill according to Section 413 to remove existing overlays. Sound the bridge deck according to ASTM D4580 to identify unsound concrete in the deck. Do not perform surface preparation within 6 feet of a new overlay until 48 hours after its placement. Submit a repair plan for approval that includes the following:

(a) Concrete repairs. Conform to Section 572.

(b) Surface profiling. Provide a minimum profile of $\frac{1}{16}$ inch and a maximum of ¼ inch on the substrate concrete to bond to the concrete. Use hydrodemolition according to Section 560 or a micro milling machine.

After surface profiling approval and within 36 hours of expected overlay placement, shot blast and pressure wash the substrate concrete. Use a potable water source with a minimum water pressure of 4000 pounds per square inch. Remove concrete laitances, oils, fuels, and other foreign and loose material detrimental to achieving a sufficient bond. Capture debris from shotblasting and pressure washing, and properly dispose of it off site. Cover the prepared surface with polyethylene sheeting to prevent contamination.

(c) Saturation. Thoroughly water-soak the clean concrete surface for at least 24 hours before placing the overlay concrete. Do not use burlap. Remove puddles of standing water using a vacuum or other approved equipment. Do not use a blower or compressed air to remove water.

569.07 Test Section. Prepare the substrate concrete surface using the same methods intended for the overlay placement. Construct a 9- by 9-foot test section on the substrate concrete at the same thickness as the overlay. Use the approved concrete mix design and the same methods of handling, placing, finishing, and curing intended for actual placement. Sample and test according to in Table 569-2.

Demonstrate the maturity meter operation. Use the strength-maturity relationship developed for the approved mix design to determine in-place compressive strength. Verify that the test section concrete has a similar time temperature relationship. Demonstrate methods for conforming to temperature requirements in Subsection 569.11.

Demonstrate methods for cleaning stains or efflorescence to provide uniform color on the concrete surface.

Start production only after the test panel is approved.

569.08 Mixing. Conform to Subsection 552.04 and the following:

(a) Class HPC(O). Provide ready-mixed concrete produced and delivered according to AASHTO M 157.

(b) Class LMC. Provide volumetric proportioning and mixing equipment with an integral mobile unit with continuous mixing capability. Provide a mixer with the following:

(1) Capable of producing at least 6.0 cubic yards of concrete without recharging;

(2) Equipped with a cement metering device and recording meter accurate within a tolerance of minus 1 to plus 3 percent and with a device to record the cement quantity added to the mix;

(3) Equipped with a latex tank with a standpipe marked in gallons and a latex metering device accurate within a tolerance of minus 1 to plus 2 percent;

(4) Equipped with a water flow control and flow indicator accurate within a tolerance of 2 percent in the range of expected use that is readily adjustable to provide for minor variations in aggregate moisture content;

(5) Equipped with controls to regulate the quantity of other components required to produce the specified mix; and

(6) Capable of discharging the mixture through a conventional chute directly in front of the finishing machine.

Calibrate LMC equipment with material for the approved mix design within 6 months before the placement date. Keep the equipment maintained, calibrated, clean, and free of partially dried or hardened material.

Protect latex emulsion from freezing and prolonged exposure to temperatures more than 85 °F. Store containers of latex admixture at the bridge site for no more than 10 days.

Add reinforcing fibers to the concrete mixture according to the manufacturer's recommendations. Add fibers to the concrete mixture gradually to ensure the fibers are uniformly distributed throughout the concrete mixture.

569.09 Delivery. Conform to Subsection 552.05, except do not use non-agitating equipment.

(a) Class HPC(O). If reinforcing fibers reduce workability, do not add additional water to the concrete mixture. Adjust workability using admixtures from the approved mix design.

If the air content is low when the concrete arrives on site, add air-entraining agent and mix.

(b) Class LMC. Deliver concrete through the conventional chute of an integral mobile volumetric mixer directly in front of the finishing machine.

569.10 Quality Control of Mix. Conform to Subsection 552.06, except as modified in Table 569-2.

569.11 Temperature and Weather Conditions. Before placement, maintain the temperature of the overlay concrete mixture between 45 and 80 ºF.

Install maturity meter probes and monitor concrete temperatures according to AASHTO T 325. Monitor the temperature differential from the center of the concrete mass to the surface. Provide internal cooling, external heating, or insulation to ensure the temperature differential is no more than 35 °F during placing, curing, and immediately after curing ends.

Using the strength-maturity relationship developed for the approved concrete mixture, determine in-place concrete compressive strength of the overlay. Measure concrete temperature and calculate in-place maturity.

(a) Cold weather. Conform to Subsection 552.07(a).

(b) Hot weather. Conform to Subsection 552.07(b).

(c) Evaporation. Conform to Subsection 552.07(c).

(d) Precipitation. Conform to Subsection 552.07(d).

569.12 Handling and Placing Concrete. Conform to Subsection 552.08 and the following:

(a) Placing methods.

(1) Class HPC(O). Do not broom mortar from the concrete from the front edge of the placement.

(2) Class LMC. Immediately ahead of placing overlay mixture, broom a thin coat of the concrete overlay mixture and scrub it into the surface as a grout-bond coat at the front edge of the placement. Work evenly over the surface in front of the front edge of the placement.

(b) Consolidation. Use a self-propelled finishing machine capable of forward and reverse movement under positive control. Ensure the length of the screed is sufficient to extend at least 6 inches beyond the edge of both ends of the section being placed. Provide a finishing machine capable of consolidating the concrete by vibration and of raising screeds to clear the concrete for traveling in reverse. Provide either a rotating roller-type or an oscillating screed-type finishing machine.

Use rotating roller-type machines with one or more rollers, augers, and 1500 to 2500 vibrations per minute vibratory pans.

Use oscillating screed-type machines with vibrators on the screeds whose frequency of vibration can be varied between 3000 and 15,000 vibrations per minute. Use metal screeds with a bottom face of at least 4 inches wide.

Use hand-held vibrators at the concrete edges and adjacent to expansion joints.

Remove and replace concrete represented by cylinders having a compressive strength less than 90 percent of the minimum 28-day strength (f'_c).

569.13 Construction Joints. Conform to Subsection 552.09. In addition, form the vertical edge at construction joints by bulkhead or saw cut. Make construction joints straight and vertical.

569.14 Expansion and Contraction Joints. Conform to Subsection 552.10.

569.15 Finishing Plastic Concrete. Conform to Subsection 552.12.

Use a self-propelled rotating cylinder machine, either single or double roller that is capable of forward or reverse movement under positive control. Equip the machine with an oscillating screed and other devices required to continuously spread, consolidate, and finish the plastic concrete. Ensure the screed extends the full width of the deck.

Produce a longitudinal troweled finish along the gutter line for a 12-inch width from the curb face.

Proceed at a constant rate so final finishing is complete before a plastic film forms on the concrete surface. Install a construction dam or bulkhead in case of delays over an hour. During delays of 1 hour or less, protect the end of the placement from drying with layers of wet burlap.

569.16 Concrete Curing. Prevent plastic shrinkage cracking and crusting of the surface. Use the water method of curing according to Subsection 552.13(b). Use washed burlap and apply soaker hoses or other approved methods to keep the coverings saturated at all times.

Install maturity meter probes and monitor concrete temperatures according to AASHTO T 325. Maintain the concrete temperature of the outermost surfaces above 45 °F. Monitor the temperature differential from the center of the concrete mass to its surface. Using the strength-maturity relationship developed for the approved concrete mixture, determine the in-place concrete compressive strength.

(a) Class HPC(O). Wet cure the concrete for at least 14 days. Provide internal cooling, external heating, or insulation to ensure the temperature differential does not exceed 35 °F. Cure until the in-place concrete compressive strength of the overlay concrete attains at least 80 percent of the minimum compressive strength shown in Table 569-1.

(b) Class LMC. Wet cure the concrete for at least 48 hours and until the maturity meter reading exceeds 48 maturity hours. Air cure the concrete for an additional 48 hours and until the maturity meter reading exceeds 96 maturity hours.

After curing, visually inspect the overlay for cracking or other damage and inspect for delamination. Perform bond test. Remove and replace delaminated or unbounded portions of the overlay or portions damaged by precipitation or freezing. Clean staining or efflorescence to provide a uniform color to the concrete overlay surface.

569.17 Texturing. After the bond strength shown in Table 569-1 is attained, groove surface according to Subsection 552.14(g).

Continuously remove slurry and other residue from the overlay by vacuum pickup or other approved methods. Properly dispose of slurry and other residue off site.

569.18 Acceptance. See Table 569-2 for sampling, testing, and acceptance requirements.

Material for concrete overlays for bridge decks will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of cementitious material.

Bond strength will be evaluated under Subsection 106.05. The lower specification limit is the minimum required bond strength at 14 days shown in Table 569-1.

Compressive strength will be evaluated under Subsection 106.05. The lower specification limit is the minimum required compressive strength at (f'_c) 28 days shown in Table 569-1.

Maximum chloride permeability will be evaluated under Subsection 106.05. The upper specification limit is the maximum specified chloride permeability value shown in Table 569-1. A single chloride permeability test result is the average result from 2 samples cast from the same load and tested.

Slump, air content, density, and temperature will be evaluated under Subsections 106.02 and 106.04.

Construction of concrete overlays for bridge decks will be evaluated under Subsections 106.02 and 106.04.

Concrete repairs will be evaluated under Section 572.

Hydrodemolition will be evaluated under Section 560.

Micro milling will be evaluated under Section 413.

Measurement

569.19 Measure the Section 569 pay items listed in the bid schedule according to Subsection 109.02.

Payment

569.20 The accepted quantities will be paid at the contract price per unit of measurement for the Section 569 pay items listed in the bid schedule, except the overlay concrete contract price will be adjusted according to Subsection 106.05. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for overlay concrete will be made at a price determined by multiplying the contract price by the lower of the three pay factors determined for compressive strength, chloride permeability, or bond strength.

Table 569-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (fine & coarse)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsections 703.01 & 703.02	1 per material type	Source of material	Yes, if requested	Before producing	Date reports within 1 year of intended use
Mix Design									
Concrete composition	Measured & tested for conformance (106.04 & 105)	All	–	Subsection 569.04	1 per mix design	Source of material	Yes, if requested	Before producing	–
Production Start-up (Test Section)									
HPC(O)	Measured & tested for conformance (106.04)	Maximum chloride permeability(1)	–	AASHTO T 277	1 set per test placement	Discharge stream at point of placement(1)	Yes, if requested	Upon completing tests	–
		Compressive strength(2)	–	AASHTO T 23 & 22	"	"	"	"	–
		Tensile bond strength	–	ASTM C1583	5 cores per test placement	In-place after curing is complete	"	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (Test Section) (continued)									
LMC	Measured & tested for conformance (106.04)	Maximum chloride permeability(1)	–	AASHTO T 277	1 set per test placement	Discharge stream at point of placement	Yes	Upon completing tests	–
		Compressive strength(3)	–	AASHTO T 23 & 22	"	"	"	"	–
		Tensile bond strength(7)	–	ASTM C1583	5 cores per test placement	In-place after curing is complete	"	"	–
HPC(O) and LMC	"	Density(4)	–	AASHTO T 121	1 per load	Point of discharge	No	Upon completing tests	–
		Air content(4)	–	AASHTO T 152 or AASHTO T 196	"	"	"	"	–
		Slump(4),(5)	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	Field measured	"	"	"	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (Test Section) (continued)									
Aggregate (fine & coarse)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–
Production									
HPC(O) & LMC	Statistical (106.05)	Maximum chloride permeability(1)	II	AASHTO T 277	1 set per 30 yd^3 but not less than 1 per day	Discharge stream at point of placement	Yes	Upon completing tests	–
		Compressive strength(6)	II	AASHTO T 23 & T 22	"	"	"	"	–
		Tensile bond strength(7)	II	ASTM C1583	1 set per 3000 ft^2 of overlay but not less than 1 per day	In-place after curing is complete	No	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
HPC(O) & LMC	Measured & tested for conformance (106.04)	Density[4]	–	AASHTO T 121	1 per load	Point of discharge	No	Upon completing tests	–
		Air content[4]	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump[4],[5]	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	ASTM C1064	"	"	"	"	–
Aggregate (fine & coarse)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes, if requested	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–

Table 569-2 (continued)
Sampling, Testing, and Acceptance Requirements

(1) Cast at least three 4- by 8-inch maximum chloride permeability cylinders per set and carefully transport the cylinders to the job site curing facility. Cure the HPC(O) cylinders for 7 days and the LMC cylinders for 3 days according to AASHTO M 201. Then cure the HPC(O) cylinders at 100±10 °F in saturated lime water until AASHTO T 277 sample conditioning starts and air dry the LMC cylinders at 73±3 °F at 40 to 60 percent relative humidity. Test for chloride permeability at 28 days by measuring the total charge passed, in coulombs, over a specified period of time according to AASHTO T 277. The test result is the average of the measurements on three cylinders cast from the same load. If pigment is used in the concrete mixture, sample concrete at the batch plant before and after adding pigment. Test at least three specimens with and without pigment. Determine the average difference between the pigmented and non-pigmented test results. Adjust production test results by the average difference. Report both initial and adjusted test results.

(2) For HPC(O), cast at least fifteen 4- by 8-inch compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders each at 1, 3, 7, 14 and 28 days. A single compressive strength test result is the average result from three cylinders cast from the same load.

(3) For LMC, cast at least eighteen 4- by 8-inch compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders each at 1, 2, 4, 7, 14 and 28 days. A single compressive strength test result is the average result from three cylinders cast from the same load.

(4) For LMC, measure density, slump, and plastic air content 5 minutes after discharge from the mixer chute. Cover wheelbarrow or other receptacle used to hold sample with a sheet of plastic to prevent evaporation during the 5 minutes before sampling.

(5) If reinforcing fibers are used at an addition rate greater than 0.3 percent by volume, measure slump at the batch plant before adding fibers.

(6) Cast at least six 4- by 8-inch compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test three cylinders at 28 days. Use the remainder of cylinders as directed.

(7) At random locations determined by the CO, core 2-inch diameter specimens through the overlay and ½ inch into the substrate concrete. Cure the specimens in situ for the same length of time as the overlay. Test the specimens in situ by attaching a loading disk with fast setting, high strength epoxy. Measure the tensile pull-off bond strength in pounds per square inch according to ASTM C1583. The average bond strength is the average of the results from three test specimens adjusted as follows: For tests where failure occurs in the substrate concrete at a depth of at least ¼ inch for more than 50 percent of the specimen, use 150 pounds per square inch for that specimen test result in the calculation of the average of the three test specimens. When two of the three test results have been adjusted, the average bond strength results use the greater of 150 pounds per square inch or the calculated value.

Section 570. — POLYESTER POLYMER CONCRETE OVERLAYS FOR BRIDGE DECKS

Description

570.01 This work consists of providing, placing, finishing, and curing a PPC overlay system on concrete surfaces.

Material

570.02 Conform to the following Subsections:

High molecular weight methacrylate	725.18
Polyester polymer concrete aggregate	703.19
Polyester resin binder	725.17
Sand	703.14
Sealants, fillers, and seals	712.01

Construction Requirements

570.03 Qualifications. Provide a system provider and system provider technical representative with experience placing PPC overlay systems. At least 30 days before starting PPC overlay work, submit the following for approval:

(a) System provider. Documentation from the system provider describing experience on at least five projects of similar size and scope within the past 5 years. Include project names, overlay system and quantities, construction dates, locations, and contact information for project owners;

(b) System provider technical representative. A résumé describing at least 5 years' experience with PPC overlay systems and at least five PPC overlay projects within the past 5 years. Include project names, overlay system and quantities, construction dates, locations, and contact information for project owners; and

(c) Contractor experience. Documentation describing at least 5 years' experience and five completed projects placing PPC overlay systems with similar equipment and scope. Include project names, construction date, overlay system and quantities, construction dates, and contact information for project owners.

570.04 Submittals. At least 30 days before the PPC pre-paving meeting, submit the following according to Subsection 104.06:

(a) Operations and placement plan. Include the following:

(1) Schedule of surface preparation, overlay work, and testing;

(2) Staging plan describing surface preparation and overlay placement sequence including:

(a) Asphalt removal methods, and other surface preparation operations;

(b) Paving widths and anticipated paving lengths;

(c) Paving directions with paving from high side of bridge to low side. Do not include gaps between passes;

(d) Joint locations placing cold joints within 1 foot of the lane lines or centered within a lane; and

(e) Location of proposed test section.

(3) Method for preventing leakage of primer onto areas of deck that have not received surface preparation;

(4) Method for isolating expansion joints including pourable joints at abutment and piers;

(5) Method for measuring and maintaining overlay thickness and profile;

(6) Finishing and texturing plan describing methods that will be used to broadcast sand and saw grooves to produce a skid-resistant surface;

(7) Cure time for polyester concrete;

(8) Storage and handling of HMWM resin and polyester concrete components;

(9) Procedure for disposal of excess HMWM resin, polyester concrete, and containers;

(10) Procedure for cleanup of mixing and placement equipment; and

(11) Proposed schedule for closing and opening lanes during milling, surface preparation, and PPC overlay placement. Include estimated duration of lane closures.

(b) Polyester polymer concrete mix design and overlay system. Include a PPC mix design and overlay system conforming to Subsection 570.06.

(c) Equipment. Include a list of equipment conforming to Subsection 570.07.

570.05 General. Provide an on-site technical representative for the duration of bridge overlay placement including test strip, surface preparation, application, and cure.

570.06 Composition (Polyester Polymer Concrete Mix Design and Overlay System). Design and produce a PPC mixture consisting of polyester resin and aggregate conforming to Table 570-1. Include a compatible primer with the overlay system.

Submit the system provider's materials information, installation instructions, and independent test results for approval.

If recommended by the overlay system provider, use accelerators or inhibitors to achieve proper setting time of the PPC.

Verify mix design with trial mixes from proposed sources or with previous PPC production data for the mix design submitted from proposed sources. Verify the performance characteristics shown in Table 570-1. Include the following in each mix design submittal:

(a) Project identification;

(b) Name and address of PPC system provider and suppliers;

(c) Materials proportions;

(d) Name and location of material sources for aggregate, binder resin, polymer, and admixtures;

(e) Type of binder resin proposed. Include content in pounds per cubic yard of mix;

(f) The dry batch mass of the aggregate in pounds per cubic yard of mix;

(g) Dosage of admixtures. Do not mix chemical admixtures together in a mix unless they are compatible. Provide supporting documentation of compatibility from the manufacturers;

(h) Test results from aggregate sieve analysis, absorption, and other specified properties;

(i) Results from tests shown in Table 570-1;

(j) Material certifications; and

(k) Material samples if requested.

Table 570-1
Composition of Polyester Polymer Concrete

PPC	Property				
	Minimum Bond Strength, ASTM C1583, pounds per square inch(1)	Abrasion Resistance, Caltrans Test 550 or approved equivalent test, maximum weight loss, grams(2)	Modulus of Elasticity, Range, ASTM C469, pounds per square inch(3)	Initial Set Time ASTM C266, minutes	Resin Content, by weight of the dry aggregate, percent
	250	< 2	1,000,000 to 2,000,000	30 to 120(4)	12±1

(1) After at least 24 hours cure time. Test on in-place material. Drill to at least 0.25 inch but no more than 0.50 inch below the bond line. An acceptable test will demonstrate that the overlay bond strength is sufficient by producing a concrete subsurface failure area greater than 50 percent of the test surface area. Repair bond test locations with polymer overlay.
(2) At 12 percent resin content by weight of dry aggregate. Provide test results that are less than 1 year old.
(3) At 12 percent resin content by weight of dry aggregate, and after at least 24 hours cure time. Provide test results that are less than 1 year old.
(4) Initial set times less than 30 minutes may be proposed by the system provider. Initial set time may also be defined as the point at which the in-place PPC cannot be deformed by pressing with a finger.

570.07 Equipment. Provide equipment to be used to prepare the surface, and to mix, place, finish, and cure the PPC. Provide equipment according to the system provider’s recommendations.

(a) Mobile mixing equipment. Keep the equipment maintained, calibrated, clean, and free of partially dried or hardened material.

(1) Use certified scales, with certification less than one month old, to calibrate mobile mixing equipment. Submit scale certification within 1 month before production. If any adjustments are made to the scales, submit a new certification.

Complete on-site calibration by demonstrating that the computer tickets are within 2 percent of the actual material weights. Produce three consecutive batches of aggregate that have batch tickets and actual materials weights that are within 2 percent of each other. Produce three consecutive batches of resin that have batch weights and actual material weights that are within 2 percent of each other.

(2) Use a continuous mixer with the following capabilities:

(a) Employs an auger screw and chute device;

(b) Measures and records aggregate and resin volumes automatically with a metering device at least every 5 minutes, including time and date. Equipped with controls to regulate the quantity of components required to produce the approved mix;

(c) Displays volumes of aggregate and resin on a visible readout gauge;

(d) Produces a satisfactory mix consistency; and

(e) Measures the resin levels in the tank of the mobile mixer during paving operations and allows access to the resin tank.

A portable mechanical mixer of appropriate size for the proposed batches and recommended by the system provider may be used.

(b) Paving machine. Submit documentation of the proposed paving machine that establishes its successful use to place PPC overlays on bridge projects. Use a self-propelled slip-form paving machine that is modified or built to place PPC overlay and has the follow capabilities:

(1) Employs a vibrating pan to consolidate and finish the PPC, and is fitted with hydraulically controlled grade automation using substrate grade averaging devices on both sides of the new placement to establish the finished profile. Use devices that average 15 feet in front and behind the automation sensors. Use sensors compatible with string-line control;

(2) Equipped with controls capable of maintaining the screed at the specified transverse slope;

(3) Sufficient engine power and weight to provide adequate vibration of the finishing pan while maintaining consistent forward placement speed. Capable of forward or reverse motion; and

As an alternative to using a paving machine, an approved self-propelled rotating cylinder machine, either single or double roller, that is capable of forward or reverse movement under positive control may be used. Conform to Subsection 552.12. Equip the machine with an oscillating screed and other devices required to continuously spread, consolidate, and finish the plastic PPC. Ensure the screed extends the full width of the placement.

(c) Other equipment. Include descriptions of equipment used for the following:

(1) Preparing the surface including grinding and shotblasting;

(2) Applying HMWM resin;

(3) Finishing and curing the polyester concrete overlay;

(4) Applying sand;

(5) Texturing and grooving the PPC surface; and

(6) Protecting and finishing inlets and bridge drains.

570.08 Production Start-Up Procedures.

(a) Preparatory phase meeting. Conduct a pre-paving preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of PPC overlay operations.

(b) Test section. Submit a proposed location of previously constructed concrete to complete a test section. Provide at least 7 days' notice before placing the test section. Prepare the substrate concrete surface using the same methods intended for the overlay placement. Construct a test section at least 20 feet long at the same thickness and paving width as the overlay. Use the approved mix design and the same methods of handling, placing, finishing, texturing, and curing intended for actual placement. Determine the initial set time. Complete one or more bond strength tests. See Table 570-1 for requirements. Demonstrate the ability to construct an acceptable test section and competency to perform the work.

Repeat the test section process until an acceptable test section is produced. If required, remove and dispose of the test section materials off site according to Subsections 203.05 and 203.07.

Start production only after the test section is evaluated and accepted.

570.09 Surface Preparation. Do not perform surface preparation within 6 feet of a new overlay until 48 hours after its placement.

(a) Removal of asphalt and membrane. Remove asphalt, asphalt membranes, and other deleterious material without damaging the concrete bridge deck. Micro mill according to Section 413 to remove the existing asphalt to a depth ½ inch away from the concrete deck surface. Use other approved methods to remove the remaining asphaltic material.

Repair concrete according to Section 572. Do not place PPC until concrete repair material has cured at least 5 days and there is no moisture in the repair areas. Test for moisture in concrete according to ASTM D4263 at locations as directed.

(b) Surface cleaning. Do not start cleaning operations until concrete repairs are complete and the deck is dry. Use equipment and procedures that do not obstruct the view or travel way of motorists in adjacent roadways. Do not power wash.

Shot blast to remove grease, oil, asphalt, coating material, membrane, concrete laitance, and other contaminants that could interfere with the proper adhesion of the overlay system. Use steel shot conforming to SSPC-AB3, *Ferrous Metallic Abrasive* or recycled steel shot conforming to SSPC-AB2, *Cleanliness of Recycled Ferrous Metallic Abrasives*. Complete enough passes at a travel speed that results in loose surface concrete being removed, aggregates of the concrete being exposed, and a visible change in concrete color occurring. Capture debris from shotblasting and dispose according to Subsection 203.07.

Cover the prepared surface with polyethylene sheeting to prevent contamination. Do not expose cleaned surfaces to traffic.

Immediately before placing primer, remove loose particles by oil-free compressed air, magnets, or vacuuming. Make a final complete pass of the area to be overlaid with oil-free compressed air to clean and dry the concrete substrate.

570.10 Handling and Storing Material. Prevent segregation, contamination, or other harmful effects during handling and storage of material. Provide aggregate with uniform moisture content at the time of batching. Submit and follow the system provider's recommendations.

570.11 Delivery. Produce and deliver PPC to allow a continuous placement with no PPC achieving initial set before the remaining PPC being placed adjacent to it. Deliver PPC through the conventional chute of a mobile mixer directly to the paving machine or use another approved delivery process.

570.12 Quality Control of Mix. Conform to Subsection 552.06, except as modified in Table 570-2.

570.13 Application of the Polyester Polymer Concrete Overlay. Application methods may be modified according to the system provider's recommendations and as approved.

(a) Moisture conditions. Do not start placement of HMWM primer and PPC overlay unless the concrete substrate is dry. Do not start placement of the PPC overlay if there is standing water, darkening of substrate surface due to moisture, or evidence of moisture in the substrate cracks. Artificial drying methods, such as using oil-free compressed air or a propane torch, may be applied as approved.

Do not start placement of HMWM primer and PPC overlay if the relatively humidity is greater than 85 percent or if precipitation is anticipated during the planned production and placement period for the PPC overlay.

(b) Concrete surface temperature. Apply HMWM primer and PPC overlay when the concrete substrate is between 40 °F and 100 °F, unless otherwise recommended by the system provider.

(c) HMWM primer. Apply primer according to the system provider's recommendations. Mix all components of the HMWM resin. Place primer within 5 minutes of mixing and at a rate of 90 square feet per gallon, or at the rate recommended by the system provider.

Uniformly spread primer to completely cover the concrete substrate to be overlaid. Do not allow leakage of primer on unprepared areas and areas that will not receive an overlay. Apply primer with push brooms or rollers. Avoid excess application that results in puddling. Remove excess material to meet the required application rate. Reapply primer to areas that appear dry after 15 minutes of absorbing the material.

(d) PPC. Apply PPC within a timeframe of 15 minutes to 2 hours after the primer has been applied. Apply PPC before gelling or 15 minutes following addition of initiator, whichever occurs first.

Completely blend and initiate the polyester resin binder. Add the aggregate and mix for at least 2 minutes, or as recommended by the system provider.

Remove and replace PPC that does not attain an initial set within the range shown in Table 570-1.

Consolidate and finish the PPC to the required grade and cross-section. Control the profile and cross-section by a taut reference string line on both sides of the paving machine. Do not start placement operations until the reference elevation and string line are approved.

Use the paving machine as the primary finishing device. Hand finish in areas that are inaccessible to the paving machine. Finish to produce a slight resin bleed.

(e) Texturing. Produce a skid resistant surface texture using the following methods:

(1) Sand friction finish. Completely cover the overlay by uniformly broadcasting at least 2.2 pounds per square yard of sand onto the glossy PPC surface immediately after finishing and before resin gelling occurs.

Repair smooth or low friction areas from insufficient quantities of sand according to the system provider's recommendations and as approved.

(2) Grooving. After the bond strength as shown in Table 570-1 is attained, groove according to Subsection 552.14(g). Complete grooving within 7 days of completing PPC overlay placement. Limit traffic speeds to 25 miles per hour or less until grooving is complete.

Continuously remove slurry and other residue from the PPC overlay by vacuum pickup or other approved methods. Dispose of slurry and other residue according to Subsection 203.07.

(f) Joints. Install construction joints and saw cut joint locations as shown in the plans. If no joint locations are shown in the plans, submit a jointing plan for approval. Form the vertical edge at construction joints by bulkhead or saw cut. Make construction joints straight and vertical. If uncontrolled cracking occurs, repair the crack according to the system provider's recommendations and as approved. Seal joints according to the system provider's recommendations and as approved.

(g) Curing. Protect the overlay from moisture for at least 4 hours. Do not open to traffic until at least 4 hours of curing has been completed.

(h) Roughness. Check PPC overlay surfaces with a 10-foot metal straightedge. Check the entire surface in both the longitudinal and transverse directions with the straightedge. Overlap the straightedge at least one-half of the length of the previous straightedge placement.

Defective areas are deviations between the surface and the bottom of the straightedge more than ¼ inch between the two contacts of the straightedge, or deviations more than ¼ inch measured at the end of the straightedge. Correct defective areas. Obtain approval for the method of correction.

(i) Tapers. Complete one lane of PPC placement for the entire length of the bridge in one placement operation. If the need arises to suspend operations and complete a transverse taper, use a bond breaker and construct an asphalt taper with a 1V:10H slope. Completely remove the bond breaker and temporary asphalt taper and clean the surface according to Subsection 570.09(b) before resuming PPC placement.

570.14 Acceptance. See Table 570-2 for sampling, testing, and acceptance requirements.

Material for PCC overlays will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of cementitious material.

The PPC overlay mix will be evaluated under Subsections 106.02 and 106.04.

Construction of PPC overlays for bridge decks will be evaluated under Subsections 106.02 and 106.04.

Concrete repairs will be evaluated under Section 572.

Micro milling will be evaluated under Section 413.

Measurement

570.15 Measure the Section 570 pay items listed in the bid schedule according to Subsection 109.02.

Payment

570.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 570 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 570-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Mix Design									
PPC composition	Measured & tested for conformance (106.04 & 105)	All	–	Subsection 570.06	1 per mix design	Source of material	Yes, if requested	28 days minimum before pre-paving meeting	–
Production Start-up (Test Section)									
PPC	Measured & tested for conformance (106.04)	Minimum bond strength, psi(1)	–	ASTM C1583	2 locations per test section minimum	In-place after curing is complete	No	Upon completing tests	–
		Initial set time, minutes	–	ASTM C266(3)	1 per test section	In-place to measure initial set time	"	"	–

Table 570-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
PPC	Measured & tested for conformance (106.04)	Minimum bond strength, psi(1)	–	ASTM C1583	1 per 300 yd^2 but not less than one per day	In-place after curing is complete	No	Upon completing tests	–
		Surface tolerance (roughness)	–	Subsection 570.13(h)	Complete coverage, see Subsection 570.13(h)	Finished PPC overlay surface	"	"	–
	Process control (153.03)	Initial set time, minutes	–	ASTM C266(3)	Continuously during production	In-place to measure initial set time	No	Upon completing tests	–
		Yield(2)	–	(2)	Daily	(2)	"	Before starting the following day's placement	–

(1) After at least 24 hours cure time. Tested on in-place material. Drill from 0.25 inch to 0.50 inch below the bond line. An acceptable test will demonstrate that the overlay bond strength is sufficient by producing a concrete subsurface failure area greater than 50 percent of the test surface area. Repair bond test locations with polymer overlay.
(2) Complete a comparison of the actual yield for each day's placement to the theoretical yield. Theoretical yield is based on the actual area paved and the planned thickness of the mixture being placed. When the variance is greater than 5 percent include a written explanation and corrective measures, as appropriate.
(3) Initial set time may also be defined as the point at which the in-place PPC cannot be deformed by pressing with a finger.

Section 571. — ULTRA-HIGH PERFORMANCE CONCRETE

Description

571.01 This work consists of providing, placing, finishing, and curing ultra-high performance concrete (UHPC).

Material

571.02 Conform to the following Subsections:

Curing material	711.01
Reinforcing fibers	711.06
Sealants, fillers, and seals	712.01
Water for cementitious materials	725.01(a)

Construction Requirements

571.03 Qualifications. At least 30 days before starting UHPC work, submit the following for approval:

(a) On-site technical representative. A résumé describing experience supervising on-site UHPC related activities including mixing, placement, and process control of the UHPC test section and UHPC production pours; and

(b) UHPC manufacturer. Documentation describing at least 3 years' experience on UHPC projects of similar size and scope. Include project names, construction dates, locations, and contact information for the project owners.

571.04 Composition (Ultra-High Performance Concrete Mix Design). Submit written concrete mix design and test results at least 14 days before test section. Include the following:

(a) Material certifications;

(b) Mass of mixing water per cubic yard of concrete; and

(c) Test results from within the last 12 months.

Produce UHPC mixtures that conform to Table 571-1 and are suitable for the application shown in the plans.

Table 571-1
Properties of UHPC

Property	Test Method	Performance
Compressive strength	ASTM C1856	≥ 13,000 psi at 4 days
		≥ 18,000 psi at 28 days
Effective cracking strength	AASHTO T 397	≥ 1100 psi
Peak tensile strength	AASHTO T 397	≥ 1250 psi
Direct tension bond strength	ASTM C1583	100% failure in substrate concrete
Modulus of elasticity	ASTM C1856	≥ 6500 ksi
Long-term drying shrinkage	ASTM C1856	≤ 800 microstrains at 28 days
Chloride ion penetrability	ASTM C1856	≤ 250 coulombs
Abrasion resistance	ASTM C1856	< 0.025 oz. lost
Freeze thaw resistance	ASTM C1856	RDME > 95%
Flow(1)	ASTM C1856	Between 7 to 10 in
ASR(2)	ASTM C1567	≤ 0.10 percent at 16 days after casting

(1) Flow property is only applicable to closure pour application.
(2) Performed on approved mix design mass percent combinations.

571.05 Placement Plan. At least 14 days before starting the test section, submit the following according to Subsection 104.06:

(a) Responsible personnel and hierarchy;

(b) Type, size, location, and number of equipment;

(c) QC of batch proportions. Include dry ingredients, fibers, water, and admixtures;

(d) QC of mixing time and batch times;

(e) Batch procedure sequence;

(f) Test section construction sequence and drawings;

(g) Form work including materials and removal;

(h) Placement procedure. Include surface preparation of existing concrete surfaces, prewetting of existing concrete surfaces to a saturated surface dry (SSD) condition before placement of UHPC, handling, transporting, placing, finishing, curing protection, and overall sequencing of placement procedure. Include provisions for acceptable ambient conditions and batch temperatures and corrective measures as required;

(i) Threshold limits for ambient temperature, ambient relative humidity, batch consistency, batch temperature, batch times, and relative corrective action;

(j) Spill prevention and cleanup plan;

(k) Cold weather placement plan including if cold weather placement is expected during placement of UHPC;

(l) Contingency plan including contingency procedures for interruption of operations by weather, equipment malfunctions, or other issues; and

(m) Sampling and testing procedures.

571.06 Production Start-up Procedures.

(a) Preparatory phase meeting. Conduct a pre-UHPC preparatory phase meeting according to Subsection 153.06(a) at least 7 days before the start of UHPC operations. In addition, be prepared to discuss the approved Placement Plan.

(b) Test section. Complete a test section at least 30 days before production according to the approved Placement Plan.

For overlays, bridge decks, and other flatwork, construct a 9- by 9-foot test section at the same thickness as the production placement. For closure pours, construct a 9-foot-long test section. For other structural elements, construct a 3- by 3- by 3-foot test section. Use the approved UHPC mix design and the same methods of handling, placing, finishing, and curing intended for production placement. Sample and test according to Table 571-2.

Construct the test section formwork according to Subsection 571.14 and as shown in the plans. Construct the test section to represent prepared surfaces and reinforcement bars in the production placement and the steepest grade and cross slope of the finished surface. Complete the test section at the project site in a location that allows the CO access to all sides.

Construct the test section in the presence of the manufacturer's technical representative and the CO. Use the same staff, equipment, forming, mixing, placing, and curing procedures as the production pour. Include all steps necessary to replicate a production UHPC pour.

After the UHPC has taken its initial set, strip the forms to allow the CO to evaluate the test section.

Demonstrate the placement plan and methods for surface preparation and compliance with temperature and finishing requirements.

Verify fresh and hardened concrete properties.

Repeat the test section process until an acceptable test section is produced.

If desired results are not achieved as determined by the CO, modify the process accordingly and complete another UHPC test section. Continue until a UHPC test section is completed successfully. Document the procedures, tools, forms, and any other equipment implemented in this successful completion. Use the same in completing production UHPC pours. Provide a revised Placement Plan as directed before production UHPC pours based on the test section results.

571.07 Handling and Storing Material. Handle and store material to ensure uniformity of mixture at time of use and to prevent loss of physical and mechanical properties, according to the manufacturer's recommendations. Do not use UHPC materials containing evidence of moisture contamination.

571.08 Batching. Batch the concrete according to the manufacturer's recommendations.

571.09 Equipment. Do not use equipment with aluminum parts that contact the UHPC.

(a) Mixers. Provide mixers capable of uniformly mixing the UHPC, according to the manufacturer's recommendations. Provide documentation that mixers are rated for use with UHPC mixtures. Provide at least two portable mixing units.

(b) Vibrating screed. When constructing UHPC overlays, use an approved power-driven finishing machine equipped with a screed that oscillates in a transverse direction.

571.10 Mixing. Ensure the manufacturer's representative is present during all UHPC mixing. Maintain the mixture at an ambient temperature below 85 °F or according to the manufacturer's recommendations. Ice may be added to the mix if recommended by the manufacturer's representative.

Mix the concrete in a portable mixer according to the manufacturer's recommendations. If multiple portable mixers are used, stagger the batching operations so that a constant supply of fresh concrete is available for placement. Operate equipment within the manufacturer's recommended capacity. Add UHPC materials according to the manufacturer's recommendations. Produce concrete of uniform consistency. Remove the contents of a mixed batch before a succeeding batch is charged into the mixer.

Regulate the delivery of the UHPC to the site so that the placing and finishing operations can proceed at a uniform rate.

571.11 Quality Control of Mix. Submit and follow a QCP according to Section 153.

Mix and place UHPC according to the manufacturer's recommendations.

Designate at least one laborer to monitor the UHPC placement for concrete leakage. Identify materials to be kept on hand and procedures to be implemented to stop any UHPC leaking from forms.

571.12 Temperature and Weather Conditions. Protect the UHPC from precipitation during and after placement. Maintain the temperature of the UHPC mixture before placement according to the manufacturer's recommendations.

During curing, maintain the temperature of the UHPC's outermost surfaces according to the manufacturer's recommendations or the following:

(a) Cold weather. Conform to Subsection 552.07(a), except as follows:

(1) Place UHPC when the ambient air temperature is 45 °F and rising, and the substrate temperature is 40 °F and rising;

(2) Maintain a minimum concrete temperature of 50 °F during curing. Protect UHPC until the concrete minimum 4-day compressive strength is attained; and

(3) Remove protection only when the average wind speed is less than 10 miles per hour as measured 3 feet from the UHPC surface.

(b) Hot weather. Conform to Subsection 552.07(b), except as follows:

(1) Place UHPC when the ambient air temperature is less than 85 °F, and the substrate temperature is less than 80 °F; and

(2) Do not remove curing material until the minimum 4-day compressive strength is attained and the average wind speed is less than 10 miles per hour as measured 3 feet from the UHPC surface.

(c) Evaporation. Conform to Subsection 552.07(c).

(d) Precipitation. Protect UHPC from precipitation during and after placement.

571.13 Surface Preparation.

(a) UHPC overlay. Conform to Subsection 569.06(b).

(b) UHPC closure pour and other structural elements. Sandblast concrete surfaces to exposed aggregate surface finish. Clean concrete surfaces by flushing with clean water from a high-pressure water jet or compressed air. Clean exposed steel. Remove any dirt, rust, oil, grease, coating material, or other contaminants which may inhibit UHPC bonding. If compressed air is used, provide a filter to deliver oil-free compressed air.

571.14 Formwork. Design and construct falsework, shoring, and bracing according to Section 562. Provide watertight formwork with a non-absorbing finish. Use an approved form release agent to produce a minimum of staining, air holes, and hydration discoloration.

Fasten formwork to existing concrete using adhesives or other approved methods that do not damage the existing concrete. Do not use drilling, nailing, or post anchor systems to fasten temporary works or formwork to existing concrete. Provide formwork according to the manufacturer's recommendations for construction of concrete elements.

571.15 Placing Ultra-High Performance Concrete.

(a) General. Ensure the manufacturer's representative is present during handling and placing of the UHPC. Prepare surfaces according to Subsection 571.13. Monitor the UHPC handling and placement for concrete leakage.

(b) Sequence of placement. Sequence UHPC placement according to the construction stages shown in the plans. Finish placing UHPC in each overlay lane or closure pour before starting placement in successive overlay lanes or closure pours.

Thoroughly moisten the forms and wet existing concrete surfaces to an SSD condition immediately before placing UHPC. Remove excess water by approved methods before placing UHPC.

Do not place concrete until the forms have been inspected and approved.

(c) Placing methods. Place UHPC according to the manufacturer's recommendations. Handle and place concrete by methods that do not cause segregation and results in dense homogenous concrete that is free of voids.

Do not pump UHPC unless it was demonstrated and approved in the test section. If ambient temperature during the UHPC placement is at least 7 °F greater than during the test section, perform another test section at the higher temperature according to Subsection 571.04.

Cast UHPC continuously without interruption. Add UHPC behind the leading edge of the flow. Do not use cold joints unless shown in the plans.

For UHPC closure pours, place UHPC using chimneys, ports, or other approved equipment that maintain a positive head of material to the flowing UHPC, according to the manufacturer's recommendations. Provide equipment with a minimum discharge opening of 3 inches. Install chimneys, ports, or other approved equipment at the highest point of each joint and at intervals no more than 10 feet.

Fill the joint from the low point. Maintain a continuous head of pressure sufficient to fill the joint to just beyond the next uphill chimney or port. Fill successive chimneys or ports in the same manner until UHPC emerges from the one placed at the highest point of the joint.

Monitor UHPC for subsidence and maintain a positive head of material to the UHPC in all chimney or ports until the UHPC has taken initial set.

(d) Consolidation. Consolidate UHPC according to the manufacturer's recommendations.

(e) Compressive strength. Remove and replace concrete represented by cylinders having a compressive strength less than 90 percent of the minimum 28-day strength.

571.16 Construction Joints. Do not use construction joints unless shown in the plans.

571.17 Expansion and Contraction Joints. Provide expansion and contraction joints as shown in the plans.

571.18 Curing Ultra-High Performance Concrete. Start curing immediately after consolidation during placement operations. Apply a curing compound to the UHPC surface and cover the UHPC surface with waterproof plastic sheeting. Ensure the UHPC surface is continuously covered by the waterproof sheeting until the UHPC has attained the 4-day minimum compressive strength shown in Table 571-1. Cure UHPC according to the manufacturer's recommendations.

571.19 Finishing Ultra-High Performance Concrete. Overfill the UHPC at least ½ inch. Perform diamond grinding of UHPC surfaces after the UHPC has attained the 4-day minimum compressive strength shown in Table 571-1.

(a) UHPC overlay. Where UHPC is the final riding surface, diamond grind the entire top surface of the overlay in the direction parallel with the centerline to provide a uniform longitudinal corduroy grooved texture. Space fins ½ to ¾ inch on centers. Cut the grooves between $^{1}/_{16}$ inch and $^{3}/_{16}$ inch wide and $^{1}/_{16}$ to $^{3}/_{16}$ inch deep.

Discontinue grooving 12 inches from curb face and provide a flat ground finish on the surface of gutters. For bridge decks, do not groove within 6 inches of joint blockouts and bridge ends.

Check the entire surface parallel to the centerline with a 10-foot metal straightedge. Overlap the straightedge at least one-half of the length of the previous straight edge placement.

Correct deviations more than ⅛ inch from the testing edge of the straightedge.

(b) UHPC closure pour. Diamond grind the top surface of the UHPC closure pour to match the existing grade and cross slope within ¼ inch.

571.20 Loads on New Ultra-High Performance Concrete Structures. Do not allow traffic or other loading, including construction loading, on UHPC decks until the deck concrete has attained the 4-day compressive design strength and the finished surface (and diamond grinding) has been approved to allow vehicular traffic.

571.21 Acceptance. See Table 571-2 for sampling, testing, and acceptance requirements.

Material for UHPC will be evaluated under Subsections 106.02 and 106.03. Provide production certifications with each shipment of UHPC material.

UHPC mix properties will be evaluated under Subsections 106.02 and 106.04.

Construction of UHPC will be evaluated under Subsections 106.02 and 106.04.

Temporary works will be evaluated under Section 562.

Measurement

571.22 Measure the Section 571 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring UHPC by the cubic yard, measure in the structure.

Do not measure test sections not incorporated in the work.

Payment

571.23 The accepted quantities will be paid at the contract price per unit of measurement for the Section 571 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 571-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
UHPC	Measured & tested for conformance (106.04)	Chloride ion penetrability(1)	–	ASTM C1856	1 per material type	Source of material	No	14 days minimum before test section	–
Production Start-up (Test Section)									
UHPC	Measured & tested for conformance (106.04)	Compressive strength(2)	–	ASTM C1856	1 set per test section	Discharge stream at point of placement	Yes	Upon completing tests	–
		Effective cracking strength	–	AASHTO T 397	"	"	No	"	–
		Peak tensile strength	–	AASHTO T 397	"	"	"	"	–
		Direct tension bond strength	–	ASTM C1583	"	"	"	"	–
		Modulus of elasticity(3)	–	ASTM C1856	"	"	"	"	–
		Long-term drying shrinkage	–	"	"	"	"	"	–
		Abrasion	–	"	"	"	"	"	–
		Freeze thaw resistance	–	"	"	"	"	"	–

Table 571-2 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production Start-up (Test Section) (continued)									
UHPC	Measured & tested for conformance (106.04)	Temperature	–	ASTM C1064	1 per batch	Discharge stream at point of placement	No	Upon completing tests	–
		Flow	–	ASTM C1856	"	"	–	"	–
Production									
UHPC	Statistical (106.05)	Compressive strength(2)	II	ASTM C1856	1 set per 30 yd^3 but not less than 1 per day	Discharge stream at point of placement	Yes	Upon completing tests	–
UHPC	Measured & tested for conformance (106.04)	Temperature	–	ASTM C1064	1 per batch	"	No	Upon completing tests	–
		Flow(4)	–	ASTM C1856	"	"	"	"	–
		Surface tolerance	–	Straightedge measurement, Subsection 571.19	Continuous after concrete has hardened	Finished surface	"	24 hours	–

(1) Cast at least three, 4- by 8-inch maximum chloride permeability cylinders per set and carefully transport the cylinders to the job site curing facility. A single maximum chloride permeability test result is the average result from three cylinders cast from the same load.
(2) Cast at least six, 3- by 6-inch compressive strength cylinders per set and carefully transport the cylinders to the job site curing facility. Test compressive strength at 4 and 28 days. A single compressive strength test result is the average result from three cylinders cast from the same load.
(3) Cast at least one, 3- by 6-inch modulus of elasticity cylinder per set and carefully transport the cylinder to the job site curing facility.
(4) Perform flow test only for UHPC closure pour.

Section 572. — CONCRETE REPAIR

Description

572.01 This work consists of repairing concrete in bridges, culverts, and other structures. This work also includes crack sealing by the gravity method.

Material

572.02 Conform to the following Section and Subsections:

Coarse aggregate for concrete	703.02
Color coating	725.15
Concrete curing material and additives	711
Epoxy resin adhesives	725.12
Fine aggregate for concrete	703.01
Galvanic anodes	725.16
High molecular weight methacrylate	725.18
Hydraulic cement	701.01
Non-shrink grout	701.04(b)(1)
Packaged repair mortar	701.05(b)
Penetrating stain for concrete	719.05
Polyester resin binder	725.17
Pozzolans	701.03
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01
Water for cementitious materials	725.01(a)

Construction Requirements

572.03 Composition. Provide repair materials for the different classes of repairs that conform to the following:

(a) Hydraulic cement concrete. Submit written concrete mix designs for approval at least 30 days before production. Include the items listed in Subsection 601.03 in each mix design submittal. Do not start production until the mix design is approved. Provide a concrete mixture that conforms to the requirements shown in Table 572-1 or 572-2.

Table 572-1
Composition of Repair and High Early Strength (HES) Concrete

Class of Concrete(1)	Early Age 48-Hour Design Compressive Strength, AASHTO T22 pounds per square inch	28-Day Design Compressive Strength, AASHTO T22 pounds per square inch	Plastic Air Content, percent minimum(2)	Maximum Water/ Cementitious Material Ratio(4)	Slump, inches(3)	Nominal Maximum Size Aggregate, AASHTO M 40
Repair	2000	4500	5.0	0.45	±1 from provided target	#67 or #78
HES	3000	5000	5.0	0.40	±1 from provided target	#67 or #78

(1) Conform to ASTM C1157 for portland cement in concrete.
(2) Measure plastic air content according AASHTO T 152 Method B. Maximum plastic air content is 9 percent.
(3) Conform to the supplier provided target slump. Maximum slump is 8 inches if approved mix design includes a high-range water reducer.
(4) If supplementary cementitious materials are used, conform to Table 552-2 limits.

Table 572-2
Composition of Very High Early Strength (VHES) Concrete

Class of Concrete(1)	Early Age 4-Hour Design Compressive Strength, AASHTO T22 pounds per square inch	28-Day Design Compressive Strength, AASHTO T22 pounds per square inch	Freeze Thaw Resistance ASTM C666 Method A (minimum)	Maximum Water/ Cementitious Material Ratio	Slump, inches(3)	Nominal Maximum Size Aggregate, AASHTO M 40
VHES	3000	5000	RDME(2) > 96%	0.42	±1 from provided target	#67 or #78

(1) Conform to ASTM C1600 Class URH or Class VRH for hydraulic cement in concrete.
(2) Relative dynamic modulus of elasticity (RDME) measured according to ASTM C666.
(3) Conform to the supplier provided target slump.

Submit concrete mix designs on Form FHWA 1606, *Minor Portland Cement Concrete Mix Design* for hydraulic cement concrete mixtures supplied by a ready-mix truck or a volumetric mixer.

For hydraulic concrete mixtures using prepackaged bags, submit the manufacturer’s product data sheet, mixing requirements, and placement methods. When using prepackaged bag mixtures for HES classes of concrete, provide mixes able to generate a stable air void system with a minimum air content shown in Table 572-1. Demonstrate that the prepackaged bag mixture conforms to the requirements of the class of concrete submitted for the items of work. Complete a trial batch to demonstrate conformance with entrained air requirement with mixing methods and type of equipment that will be used for the work.

(b) Polymer resin concrete. Provide an organic polymer resin concrete mixture consisting of organic polymer and aggregates, including an epoxy resin adhesive or polyester resin binder. Submit the manufacturer's product data sheet, mixing requirements, and placement methods. Conform to the requirements shown in Table 572-3.

Table 572-3
Composition of Polymer Resin Concrete

Class of Concrete	6-Hour Compressive Strength, AASHTO T22 pounds per square inch	24-Hour Compressive Strength, AASHTO T22 pounds per square inch	Thermal Compatibility ASTM C884	ASTM C1202 Rapid Chloride Permeability, Coulombs	Nominal Maximum Size Aggregate AASHTO M 40
Polymer resin concrete	1000	3500	Pass	<100	#67, #78, or #8

(c) Hydraulic cement repair mortar. Provide a mortar that conforms to the requirements of ASTM C882 R1, R2, or R3 as modified in Table 572-4.

Table 572-4
Hydraulic Cement Repair Mortar

Class of Mortar(1)	24-Hour Compressive Strength, ASTM C109 pounds per square inch	7-Day Compressive Strength, ASTM C109 pounds per square inch	Freeze Thaw Resistance, ASTM C666 Method A (minimum)	Maximum Drying Shrinkage, ASTM C157, (modified by ASTM C882) 28-Day
Horizontal	2000	4500	RDME(2) > 95%	0.06%
Vertical & overhead	3000	5000	RDME(2) > 95%	0.07%

(1) Conform to ASTM C1157 or ASTM C1600 hydraulic cement in repair mortar.
(2) Relative dynamic modulus of elasticity (RDME) as measured according to ASTM C666.

Submit the manufacturer's product data sheet, mixing requirements, and placement methods.

(d) Polymer resin mortar. Provide an organic polymer binder mortar mixture consisting of organic polymer and fine aggregates, including an epoxy resin adhesive or polyester resin binder. Submit the manufacturer's product data sheet, mixing requirements, and placement methods for the polymer mortar. Conform to the requirements shown in Table 572-5.

Table 572-5
Composition of Polymer Resin Mortar

Class of Mortar	8-Hour Compressive Strength, ASTM C109, pounds per square inch	24-Hour Compressive Strength, ASTM C109, pounds per square inch	Thermal Compatibility, ASTM C884
Polymer resin mortar	3000	7000	Pass

(e) Crack sealing (gravity feed method). Provide low viscosity epoxy resin adhesive or low viscosity high molecular weight methacrylate (HMWM), for crack sealing by the gravity feed method. Conform to AASHTO M 235, Type I, Class C performance requirements for epoxy resin adhesive. For low viscosity HMWM conform to requirements shown in Table 572-6.

Table 572-6
Performance Requirements of High Molecular Weight Methacrylate for Gravity Feed Crack Sealing

Maximum Viscosity, ASTM D1084, centipoises	Minimum 7-Day Tensile Strength, ASTM D638, pounds per square inch	Minimum 7-Day Compressive Strength, ASTM D638, pounds per square inch	Minimum Elongation at Break, ASTM D638, percent
25	7000	12,000	4.0

572.04 Concrete Repair Mapping and Repair Type Categorization. Verify each concrete repair shown in the plans. Sound concrete or use other approved methods to verify that concrete adjacent to the designated repair area is not defective. Determine the extent of the additional unsound concrete around designated repair area. Mark boundaries and document extent of repair area. Determine length of cracks that are designated in the plans for sealing. Determine if the cracks have extended in length. Mark length and document.

Verify that shallow repairs shown in the plans have not deteriorated into a deep repair by sounding with a hammer or other approved methods. Categorize type of repair as follows:

(a) Shallow repairs. Repairs that do not extend to the depth of the reinforcing steel.

(b) Deep repairs. Repairs in which reinforcing steel is exposed and will require removal of concrete under the reinforcing steel.

Submit results of findings for concrete repair mapping and repair types to the CO. Do not start preparation for additional concrete repair areas or cracks lengths discovered during mapping until approved. Repair areas, repair types, and cracks with no changes from plans may be prepared for the selected concrete repair material according to Subsection 572.06.

572.05 Quality Control Plan for Concrete Repair. Submit a QCP according to Section 153. Include the following:

(a) Concrete repair material for each repair area;

(b) Substrate preparation work required for the repair material;

(c) Concrete repair conditioning requirements of repair area. List hold points for CO to inspect repair area before placing repair material;

(d) Testing and sampling plan;

(e) Repair material placement methods for each type of repair;

(f) Curing method for each type of repair;

(g) Method to protect concrete repairs during adverse weather conditions during repair material curing period; and

(h) Method to protect the concrete adjacent to the repair.

572.06 Concrete Repair. Saw cut ¾ inch deep along boundaries of repair areas. Use power-driven hand tools to remove existing concrete. Do not damage concrete designated to remain in place. Construct structurally adequate debris shields to contain debris within the construction limits. Do not allow debris to enter waterways, travel lanes open to public traffic, or areas designated not to be disturbed.

Where the bond between existing concrete and reinforcing steel is destroyed, remove concrete adjacent to the steel to provide at least ¾-inch clearance for the new concrete to bond to the reinforcing steel. Use care to prevent damage to remaining concrete when achieving the final surface.

Clean exposed concrete surfaces that will be in contact with repair material. Provide a residue free surface.

Before placing hydraulic cement-based repair materials, thoroughly flush repair area with clean water under pressure or with compressed air. If compressed air is used, provide a filter in the airline to ensure that the air is oil-free. For non-hydraulic cement-based repair materials, use compressed air to flush repair area.

Cover prepared substrate to prevent recontamination. Obtain approval of substrate preparation and cleanliness before placement of repair material. Place repair material within 24 hours of preparing the repair area.

(a) Deep repairs. Chip at least a 1-inch clearance under and behind the exposed reinforcing steel. Examine exposed reinforcing steel for evidence of corrosion. If reinforcing steel is exposed and exhibits corrosion, clean the reinforcing steel until corrosion is eliminated. Remove concrete cover 2 inches beyond the endpoints of the original corroded portion of the reinforcing steel. Inspect for corrosion. Continue this process until reaching the boundary of the approved repair area. If corrosion is still evident at the boundary of the previously approved repair area, obtain approval to remove additional concrete cover. Do not strike the reinforcing steel with heavy blows. If the bond between existing concrete and reinforcing steel has been compromised, remove the concrete adjacent to the steel to a depth that will allow new concrete to bond to the entire periphery of the exposed steel. Provide at least 2 inches of clearance behind the steel if galvanic anodes are used with low resistivity mortar.

Remove and replace deteriorated reinforcing steel according to Section 554. Remove and replace reinforcing steel that has lost 25 percent or more of its original cross-section area with new bars of the same size, shape, and composition. If a sufficient length of the existing bar is exposed, lap the new bars with the existing bars for a length of 30 diameters on each side of the damaged portion. Otherwise, connect the new bar by mechanically connecting the new bar to the existing according to Section 554.

Shot blast exposed structural steel, reinforcing steel, and concrete surfaces which will be in contact with repair material until free of rust and foreign material. Clean the sound concrete surface by flushing with clean water from a high-pressure water jet or compressed air.

In repair areas with exposed reinforcing steel, install galvanic anodes on the reinforcement according to ACI Repair Application Procedure Bulletin 8, *Installation of Embedded Galvanic Anodes*, the manufacturer's recommendations, and the following:

(1) For repair areas less than 2 square feet, install one anode.

(2) For repair areas between 2 and 4 square feet, install two anodes on the reinforcement. Install the anodes at opposite sides of the repair and within 4 inches of the edge of the repair.

(3) For repair areas 4 square feet and larger, install anodes at the rate of 2 anodes for each 4-square foot of repair area. Install the anodes in a grid pattern.

Maintain a minimum concrete cover of 1 inch around each anode.

If a concrete repair material that has a chloride permeability of less than 2000 coulombs is used, encase the anode in a low resistivity mortar bed which extends to the sound substrate concrete and 2 inches beyond the anode on all sides.

If the reinforcing steel is to receive a barrier coating, do not coat the reinforcing steel within 1 inch of the anode and do not apply coating to any surface of the anode or the steel tie wires.

Verify steel-to-steel continuity and anode-to-steel continuity within the repair area with a direct current (DC) multimeter. Tie discontinuous reinforcing to continuous reinforcing using tie wire and retest. The electrical connection is acceptable if the DC resistance measured with the multimeter is no more than 1.0 ohm or the DC potential is no more than 1 millivolt.

Pre-wet the concrete substrate and the anodes to achieve a saturated surface dry condition before placing the hydraulic cement repair material. Do not soak anodes for more than 20 minutes.

Apply a scrub coat of the hydraulic cement repair material immediately before placement of the repair material if recommended by repair material manufacturer. Place hydraulic cement-based repair material before scrub coat dries out.

(b) Shallow repairs. Remove concrete to the boundary of the approved repair area. If unsound concrete is still evident at the boundary of the approved repair area, obtain approval to remove additional concrete until sound concrete is encountered. Roughen saw cuts to provide bond by shotblasting or other approved methods. Shot blast the substrate concrete at the bottom of the repair to remove any microcracked concrete from any chipping operations.

If recommended for use by the concrete repair material manufacturer, a bonding coat of an epoxy resin adhesive that conforms to AASHTO M 235, Type V may be applied to surfaces of the concrete repair. Follow the epoxy resin adhesive manufacturer’s recommendations for application time before placement of concrete repair material to promote optimal bonding.

(c) Crack sealing. Remove dirt, laitance, and other debris from the exterior and interior of the crack. Rout the surface of the crack to provide a reservoir for crack sealant. Clean the adjacent surface to the crack and apply a temporary dam on each side of the crack. Obtain approval of crack preparation and cleanliness before placing repair material. Protect cleaned crack from debris and dirt. Ensure that dam material is functional before placing crack sealant.

572.07 Handling and Storing Material. Handle and store material to prevent segregation, contamination, or other harmful effects. Do not use cement and fly ash containing evidence of moisture contamination. Store and handle aggregate to ensure uniform moisture content at the time of batching. Store prepackaged repair materials according to the manufacturer’s recommendations for protection from moisture and within the allowable temperature range. Submit documentation of proper storage when requested. Do not use prepackaged materials in the work that has moisture damage or exposed to temperatures exceeding the manufacturer's recommended range.

572.08 Batching. Conform to the following:

(a) Hydraulic cement-based repair products. When using prepackaged bags, provide a scale that has accuracy to the nearest 0.001 kilogram. Convert mixing water required according to the manufacturer's recommendations from volumetric measurement to mass of water. Batch water to within ±100 grams of the target.

(b) Polymer concrete and polymer mortar. Weigh or measure ingredients according to the manufacturer's recommendations.

(c) Crack sealer. Weigh or measure ingredients according to the manufacturer's recommendations.

572.09 Mixing. For hydraulic cement concrete mixed in a central plant, conform to Subsection 552.04(b). For truck mixed hydraulic cement concrete, conform to Subsection 552.04(c). Produce concrete of uniform consistency.

Provide mixer type recommended by product manufacturer for mixing of prepackaged hydraulic cement concrete mixes, hydraulic cement repair mortar, polymer concrete, polymer mortars, and crack sealers. Size mixer to the repair such that all batches of prepackaged repair materials can be mixed, discharged, and placed within the manufacturer's placement limits for each repair. Maintain batch size of repair materials for mixing at a minimum of 20 percent but no more than 80 percent of rated mixer capacity. Keep mixer maintained, clean, and free of partially dried or hardened material.

(a) Volumetric batching and continuous mixed concrete. Provide proportioning and mixing equipment with an integral mobile unit with continuous mixing capability that meets the requirements of ASTM C685 and the following:

(1) Capable of producing at least 6 cubic yards of concrete without recharging; and

(2) Capable of discharging the mixture through a conventional chute directly into the work.

Calibrate equipment with material for the approved mix design within 6 months of the placement date. Calibrate according to VMMB 1000-01, *Volumetric Mixer Standards of the Volumetric Mixers Manufacturers* and ACI 304.06, *Guide for Use of Volumetric Measuring and Continuous-Mixing Concrete Equipment*. Submit documentation on mixing uniformity according to ASTM C685, Annex A.1.

(b) Small quantities (less than 0.5 cubic yards per repair). Provide mixer type recommended by product manufacturer for mixing of prepackaged hydraulic cement concrete mixes, hydraulic cement repair mortar, polymer concrete, and polymer mortars. Size mixer to the repair such that all batches of prepackaged repair materials can be mixed, discharged, and placed within the manufacturer's placement limits for each repair. Maintain batch size of repair materials for mixing at a minimum of 20 percent but no more than 80 percent of rated mixer capacity.

(c) Polymer concrete and polymer mortars. Provide a hand-held mixing device recommended by the manufacturer.

(d) Crack sealers. If crack sealer is a multicomponent system, mix according to the manufacturer's recommendations. Mix in the appropriate component sequence. Size mixing container so that the crack sealer being mixed is at least 20 percent of the volume of the container but no more than 80 percent of the container. Provide a hand-held mixing device recommended by the manufacturer. Ensure the mixing container, mixer blades, and mixer shaft are clean and free of any deleterious material.

572.10 Delivery. Produce and deliver concrete repair materials to allow a continuous placement for each repair area. Place concrete repair material according to the manufacturer's recommendations for time, substrate temperature, repair material temperature, and ambient weather conditions. Deliver, handle, and place repair materials to minimize rehandling and to prevent damage to the structure. For hydraulic cement concrete and mortar, do not place material that has developed an initial set. Do not re-temper hydraulic cement concrete and mortar by adding water.

(a) Hydraulic cement concrete mixed in a central mix plant or truck mixed hydraulic cement concrete. Conform to Subsection 552.05.

(b) Hydraulic cement concrete mixed in a volumetric mixer. Mix on site adjacent to concrete repair. Discharge directly into repair area unless repair is inaccessible to the volumetric mixer. If inaccessible, discharge into wheelbarrows or buggies and deliver concrete to repair areas.

(c) Prepackaged hydraulic cement concrete and hydraulic cement repair mortars. Mix on site adjacent to concrete repair. Evaluate uniformity of mixed repair material after discharge into wheelbarrow or buggy. If segregation or phase separation occurs, do not use in repair area and dispose according to Subsection 203.07.

(d) Polymer concrete, polymer mortars, and crack sealer. Mix on site adjacent to concrete repair.

572.11 Temperature and Weather Conditions. Conform to Subsection 552.07 for hydraulic cement-based repair materials. Conform to manufacturer's temperature and weather condition limits for non-hydraulic cement-based repair materials.

572.12 Handling and Placing Concrete Repair Material.

(a) Hydraulic and non-hydraulic cement concrete and mortars. Conform to Subsection 552.08 for hydraulic cement concrete and hydraulic cement mortars. Handle and place non-hydraulic cement-based repairs according to the manufacturer's recommendations.

If formwork is required, conform to Section 562 including use of an approved formwork release agent.

Place repair material continuously without interruption unless there is a planned construction or expansion joint in the repair area. Do not create cold joints in a repair area. Control the delivery rate, placing sequence, and construction methods to ensure fresh repair material is always placed and consolidated against previously placed material before the setting or the maximum allowable working time of the material has been reached.

Remove and replace concrete repair material represented by the appropriate test sample and test method having a compressive strength less than 90 percent of the latest age compressive strength according to Subsection 572.03 for each of the concrete repair material type.

(b) Crack sealant. Place crack sealant by gravity feed methods according to ACI Repair Application Procedure Bulletin 2, *Crack Repair by Gravity Feed with Resin* and the manufacturer's recommendations. Keep crack sealant within dams. Grind the excess crack sealant on the concrete surface when crack sealant has hardened and gained sufficient strength. Remove dams before grinding.

572.13 Construction Joints. Provide construction joints at locations shown in the plans. Conform to Subsection 552.09. Obtain approval for additional construction joints.

572.14 Expansion and Contraction Joints. Provide expansion and contraction joints at locations shown in the plans. Conform to Subsection 552.10.

572.15 Finishing Concrete Repair Material. Strike off concrete repair material surfaces that are not placed against forms. Finish the concrete repair material surface. Use straightedge with sufficient length to span the concrete repair. Correct deviations more than ⅛ inch from the testing edge of the straightedge. For concrete bridge deck repairs that are to receive an overlay, correct deviations more than ¼ inch. Remove excess material from concrete surfaces adjacent to the repair immediately. Dispose of excess material properly.

Protect the surface from precipitation damage.

When the repair has gained enough strength to not be damaged by texturing, texture the surface of the repair. Texture surface of concrete repair to match surrounding concrete unless directed to provide another texture. For a concrete repair that requires the use of formwork, finish surface according to Subsection 552.14 after formwork is stripped. For a surface subject to foot traffic or vehicular traffic, provide a skid resistant surface matching adjacent existing concrete according to Subsection 552.12(c)(1) or 552.12(c)(2).

For surfaces underneath bearings, finish bearing surfaces to within ⅛ inch of the plan elevation. If applicable, set masonry plate according to Subsection 552.12(d).

572.16 Curing Concrete Repairs. For hydraulic based cement concrete repair materials, start curing immediately after finishing and texturing is complete. If the surface of the concrete starts to dry before the selected curing method can be implemented, keep concrete surface moist using a fog spray without damaging the surface.

Cure hydraulic based cement concrete repair materials according to Subsection 552.13(b) or (c).

Cure hydraulic based cement concrete repair materials at least 7 days.

Cure non-hydraulic cement-based materials according to the manufacturer's recommendations. Adjust curing period to account for variations in field temperature and humidity. Cure until a minimum compressive strength of 3000 pounds per square inch is attained.

Sound concrete repairs at 28 days after repair installation. If a concrete repair when sounded indicates the presence of delamination, remove and replace. If concrete repairs exhibit excessive cracking 28 days after installation, remove or replace as directed. Excessive cracking is defined for a shallow concrete repair that exhibits cracking of 12 linear inches of cracking per square foot of concrete repair or for a deep concrete repair that exhibits more than 6 linear inches of cracking per square foot. A crack is defined as having a measured width greater than 0.006 inch in three locations.

572.17 Loads on Concrete Repairs. Do not allow traffic over a concrete repair until the repair has attained a compressive strength of at least of 3000 pounds per square inch.

572.18 Acceptance. See Table 572-7 for sampling, testing, and acceptance requirements.

Material for concrete repairs will be evaluated under Subsections 106.02 and 106.03, except compressive strength will be evaluated under Subsections 106.02 and 106.04. Provide production certifications with each shipment of cementitious material.

Hydraulic cement concrete mixture's slump, air content, density, and temperature will be evaluated under Subsections 106.02 and 106.04.

Construction of concrete repairs will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Temporary works will be evaluated under Section 562.

Measurement

572.19 Measure the Section 572 pay items listed in the bid schedule according to Subsection 109.02.

Payment

572.20 The accepted quantities will be paid at the contract price per unit of measurement for the Section 572 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 572-7
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (fine & coarse) (concrete repair materials containing aggregate)	Measured & tested for conformance (106.04)	Quality	–	Subsections 703.01 & 703.02	1 per material type	Source of material	If requested	Before batching	–
	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	"	"	"	"	–
Mix Design - For Central Batched, Truck Mixed, Volumetric Mixer Mixed Hydraulic Cement-Based Concrete									
Concrete composition (repair, HES, & VHES concrete class)	Measured & tested for conformance (106.04)	All	–	Subsection 552.03	1 per mix design	"	If requested	"	–
Production - For Central Batched, Truck Mixed, Volumetric Mixer Mixed Hydraulic Cement-Based Concrete									
Produced aggregate (fine & coarse)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per day	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes	Before batching	–
		Fineness modulus	–	AASHTO T 27	–	"	"	"	–
		Moisture test	–	AASHTO T 255	–	"	"	"	–

Table 572-7 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production - For Central Batched, Truck Mixed, Volumetric Mixer Mixed Hydraulic Cement-Based Concrete (continued)									
Hydraulic cement concrete[1] (572.03)	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load after 0.25 yd^3 minimum is discharged[4]	Point of discharge	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump	–	AASHTO T 119	"	"	No	"	–
		Temperature	–	ASTM C1064	"	"	No	"	–
		Compressive strength[2],[3] (at specified ages according to hydraulic cement concrete class)	–	AASHTO R 100 & T 22	"	Discharge stream at point of placement	Yes	24 hours after completion of test	Deliver verification cylinders to the CO or designated laboratory for scheduled testing

Table 572-7 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production - For Bagged Products									
Hydraulic cement concrete[1] (572.03)	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per 0.33 yd^3 & one per day minimum[4]	Point of discharge	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or AASHTO T 196	"	"	No	"	–
		Slump	–	AASHTO T 119	"	"	No	"	–
		Temperature	–	ASTM C1064	"	"	No	"	–
		Compressive strength[2],[3] (at specified ages according to hydraulic cement concrete class)	–	AASHTO R 100 & T 22	"	Discharge stream at point of placement	Yes	24 hours after completion of test	Deliver verification cylinders to the CO or designated laboratory for scheduled testing

Table 572-7 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production - For Polymer Concrete									
Polymer concrete[1] (572.03)	Measured & tested for conformance (106.04)	Compressive strength[2],[3] (at specified ages)	–	AASHTO R 100 & T 22	1 per day minimum[4]	Point of discharge	If requested	Upon completing tests	Deliver verification cylinders to the CO or designated laboratory for scheduled testing
Production - For Hydraulic Cement Repair Mortar									
Hydraulic cement repair mortar (572.03)	Measured & tested for conformance (106.04)	Compressive strength[2],[3] (at specified ages according to hydraulic cement concrete class)	–	ASTM C109	1 per day minimum[4]	Point of discharge	Yes	Upon completing tests	Deliver verification cylinders to the CO or designated laboratory for scheduled testing

Table 572-7 (continued)
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production - For Polymer Repair Mortar									
Polymer repair mortar (572.03)	Measured & tested for conformance (106.04)	Compressive strength(2),(3) (at specified ages)	–	ASTM C109	1 per day minimum(4)	Point of discharge	If requested	Upon completing tests	Deliver verification cylinders to the CO or designated laboratory for scheduled testing
Production - For Crack Sealing by Gravity Method									
Crack sealing (572.03)	Measured & tested for conformance (106.04)	Tensile strength (at specified ages)	–	ASTM D638	If requested	Point of discharge	No	Upon completing tests	–

(1) Sample according to AASHTO R 60, except composite samples are not required.
(2) Cast at least four compressive strength test cylinders for 6- by 12-inch specimens or six compressive strength cylinders for 4- by 8-inch specimens and transport the cylinders to the job site curing facility.
(3) A single compressive strength test result is the average result from two 6- by 12-inch or three 4- by 8-inch cylinders cast from the same load.
(4) If three successive samples are tested and compliance to the specifications is indicated, screening tests may be reduced to an approved frequency. Resume Table 572-7 testing frequency if a test shows a failing temperature, air content, or slump, or when directed.

Section 573. — HELICAL PILES

Description

573.01 This work consists of designing, providing, and installing helical piles.

Material

573.02 Conform to the following Subsection:

Helical piles	715.08

Construction Requirements

573.03 Submittals. At least 30 days before starting helical pile work, submit the following according to Subsection 104.06(b)(3):

(a) Product data. Manufacturer's product data including appurtenances and installation instructions.

(b) Drawings and calculations. Drawings and calculations complying with the helical pile capacity shown in the plans. At a minimum, include the following:

(1) Pile number, location, and pattern by assigned identification number;

(2) Pile design load and design calculations. Include the relevant references used for design;

(3) Design notes. Include a description of symbols, terminology, and computer programs used in the design;

(4) Type and size of central shaft;

(5) Helix configuration;

(6) Minimum effective installation torque;

(7) Displacement plates or centralizers and their locations;

(8) Minimum and anticipated overall pile length and tip elevation;

(9) Inclination of pile;

(10) Minimum cased length, if applicable;

(11) Cut-off elevation; and

(12) Working drawings for the temporary yoke or load frame to be used for testing. Include identification number and calibration test certification for each load cell, test jack pressure gauge, and master pressure gauge. Clearly indicate the serial number of each component of the testing assembly on calibration graphs. Include results from calibration tests conducted by an independent testing laboratory within the previous 60 days.

(c) Equipment. A listing of excavating and drilling equipment with the capacity to install helical piles at the maximum specified diameter to the depth and capacity specified in the plans and conforming to the following:

(1) Torque motor. A torque motor capable of continuous adjustment to number of revolutions per minute during installation and with a torque capacity 15 percent greater than the torsional strength rating of the central steel shaft to be installed. Do not use percussion drilling equipment.

(2) Installation equipment. Installation equipment of rotary type, with hydraulic power-driven torque motor with clockwise and counterclockwise rotation capabilities, that can apply adequate downward pressure and torque simultaneously to suit project soil conditions and load requirements, and that can continuously adjust position to maintain proper pile alignment.

(d) Construction methods. A detailed construction sequence for helical pile work describing materials, methods, and equipment to be used. Include the following:

(1) Drilling equipment including the manufacturer's specifications for the drill rig.

(2) Installation methods to ensure required helical pile placement and inclination.

(3) Methods of materials handling and disposal.

573.04 Production Start-Up Procedures. Conduct a pre-helical pile preparatory phase meeting at least 7 days before the start of helical pile operations according to Subsection 153.06(a).

573.05 Installation of Helical Piles. Install the helical piles according to the approved drawings.

Install piles within 1 inch of the position or the line, and within ½ inch of the elevation shown in the plans. Install piles so that the axial alignment is within ¼ inch per foot along the longitudinal axis of the required alignment.

Piles will be rejected if any of the following occurs:

(a) Damaged by internal defects or by improper installation;

(b) Unable to provide the design capacity shown in the plans; or

(c) Installed out of tolerance.

Correct rejected piles using an approved method according to Subsection 106.01.

573.06 Construction Memorandum. Submit a helical pile foundation memorandum that includes the following for all piles:

(a) Installed tip elevation;

(b) Installation torque with depth including maximum torque; and

(c) Load tests results.

Provide confirmation of the adequacy of the helical pile axial and lateral capacity based on the installation and load test results. Provide a memorandum that bears the seal and signature of a professional engineer according to Subsection 104.06(b)(2).

573.07 Acceptance. Material for helical piles will be evaluated under Subsections 106.02 and 106.03.

Construction of helical piles will be evaluated under Subsections 106.02 and 106.04.

Measurement

573.08 Measure the Section 573 pay items listed in the bid schedule according to Subsection 109.02.

Payment

573.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 573 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 574. — GEOSYNTHETIC REINFORCED SOIL-INTEGRATED BRIDGE SYSTEM

Description

574.01 This work consists of constructing geosynthetic reinforced soil-integrated bridge systems (GRS-IBS).

Material

574.02 Conform to the following Subsections:

GRS reinforcement geosynthetic	714.06
GRS open-graded backfill	703.20
Segmental retaining wall units	720.01(a)
Select borrow	704.02

Construction Requirements

574.03 Qualifications. Submit one of the following for approval at least 30 days before starting GRS-IBS work:

(a) On-site supervisor and installation personnel. A résumé for each individual describing at least five constructed projects of similar size and complexity. Include project names, locations, contact information for project owners, and at least two photographs of each of the completed projects; or

(b) Manufacturer's representative. Submit a list of five previously constructed projects of similar size and complexity assisted by the manufacturer's representative. Provide at least two photographs of each of the completed projects. Include project names, locations, and contact information for project owners.

574.04 Submittals. At least 30 days before starting GRS-IBS work, submit the following according to Subsection 104.06:

(a) Plan and elevation drawings for the structure containing the following:

(1) A plan view of the structure showing:

(a) Horizontal offset from the construction centerline to the face of the structure at defining points along the base. Include start and end roadway stations, and start and end wall stations, if different;

(b) Location, length, coverage ratio, and type of reinforcement;

(c) Centerline and size of drainage structure or drainage pipe behind, passing through, or passing under the structure; and

(d) Location, length, and offset from the face of wall to guardrail, guardwall, and parapet structures.

(2) An elevation view of the structure showing:

(a) Elevation and station at horizontal and vertical break points and at least every 20 feet along the top of the structure face;

(b) Elevation and station at the top of the reinforced soil foundation (RSF) and at least every 20 feet along the structure base;

(c) Length and type of reinforcement;

(d) Location and elevation of each layer of geosynthetic;

(e) Distance and elevation along the structure face to all steps of the RSF;

(f) Distance along the structure face to where change in reinforcement lengths occur;

(g) Construction joints; and

(h) Original and final ground-lines.

(b) A typical cross-section view showing:

(1) Type and depth of facing elements and structural connections to reinforcing elements;

(2) Structure batter and angle of slopes below and above wall, if any;

(3) Length, spacing and type of reinforcement, and corresponding limits of excavation and reinforced fill placement zones;

(4) Location of guardrail, guardwall, and parapet structures. Include embedment depths, offset from structure facing, and connection details with structure reinforcement;

(5) Original and final ground-lines, including right-of-way limits;

(6) Estimated or known location of subsurface soil and rock units;

(7) Beam seat and beam seat retention details; and

(8) Top of abutment cap or coping details.

(c) General construction notes.

(d) Horizontal and vertical curve data and superelevation affecting the structure. Include match lines or other details to relate structure stationing to centerline stationing.

(e) Material list and summary of quantities.

(f) Details and dimensions for the RSF. Include steps and step encapsulation details.

(g) Details for the installation of structure drainage features. Include strip, sheet, edge, blanket, and underdrain systems, and associated piping if shown in the plans.

(h) Details for constructing the structures around drainage features, utilities, lighting foundations, traffic barriers, and other obstructions.

(i) Details for end of wall construction and transition to adjacent ground.

(j) Details for architectural treatment.

(k) Details for corners and curves.

(l) Details and dimensions of SRWU.

(m) Proposed compaction equipment. Include light-weight equipment for use within 3 feet of the wall face and methods for stabilizing the face during compaction.

Include a checklist showing each of the items specified have been addressed. If revisions are required, make corrections and resubmit.

574.05 General. Survey according to Section 152 and verify the limits of the GRS-IBS installation. Perform excavation and dewatering according to Section 209.

Excavate wall foundations to within 4 inches horizontally and vertically from the staked location.

574.06 Reinforced Soil Foundation Construction. RSF consists of GRS open-graded backfill encapsulated in geosynthetic reinforcement.

Provide a smooth, uniform foundation surface without protruding objects. Place geosynthetic reinforcement perpendicular to the abutment and wingwall faces. Overlap geosynthetic reinforcement so the upstream geosynthetic sheet overlies the downstream sheet (such as shingled). Overlap geosynthetic joints at least 3 feet in all directions. Pull the geosynthetic taut, remove wrinkles, and lay flat before placing the GRS open-graded backfill.

Do not operate equipment directly on the geosynthetic reinforcement. Place at least a 6-inch lift of GRS open-graded backfill over the geosynthetic reinforcement before operating equipment over the reinforcement. Compact GRS open-graded backfill according to Subsection 574.09. Grade and level the top of the RSF before final encapsulation. Construct the top of the RSF to within 1 inch of plan elevation.

Final encapsulation includes the following:

(a) Fold the geosynthetic from the back of the RSF at the top finish elevation, then fold over the geosynthetic from the front of the RSF so it overlies the geosynthetic at the back of the RSF and secure.

(b) Secure geosynthetic firmly against the backfill, wrapping and securing the geosynthetic tight around the corners of the RSF.

(c) Do not leave exposed backfill or loose geosynthetic.

574.07 Segmental Retaining Wall Units Requirements. Provide SRWUs that have smooth upper and lower bearing surfaces. Do not use SRWUs with finished faces containing chips larger than 1 inch in any direction, finished faces having cracks in any orientation wider than 0.02 inch and longer than 25 percent of the nominal height of the unit, or SRWUs that are broken. Remove without damaging the SRWUs protrusions and loose material from the SRWU surfaces that come in contact with one another or the geosynthetic reinforcement to achieve full contact between the geosynthetic reinforcement and the SRWU surfaces.

574.08 Erection Procedures. Erect the GRS-IBS according to the approved drawings and manufacturer's recommendations and to the tolerance requirements in Table 574-1.

Table 574-1
Construction Tolerance

Facing Type	Vertical, inch(1) (±)	Horizontal, inch(2) (±)	Horizontal Straightedge Point Check, inch(3) (±)
SRWUs	0.6	0.6	0.6

(1) Wall vertical tolerance at top of wall for every 10 feet of wall height. For example, 65 feet wall height multiply 6.5×value.
(2) Wall horizontal tolerance at top of wall for every 10 feet of wall height.
(3) Maximum horizontal deviation at a point in the wall from a 10-foot metal straightedge placed horizontally or vertically on the theoretical plane of the design face.

Place the first course of SRWUs so that they are level, even, and within 1 inch of planned horizontal and vertical locations. Fill SRWUs with unit fill as shown in the approved drawings. Construct the external face of the first row of SRWUs in the abutment face and wingwalls to within 1 inch of the horizontal location shown in the approved drawings. Place SRWUs side by side for the full length of the wall such that adjoining blocks are located according to the manufacturer's recommendations.

Sweep the top of the SRWU clean of debris and fill material before placement of geosynthetic reinforcement and SRWUs. Place each SRWU tightly against the adjacent SRWU so that vertical joints of each course have less than a ¼-inch gap and the joint is midway between those of the underlying course. Remove SRWUs that have become cracked, chipped, or broken. Complete each course of SRWUs before starting the next course.

Pull layers of geosynthetic reinforcement taut, remove wrinkles, and lay flat. Use pins, stakes, fill piles, or the manufacturer's recommended method to anchor the reinforcement before placing backfill to prevent wrinkles and ensure full contact between the reinforcement and top of the RSF backfill. Place the geosynthetic within 1 inch of elevations shown in the approved drawings. Where placing geosynthetic reinforcement between SRWUs place the reinforcement so that no less than 85 percent of the full depth (front to back) of the SRWU is covered by the reinforcement as measured to the front face of the wall. Cut excess geosynthetic reinforcement that extends past the front face of the SRWUs clean and flush with the wall face.

Construct subsequent courses following the same procedure.

Check the GRS wall for plumbness at least every other lift. Correct deviations greater than 1 inch when measured vertically with a 10-foot metal straightedge. Correct high areas by grinding or shimming with manufacturer recommended shims. Do not use shims over $\frac{1}{16}$ inch in stack thickness or within 1 inch of the face. Check every other row of SRWU alignment before placing backfill. Construct corners according to the approved drawings.

In the bearing bed zone, place secondary geosynthetic reinforcement as shown in the plans. No connection between the SRWUs and secondary geosynthetic is required. When seams are necessary, butt adjacent rolls together without overlap. Stagger seams at least 24 inches apart on subsequent lifts and only in the direction parallel to bridge centerline. Trim geosynthetic reinforcement overlaps in contact with the surfaces between the SRWUs to avoid varying the geotextile reinforcement thicknesses between the SRWUs.

574.09 Backfilling and Compaction. Do not operate equipment directly on the geosynthetic reinforcement. Place at least 6 inches of uncompacted GRS open-graded backfill over the geosynthetic reinforcement before operating equipment over the reinforcement except in the bearing bed zone where at least 4 inches of uncompacted GRS open-graded backfill is allowed. Place GRS open-graded backfill immediately following placement of each course of SRWUs and geosynthetic reinforcement. Backfill from the front of the wall to the back and remove wrinkles that form during the backfilling operation. Correct damaged or misaligned geosynthetic reinforcement.

Place and grade the GRS open-graded backfill level for areas behind the SRWUs before compacting. Except for the area within 3 feet from the SRWUs, use only light-weight mechanical tamper, plate, or roller or rubber-tire equipment for compaction. If rubber tire equipment is used, limit speeds to less than 5 miles per hour with no sudden starting, braking, or sharp turning. Use only an approved hand-operated lightweight vibrating plate or roller within 3 feet of the back of the SRWUs. Correct SRWUs that are displaced by compaction operations before placing additional rows of SRWUs.

Perform a method compaction test for approval on the first two lifts to establish the number of passes, lift thickness, and quantity of wetting needed to adequately consolidate the GRS open-graded backfill until there is no visible evidence of further consolidation. Follow the approved compaction procedure for the remainder of the abutment construction without the need for density tests.

Fill and compact depressions caused during compaction so that the compacted lift is level with the top of the SRWUs before constructing the next lift.

At the end of the day's operation, slope the last lift of backfill away from the GRS-IBS structure to direct surface runoff away from the interior of the structure. Do not allow surface runoff from adjacent areas or stream flow to enter the GRS abutment construction area.

574.10 Wingwall Fill Slope Side. Construct wingwalls above the RSF. Backfill in front of the wingwalls as the GRS wall advances upward. Construct the fill slope to original ground elevation that allows water to drain from wall face outward. Prevent surface water runoff on fill slopes.

574.11 Superstructure Placement. After folding the final wrap in the beam seat zone, adjust the final grade to provide an even contact between the top of the reinforced beam seat zone and the bottom of the concrete beam seat. Set bridge structure elements square and level without dragging across the beam seat surface.

574.12 Integrated Approach Construction. Following the placement of the superstructure, place geosynthetic reinforcement layers along the back of the superstructure and backfill according to Subsection 574.09. Place geosynthetic reinforcement with seams that are perpendicular to the abutment face.

574.13 Acceptance. See Table 574-2 for sampling, testing, and acceptance requirements.

Material for GRS-IBS will be evaluated under Subsections 106.02 and 106.03.

Construction of GRS-IBS will be evaluated under Subsections 106.02 and 106.04.

Excavation and dewatering will be evaluated under Section 209.

Survey work will be evaluated under Section 152.

Measurement

574.14 Measure the Section 574 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring GRS-IBS by the square foot, measure the front face of wall, including cap units.

Payment

574.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 574 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 574-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Tolerance	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
GRS-IBS backfill	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	–	1 per 1000 tons	Each source	Yes	Before use in work	See Subsection 703.20
GRS-IBS backfill	Measured & tested for conformance (106.04)	Quality	–	AASHTO T 104	–	"	Each source	Yes	"	See Subsection 703.20
		Quality Electrochemical requirements	–	AASHTO T 90	–	"	Each source	Yes	"	See Subsection 703.20
				AASHTO D 5821	–	"		Yes	"	
				ASTM T289	–	"			24 hours	
		Compaction	–	(1)	–	1 for each lift	In place	Yes, if requested	"	–

(1) Do not apply density requirements as measured by AASHTO T 310 to material cannot be tested or compacted to maximum values determined by AASHTO T 99. Compact each lift, full width, until there is no visible evidence of further consolidation.

Section 575. — TEMPORARY BRIDGES

Description

575.01 This work consists of designing, constructing, maintaining, and removing temporary bridges.

Construction Requirements

575.02 Submittals. Submit drawings and calculations according to Subsection 104.06. Submit detailed drawings showing sizes, arrangement, and quality of materials to be used in the construction. Provide design calculations and supporting data in sufficient detail to allow a structural and safety review of the proposed design. Provide catalog or equivalent data indicating a manufactured device's recommended safe load capacity. Include foundation design calculations and other relevant foundation design data.

575.03 General. Construct concrete structures according to Section 552.

Construct prestressed concrete structures according to Section 553.

Construct steel structures according to Section 555.

Construct timber structures according to Section 557.

Construct falsework according to Section 562.

Construct bearing devices according to Section 564.

Construct temporary bridges that meet the minimum strength requirements for the HL-93 live load according to AASHTO, *LRFD Bridge Design Specifications*. Provide bridges that can carry applied loadings from construction vehicles that will cross the temporary bridge. Design the temporary bridge to meet 2-year flood requirements.

Remove temporary bridges when they are no longer needed as directed or approved. Repair damage to the existing structure or roadway approaches due to the Contractor's activities as directed.

Limits of the available work area are shown in the plans.

575.04 Acceptance. Material for temporary bridges will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of temporary bridges will be evaluated under Subsections 106.02 and 106.04.

Bearing devices will be evaluated under Section 564.

Concrete will be evaluated under Section 552.

Prestressing steel will be evaluated under Section 553.

Steel structures will be evaluated under Section 555.

Timber structures will be evaluated under Section 557.

Temporary works will be evaluated under Section 562.

Measurement

575.05 Measure the Section 575 pay items listed in the bid schedule according to Subsection 109.02.

Payment

575.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 575 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for temporary bridges by the lump sum will be paid as follows:

(a) 25 percent of the pay item amount will be paid after the drawings are approved.

(b) An additional 50 percent of the pay item amount will be paid after installation.

(c) The remaining portion of the pay item amount will be paid after the temporary bridge is removed from the project.

Section 576. — RESERVED

Section 577. — FIBER-REINFORCED POLYMER STRUCTURES

Description

577.01 This work consists of designing, fabricating, transporting, and erecting FRP bridges and structural components.

Material

577.02 Conform to the following Subsections:

Bolts and nuts	717.01(d)
Fiber-reinforced polymer	725.19

Construction Requirements

577.03 Qualifications. At least 30 days before starting FRP work, submit the following for approval:

(a) On-site supervisor. A résumé describing experience on at least five projects of similar construction and complexity, each of which have been in service for at least 2 years. Include bridge size, project names, locations, and contact information for project owners; and

(b) FRP components manufacturer. Documentation describing experience on at least five projects of similar size and scope within the past 5 years. Include project names, overlay system and quantities, construction dates, locations, and contact information for project owners.

577.04 Submittals. At least 30 days before starting FRP structure fabrication, submit the following according to Subsection 104.06:

(a) Drawings. Drawings and calculations for the design of FRP bridges and structural components;

(b) Fabrication drawings. Detailed dimensions and sizes of component parts of the structure and details of miscellaneous parts, including FRP components, decking, hardware, railings, and accessories; and

(c) Erection drawings. Proposed method of erection. Show details of falsework, bracing, lifting devices, and bridge member attachments. Include the erection sequence, equipment locations, lifting point locations, and bridge member masses. Include details for anticipated phases and erection conditions, which account for the limitations of the construction site.

577.05 General. Construct falsework according to Section 562.

Construct bearing devices according to Section 564.

577.06 Design. Design FRP structures according to AASHTO, *Guide Specifications for Design of FRP Pedestrian Bridges* and AASHTO, *LRFD Guide Specifications for Design of Pedestrian Bridges*.

577.07 Fabrication and Installation. Protect corners and edges of structural members by using slings or other devices.

Store components on site flat and off the ground, and support with blocks to prevent bending and damage from water and dirt.

Cut and form structural members so all joints have even bearing over the entire contact surface. Do not use shims in making joints. Construct all joints to be closed. Do not perform field cutting, drilling, or other field modifications unless shown in the plans or approved fabrication drawings.

Fabricate structural members from pultruded FRP composite profiles and structural shapes as required. Fabricate pultruded parts according to ASTM D4385 and ASTM D3917.

Use carbide or diamond-tipped tooling to a tolerance of $\frac{1}{16}$ inch when cutting or drilling FRP material. Clean and seal cut edges.

Camber FRP structures to eliminate initial dead load deflection.

Provide structural components with a minimum thickness of ¼ inch.

577.08 Acceptance. Material for FRP structures will be evaluated under Subsections 106.02 and 106.03.

Construction of FRP structures will be evaluated under Subsections 106.02 and 106.04.

Bearing devices will be evaluated under Section 564.

Temporary works will be evaluated under Section 562.

Measurement

577.09 Measure the Section 577 pay items listed in the bid schedule according to Subsection 109.02.

Payment

577.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 577 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for FRP bridges by the lump sum will be paid as follows:

(a) 25 percent of the pay item amount will be paid after the design submittal is approved.

(b) An additional 40 percent of the pay item amount will be paid after the bridge components are delivered to the project site.

(c) The remaining portion of the pay item amount will be paid after the bridge components are installed.

Section 578. — PRECAST CONCRETE ELEMENTS

Description

578.01 This work consists of providing and installing precast concrete elements.

Material

578.02 Conform to the following Subsections:

Anchorage devices	722.01
Non-shrink grout	701.04(b)(1)

Construction Requirements

578.03 Qualifications. Provide a precast concrete manufacturing plant, precast concrete QCM, and grouting personnel with experience in precast concrete. At least 30 days before starting precast concrete work, submit the following for approval:

(a) Precast concrete QCM. Appropriate certifications;

(b) Plant certification. NPCA certification or equivalent PCI certification. Use the same precast plant for the fabrication of all the precast elements; and

(c) Grouting personnel. A résumé for each individual that will be responsible for grouting if grouting operations will be necessary for the fabrication or installation of the precast elements. Describe installation experience on at least two projects of similar complexity within the past 3 years.

578.04 Submittals. At least 30 days before starting precast concrete work, submit the following according to Subsection 104.06:

(a) Precast bridge elements. Prepare fabrication and installation drawings and an installation plan.

(1) Fabrication. Show details necessary for fabrication. Include the following:

(a) Details and location of lifting holes, inserts, hardware, devices, and any additional reinforcing required for lifting;

(b) Size of precast elements with consideration for shipping restrictions, equipment availability, and site constraints;

(c) Method of curing, handling, storing, and transporting the elements;

(d) Leveling inserts in the deck and leveling procedure;

(e) Details of vertical elevation adjusting hardware;

(f) Minimum compressive strength to be attained before handling precast concrete deck and deck overhang elements;

(g) Details of structural steel, shear connectors, bearing assemblies, and elastomeric bearing pads; and

(h) Concrete volume, reinforcing steel weight, and total section weight for each element.

(2) Installation. Describe details necessary for installation. Include the following:

(a) A work area plan depicting utilities overhead and below the work area, drainage inlet structures, protective measures, temporary staging areas, crane locations, and other features of the site necessary for successful installation;

(b) Lifting procedures and supporting calculations, including details of equipment and devices (including slings, hooks, and jacks) used for lifting and assembling the superstructure, substructure, and approach slabs. Include the make, model, lift capacity, and operating radii;

(c) Computations showing the magnitude of stress in the prefabricated components during erection is within allowable limits, and that the erection equipment has adequate capacity for the work to be performed;

(d) Detailed sequence of construction activities, and a CPM schedule according to Section 155 for installation operations. Include setting and cure time for grout, concrete closure pours, splice couplers, and fill of pile pockets;

(e) Methods of providing temporary support of the elements. Include methods of adjusting, bracing, and securing the element after placement;

(f) Procedures for controlling tolerance limits;

(g) Methods of forming closure pours and fill concrete, and sealing lifting holes; and

(h) Methods for curing grout, closure pours, and lifting hole concrete.

(b) Other precast elements.

(1) Fabrication. Submit drawings including tolerances.

(2) Installation. Submit an installation plan. Describe details necessary for installation. Include the following:

(a) A work area plan depicting utilities overhead and below the work area, drainage inlet structures, protective measures, temporary staging areas, crane locations, temporary support elements, and other features of the site necessary for successful assembly; and

(b) Details of equipment and devices (including slings, hooks, and jacks) used for lifting and installation. Include the make, model, lift capacity, and operating radii.

578.05 Tolerances. Fabricate precast bridge elements conforming to the tolerances shown in Tables 578-1, 578-2, and 578-3. Fabricate other precast elements conforming to the tolerances in the approved drawings. Provide measurements and documentation to support that the precast elements were fabricated in conformance with the requirements.

Before shipping precast elements from the fabrication plant, verify that the precast elements will fit-up and align properly by assembling the elements or using other approved methods. Dry fit connections in the fabrication yard before installation of the elements at the project site.

Table 578-1
Precast Bent Cap Fabrication Tolerances

Property	**Tolerance, inch (±)**
Length	¾
Width (overall)	¼
Depth (overall)	¼
Variation from specified plan end squareness or skew	¼ per 1 ft width ½ maximum
Variation from specified elevation end squareness or skew	¼ per 1 ft width ½ maximum
Location of grouted splice coupler measured from a common reference point	½ maximum
Local smoothness of any surface	¼ per 10 ft
Erection elevation tolerance	¼

Table 578-2
Precast Abutment and Wall Elements Fabrication Tolerances

Property	**Tolerance, inch (±)**
Length	¼
Width (overall)	¼
Depth (overall)	¼
Variation from specified plan end squareness or skew	⅛ per 1 ft width ½ maximum
Variation from specified elevation end squareness or skew	¼ per 1 ft width ½ maximum
Location of grouted splice coupler measured from a common reference point	¼
Local smoothness of any surface	¼ per 10 ft
Location of blockouts for piles or voids	1

Table 578-3
Precast Approach Slab Fabrication Tolerances

Property	Tolerance, inch (±)
Length	¼
Width (overall)	¼
Depth (overall)	¼
Variation from specified plan end squareness or skew	½
Location of leveling bolts	1
Sweep over member length	⅜
Location of projecting reinforcing measured from a common reference point	½
Local smoothness of any surface	⅛ per 10 ft
Erection elevation tolerance (surface approach slab only)	⅛
Location of blockouts	½

578.06 Concrete and Reinforcing Steel. Construct concrete for precast bridge elements according to Section 552. Construct concrete for other precast elements according to Section 601. Construct reinforcing steel according to Section 554.

Rough cast the top surface of members against which concrete will be cast. Rake the top surface of members receiving a concrete overlay to a depth of ⅜ inch.

Do not expose the concrete to temperatures below 40 °F for at least 7 days after casting.

578.07 Quality Control.

(a) Precast bridge elements.

(1) Permanently mark each element with date of fabrication, supplier identification, and module identification. Stamp markings in fresh concrete;

(2) Prevent cracking or damage of precast components during handling and storage;

(3) Replace or repair defective or broken precast concrete deck and concrete deck overhang elements as approved. Requests to repair defective or broken elements are subject to the following:

(a) Obtain approval before performing concrete repairs;

(b) Repair concrete to reestablish the precast elements structural integrity, durability, and aesthetics;

(c) Describe the cause of damage and the corrective action taken to eliminate future damage; and

(d) Update the CPM schedule showing the effects of repair work on project completion.

(4) Reject elements if they do not conform to the contract and for the following:

(a) Elements fabricated before the date that drawings are approved;

(b) Full-depth cracking of concrete, and concrete breakage that is not repairable;

(c) Cracks that extend to the nearest reinforcement plane, or fine surface cracks that do not extend to the nearest reinforcement plane but are numerous or extensive;

(d) Camber that does not meet the requirements of the plans or approved drawings;

(e) Honeycombed texture; and

(f) Damage during fabrication, transportation, erection, or construction.

(5) Document and submit the following:

(a) Element identification;

(b) Date and time of fabrication concrete pour;

(c) Concrete cylinder test results;

(d) Concrete mix design and the batch print out;

(e) Form-stripping date;

(f) Location and number of blockouts and lifting inserts;

(g) Temperature, moisture, and duration of curing period; and

(h) Approved repair procedures.

(b) Other precast elements.

(1) Document and submit the following:

(a) Date and time of fabrication concrete pour;

(b) Concrete cylinder test results;

(c) Concrete mix design and the batch print out; and

(d) Temperature, moisture, and duration of curing period.

(2) Inspect elements for damage and cracking on site before installation. Reject elements if they do not conform to the contract and for the following:

(a) Full-depth cracking of concrete;

(b) Concrete breakage that is not repairable; and

(c) Cracks that extend to the nearest reinforcement plane, or fine surface cracks that do not extend to the nearest reinforcement plane but are numerous or extensive.

578.08 Transporting, Handling, and Storing. Before transporting precast elements, provide written certification from the precast concrete manufacturing plant QCM that the precast elements were fabricated and inspected to ensure compliance with the contract requirements. Move elements after the concrete attains a minimum compressive strength of 4500 pounds per square inch for precast bridge elements or a minimum of 80 percent of the required design compressive strength for other precast elements or as shown in the plans.

(a) Transporting. Transport precast elements horizontally with beams on the bottom side for support. Support the precast elements at approximately the same points they will be supported when installed. Use shock-absorbing material at bearing points during transportation. Locate the tie-down straps at the lines of blocking only.

(b) Handling and storing. Store the precast elements in a horizontal and upright position, supported at their designated bearing points. Follow Chapter 5 of the *PCI Design Handbook* for handling and erection bracing requirements.

Lift the precast elements so that the angle between the top surface of the precast element and the lifting line is not less than 60 degrees when measured from the top surface of the precast elements to the lifting line. If two cranes are used, maintain vertical lifting lines. Lift the precast elements at the designated points. Account for stresses in precast elements during handling operations. Choose the locations of the lifting points so that the anticipated flexural tensile stress induced in the top of the structural concrete for the assumed support locations is not greater than the allowable stress.

Select smooth and well compacted storage areas to prevent damage due to differential settlement. Support precast elements during storage to prevent cracking or creep-induced deformation (sagging). Check precast elements at least once per month to ensure that creep-induced deformation does not occur.

(c) Lifting devices. Do not cause damage, cracking, or torsional forces when using lifting devices. Place the lifting devices in locations that are not visible once the precast element is placed, or within recessed pockets that can be patched after installation.

(d) Safety. Ensure the safety and stability of precast elements during all stages of handling, transportation, and construction.

(e) Damage and cracking. Prevent cracking or damage of precast elements during storing, transporting, and erecting. Replace or repair damaged precast elements as approved.

578.09 Acceptance. Anchor devices and material for grout will be evaluated under Subsections 106.02 and 106.03.

Construction of precast elements will be evaluated under Subsections 106.02 and 106.04.

Concrete for precast bridge elements will be evaluated under Section 552.

Concrete for other precast elements will be evaluated under Section 601.

Reinforcing steel will be evaluated under Section 554.

Measurement

578.10 Measure the Section 578 pay items listed in the bid schedule according to Subsection 109.02.

Payment

578.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 578 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

DIVISION 600
INCIDENTAL CONSTRUCTION

Section 601. — MINOR CONCRETE

Description

601.01 This work consists of constructing minor concrete.

Material

601.02 Conform to the following Section and Subsections:

Coarse aggregate for concrete	703.02
Color coating	725.15
Concrete curing material and additives	711
Fine aggregate for concrete	703.01
Hydraulic cement	701.01
Penetrating stain for concrete	719.05
Pozzolans	701.03
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01
Water for cementitious materials	725.01(a)

Construction Requirements

601.03 Composition (Concrete Mix Design). Conform to Table 601-1. Before batching concrete, submit the proposed concrete proportions for approval on Form FHWA 1606, *Minor Portland Cement Concrete Mix Design* or other approved form. As a minimum, submit the following at least 30 days before production:

(a) Concrete. Include the following in each mix design submittal:

(1) Type and sources of material;

(2) Material certification for material;

(3) Saturated surface dry mass of the fine and coarse aggregate per cubic yard of concrete;

(4) Gradation of fine and coarse aggregate;

(5) Mass of mixing water per cubic yard of concrete;

(6) Mass of cement per cubic yard of concrete. Fly ash, ground iron blast-furnace slag, or silica fume (micro-silica) may be substituted for cement according to Table 552-2;

(7) Entrained air content of plastic concrete in percent by volume; and

(8) Maximum slump of plastic concrete in inches.

(b) Integral colored admixture. If integral color admixture is used, prepare five 2- by 2-foot test panels. Construct the test panels using the proposed mix design. Determine coloring agent batch amounts by weight. Use variable quantities of coloring agent as approved. Provide additional mixing time according to the manufacturer's recommendations. Cure the test panels similar to the structure. Transport the panels to an approved location. Provide at least 2 weeks outside exposure. The CO will select the acceptable test panel. Use the same rate of integral color admixture for the item of work.

Table 601-1
Composition of Minor Concrete

Property	Specification
Water to cementitious material ratio	0.49 maximum
Air content	4% minimum
Size of coarse aggregate	AASHTO M 43 with 100% passing the 1½-in sieve
28-day compressive strength	4000 psi minimum

601.04 General. Excavate and backfill according to Section 209.

Design and construct forms that are free of bulge and warp and allow for removal without injuring the concrete. Design the forms for a lateral pressure equal to that exerted by a fluid weighing 150 pounds per cubic foot.

Use wood, metal, or other suitable material for forms. Keep forms clean and coat with a form release agent or form oil before placing concrete.

Place and fasten reinforcing steel according to Subsection 554.08.

601.05 Placing Concrete. Conform to Subsection 552.07. Moisten the forms and foundation immediately before placing concrete. Discharge concrete within the time limit shown in Table 552-5.

Place concrete to avoid segregation of material. Consolidate with vibrators according to Subsection 552.08(c). Do not use aluminum pipe for transporting or placing concrete. Do not exceed 30 minutes between deliveries of batches for a single pour on a structure.

Do not apply water to plastic concrete surfaces during finishing operations.

601.06 Curing and Finishing of Concrete. Cure concrete at least 7 days. Cure according to Subsection 552.13. Finish exposed concrete surfaces according to Subsection 552.14 as applicable.

Do not place backfill against concrete until 80 percent of the design strength is attained. Construction loads less than 4000 pounds may be placed on the concrete when 80 percent of the design strength is attained.

Remove and replace cracking, spalling, or scaling concrete to the nearest joint.

601.07 Acceptance. See Table 601-2 for sampling, testing, and acceptance requirements.

Material for minor concrete including concrete, reinforcing steel, and structural steel for minor structures will be evaluated under Subsections 106.02 and 106.03.

The concrete mixture's density, air content, slump, temperature, and compressive strength will be evaluated under Subsections 106.02 and 106.04.

Construction of minor concrete will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

601.08 Measure the Section 601 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When concrete is measured by the cubic yard, measure in the structure.

Payment

601.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 601 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 601-2
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Aggregate (fine & coarse)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsections 703.01 & 703.02	1 per material type	Source of material	Yes	Before producing	–
Mix Design									
Concrete composition (601.03)	Measured & tested for conformance (106.04 & 105)	All	–	Subsection 601.03	1 per mix design	Source of material	If requested	Before producing	–
Production									
Concrete(1)	Measured & tested for conformance (106.04)	Density	–	AASHTO T 121	1 per load after 0.25 yd^3 minimum is discharged(4)	Point of discharge	No	Upon completing tests	–
		Air content	–	AASHTO T 152 or AASHTO T 196	"	"	"	"	–
		Slump	–	AASHTO T 119	"	"	"	"	–
		Temperature	–	ASTM C1064	"	"	"	"	–
		Compressive Strength(2),(3) (28-day)	–	AASHTO R 100 & T 22	1 set per 30 yd^3 but not less than 1 per day	"	Yes	28 days	Deliver verification cylinders to the CO or designated laboratory for scheduled testing

Table 601-2 (continued)
Sampling, Testing, and Acceptance Requirements

(1) Sample according to AASHTO R 60, except composite samples are not required.
(2) Cast at least four compressive strength test cylinders for 6- by 12-inch specimens or six compressive strength cylinders for 4- by 8-inch and carefully transport the cylinders to the job site curing facility.
(3) A single compressive strength test result is the average result from two 6- by 12-inch or three 4- by 8-inch cylinders cast from the same load.
(4) If three successive samples are tested and compliance to the specifications is indicated, screening tests may be reduced to an approved frequency. Resume Table 601-2 testing frequency if a test shows a failing temperature, air content, slump, or when directed.

Section 602. — CULVERTS AND DRAINS

Description

602.01 This work consists of providing and installing culverts, drains, and precast concrete box culverts.

Material

602.02 Conform to the following Sections and Subsections:

Asphalt mastic	702.04
Concrete pipe	706
General mortar	701.05(a)
Metal pipe	707
Plastic pipe	708
Precast concrete units and accessories	725.09
Sealants, fillers, and seals	712.01

Construction Requirements

602.03 General. Provide culvert pipe with a wall thickness at least that shown in the plans or determined from the fill-height tables shown in the plans. Use the same material and coating on contiguous pipe sections and special sections (such as elbows and branch connections). For culvert extensions, provide the same material as the existing culvert.

Plans show the size, length, and approximate location of culverts. Determine final location, skew, length, elevations, and grade according to Section 152. Do not order culvert material until the CO has accepted the final structure size, length, and alignment.

Construct cast-in-place concrete box culverts according to Section 552. For precast concrete box culverts, submit design drawings and details with supporting calculations according to Subsection 104.06. Design and construct precast concrete box culverts according to Section 578.

Excavate and backfill according to Section 209.

Place elongated pipes with the minor axis within 5 degrees of vertical.

Construct a piping plug unless the culvert inlet is protected with a full-height headwall, slope paving, or an embankment consisting of AASHTO M 145 classification A-6 or A-7 material. Construct the piping plug with AASHTO M 145 classification A-6, A-7, or other approved material with a permeability no more than 0.004 inch per second.

602.04 Laying Concrete Pipe and Precast Concrete Box Culverts. Start at the lower end and lay the bell or groove end upgrade. Fully join sections with leak-resistant seals using one of the following methods:

(a) Mortared joints. Clean the lower portion of the receiving end of the pipe. Plaster the inside with sufficient joint mortar to bring the inner surfaces of the abutting pipe sections flush and even. Fit the sections as close as the construction of the culvert allows. Fill and seal joints with mortar inside and out. Use the mortar within 30 minutes after mixing. Clean excess mortar from the inside of the joint.

Cure mortar outside of joints by covering with polyethylene sheeting or spraying with a curing compound. Backfill while mortar is plastic or, if mortar sets before backfilling, wait at least 24 hours before backfilling.

(b) Gasket joints. Conform to ASTM C990 or ASTM C443 and the following:

(1) Protect the joint ends from mud, silt, gravel, or other foreign material. Lay the pipe sections with gaskets attached. Remove, clean, relubricate, and reseat gaskets disturbed or contaminated.

(2) Align the pipe sections. Force the joints home using the pipe manufacturer's recommended procedure. Do not drive or ram by hand or machinery. Block the last section of each day's run to prevent creep.

Install supplemental concrete pipe ties on the last downstream pipe-to-pipe joint and at the downstream pipe-to-end section joint, if present.

602.05 Laying Metal Pipe. Position the pipe with a longitudinal joint so the joint is opposite the invert. Fully join pipe sections with leak-resistant seals according to AASHTO M 36 or AASHTO M 196. Use one of the following:

(a) Gasket, bell, and spigot joints. Use on slopes of 10 percent or less and lay the pipe with the bell end up slope.

(b) Coupling bands with gaskets. Limit the use of coupling bands with projections (dimples) to attaching prefabricated flared end sections.

If aluminum alloys come in contact with other metals, coat the contacting surfaces with asphalt mastic or a preapproved impregnated caulking compound.

602.06 Laying Plastic Pipe. Lay plastic pipe according to the pipe manufacturer's recommendations.

Fully join pipe sections with leak-resistant seals using gasket, bell, and spigot joints according to ASTM D3212.

602.07 Laying Slotted Drain Pipe. Fully join pipe sections with leak-resistant seals using coupling bands and gaskets. Cover the slots with roofing paper or other approved covering during backfilling and paving to keep material out of the pipe. Backfill with a flowable backfill.

602.08 Acceptance. Material for culverts and drains will be evaluated under Subsections 106.02 and 106.03.

Installation of culverts and drains will be evaluated under Subsections 106.02 and 106.04.

Cast-in-place concrete box culverts will be evaluated under Section 552.

Excavation and backfill will be evaluated under Section 209.

Precast concrete box culverts will be evaluated under Section 578.

Survey work will be evaluated under Section 152.

Measurement

602.09 Measure the Section 602 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring pipe and box culverts by the linear foot, measure along the invert.

Measure end sections, elbows, and branch connections by the each. If there is no pay item for elbows or branch connections, measure them as additional pipe length along the invert.

Payment

602.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 602 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 603. — STRUCTURAL PLATE STRUCTURES

Description

603.01 This work consists of designing and constructing structural plate pipes, arches, pipe arches, boxes, and underpasses.

Material

603.02 Conform to the following Subsections:

Aluminum-alloy structural plate structures	707.06
Asphalt-coated structural plate structures	707.07
Steel structural plate structures	707.05

Construction Requirements

603.03 General. Excavate and backfill according to Section 209.

603.04 Erecting. Provide steel, aluminum alloy, asphalt coated steel, or asphalt-coated aluminum alloy structural plate structures.

Submit a copy of the manufacturer's assembly instructions before assembly. Show the position of each plate and assembly order.

Assemble the structural plates according to the manufacturer's recommendations. Prevent damage to the structural plate and its coating. Clear sand, gravel, and other foreign material from the corrugations within lapped sections of the plates. Ensure plates have a proper fit-up.

Where aluminum alloys come in contact with other types of metal, coat the contacting surfaces according to Subsection 602.05.

Torque bolts according to the manufacturer's recommendations.

For structures having a span greater than or equal to 20 feet:

(a) Tighten the longitudinal seams when the plates are assembled unless the plates are held in shape by cables, struts, or backfill. Properly align plates circumferentially to avoid permanent distortion from the design shape. Before backfilling, do not exceed 2 percent variation from the design shape;

(b) Do not distort the shape of the structure by operating equipment over or near it;

(c) Provide survey control on the structure to check structure movement;

(d) Check and control the deflection movements of the structure during the backfilling operation. Do not exceed the manufacturer's recommended limits; and

(e) Provide a manufacturer's representative to monitor the erecting and backfilling of the structure.

603.05 Acceptance. Material for structural plate structures will be evaluated under Subsections 106.02 and 106.03.

Installation of structural plate structures will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

603.06 Measure the Section 603 pay items listed in the bid schedule according to Subsection 109.02.

Payment

603.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 603 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 604. — MANHOLES, INLETS, AND CATCH BASINS

Description

604.01 This work consists of constructing, adjusting, shifting, or modifying manholes, inlets, and catch basins.

Material

604.02 Conform to the following Subsections:

Concrete building brick	725.06
Concrete masonry units	725.07
Corrugated metal units	707.09
Frames, grates, covers, and ladder rungs	725.10
Gaskets for concrete pipe	706.08
Gaskets for metal pipe	707.17
General mortar	701.05(a)
Neat hydraulic cement grout	701.04(a)(2)
Precast concrete units and accessories	725.09
Reinforcing steel	709.01
Sealants, fillers, and seals	712.01

Construction Requirements

604.03 General. Excavate and backfill according to Section 209.

Separate catch basins and inlets from adjacent concrete structures with at least ½-inch thick preformed expansion joint.

Construct minor concrete according to Section 601.

604.04 Concrete Construction. Concrete units may be cast-in-place or precast.

Finish surfaces according to Subsection 552.14 as applicable.

Finish the flow line in manholes, inlets, and catch basins to match the pipe flow line.

Assemble precast concrete manhole sections with flexible gaskets or fillers in the tongue and groove joints. Handle the precast units carefully after the gasket has been attached to avoid damaging the gasket or contaminating the joint. Ensure the proper alignment before the joints are forced home. Seat gaskets uniformly. If mastic is used, apply mastic joint filler according to the manufacturer’s recommendations.

Set metal frames in a full mortar bed.

Space ladder rungs uniformly on 12-inch centers and align vertically. Grout ladder rungs into precast concrete walls.

604.05 Concrete Masonry Unit Construction. Construct masonry block plumb. Stagger vertical joints and set block with the cells vertical. Moisten blocks before using in work. Butter bearing members and vertical joints full of mortar. Bond block using mortar on sides. Construct joints straight, level, plumb, flush, and ¼ to ½ inch thick. Backfill the structure after the masonry block joints have moist cured for 7 days.

604.06 Metal Construction. Fabricate metal drop inlets from the same material and thickness as adjoining metal pipes. Connect metal inlets to adjoining metal pipes according to Subsection 602.05.

604.07 Grade Adjustment of Structures. Adjust metal frames and grates to grade before placing the surface course.

Remove and clean the frames, covers, and grates. Trim the walls down to solid material. Reconstruct the walls with the same material as existing and reset the cleaned frames at the required elevation.

If the existing casting and supporting walls are in good condition, an approved device may be used to adjust the manhole casting cover to the correct grade.

Clean each structure of foreign material.

604.08 Shifting and Modifying Structures. Shift structures using methods to ensure structural integrity. Reshape the channel flow line in manholes, inlets, and catch basins as necessary to match the pipe flow line.

Set and reassemble structures according to the applicable requirements of Subsections 604.04 through 604.07. Provide and install gaskets, seals, and other accessories according to the applicable requirements of Subsections 604.04 through 604.06. Grout or use a preformed joint seal to make joints and openings leak resistant. Finish mortar joints with a bead on the outside and a smooth finish on the inside.

When modifying a concrete structure, do not loosen the reinforcement in the wall. Cut the reinforcing steel flush with the opening wall face. Grout joints and openings cut in the wall.

Seal openings no longer required in the structure.

Abandon structures according to Subsection 203.06.

604.09 Acceptance. Material for metal, concrete brick, concrete masonry, precast concrete units, and cast-in-place concrete (except concrete) units will be evaluated under Subsections 106.02 and 106.03.

Construction of metal, concrete brick, and concrete masonry units will be evaluated under Subsections 106.02 and 106.04.

Installation of precast concrete units will be evaluated under Subsections 106.02 and 106.04.

Shifting, modifying, and adjusting units will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Measurement

604.10 Measure the Section 604 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring manholes by the linear foot, measure from finished grade to the flow line surface of the manhole.

Do not measure metal frames and grates when included as part of the original inlet, manhole, or catch basin construction.

Payment

604.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 604 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 605. — UNDERDRAINS, SHEET DRAINS, AND PAVEMENT EDGE DRAINS

Description

605.01 This work consists of providing and installing underdrains, sheet drains, and pavement edge drains.

Material

605.02 Conform to the following Section and Subsections:

Aluminum-alloy corrugated pipe	707.03
Asphalt-coated pipe	707.04
Geocomposite drain	714.02
Geotextile	714.01
Metallic-coated corrugated steel pipe	707.02
Perforated concrete pipe	706.03
Plastic pipe	708
Sand	703.14
Soil and soil-aggregate materials	704.01
Underdrain backfill	703.03

Construction Requirements

605.03 General. Elevate and protect sheets, panels, or rolls of geotextile filter and geocomposite with a waterproof and ultraviolet resistant cover if stored outdoors. Limit geotextile filter and geocomposite exposure to less than 10 days if using for a permanent installation.

Use the same material and coating on contiguous drain sections, extensions, elbows, branch connections, and other special sections.

Drain material, size, and approximate location are shown in the plans. Determine the final location and length in the field.

Do not install drain material until the CO has accepted the final location and length.

Excavate and backfill according to Section 209.

If geotextile filter or geocomposite is used, smooth the trench surfaces by removing projections that may damage the geotextile filter or geocomposite. Replace geotextile filter or geocomposite damaged during installation.

Do not allow soil or other foreign material to enter the drain systems. Plug the highest end of installations.

Provide nonperforated pipe for outlet pipe. Install outlet pipe according to Section 602. Immediately place and secure a screen made of 0.055-inch diameter galvanized wire having approximately ½- by ½-inch mesh openings over the outlet ends of exposed pipes and weep holes.

605.04 Placing Underdrain. Join pipe sections securely with coupling fittings or bands. Join PVC and acrylonitrile-butadiene-styrene (ABS) pipe using either a flexible elastomeric seal or solvent cement. Join polyethylene pipe with snap-on, screw-on, or wrap around coupling bands according to the manufacturer's recommendations.

Backfill and compact trenches within the limits of the roadbed according to Section 209, except use underdrain backfill. Trenches for geocomposite underdrains within the limits of the roadbed may also be backfilled with sand and compacted.

If underdrain is placed in ditch lines, prevent infiltration of surface water by placing material conforming to AASHTO M 145, classification A-4, A-5, A-6, or A-7 in the top 12 inches of the trench.

(a) Standard underdrain. Place the long dimension of the geotextile filter parallel to the centerline of the trench. Position the geotextile filter, without stretching, in contact with the trench surface. Overlap the joints at least 24 inches with the upstream geotextile filter placed over the downstream geotextile filter.

Place collector pipe with the perforations facing downward.

Place underdrain backfill to a height of 12 inches above the top of the collector pipe and compact. Do not displace the collector pipe. Place and compact the remainder of the underdrain backfill according to Section 209.

Fold the geotextile filter over the top of the underdrain backfill with a minimum overlap of 12 inches.

(b) Geocomposite underdrain. Extend the geotextile filter from the bottom of the drainage core around the collector pipe.

Construct splices and install outlet fittings according to the manufacturer's recommendations. Prevent infiltration of soil into the geocomposite core.

Place the assembled geocomposite in the trench with the face of the geocomposite against the inflow side of the trench. If the trench wall is irregular, smooth the trench wall or place a lift of underdrain backfill between the geocomposite and the trench wall. Temporarily support the drain against the trench wall while backfilling.

If the trench is less than 18 inches wide, backfill the trench using sand. Backfilling and compacting in lifts are not required. Compact the sand by vibrating or tamping with a mechanical tamper.

If the trench is at least 18 inches wide, place underdrain backfill or sand to a height of 12 inches above the top of the collector pipe and compact. Place and compact the remainder of the underdrain backfill or sand according to Section 209.

605.05 Placing Geocomposite Sheet Drain System. Do not place sheet drains against a mortar course less than 4 days old.

If a geocomposite is used in conjunction with a waterproof membrane, install drainage panels compatible with the membrane according to the membrane manufacturer's recommendations. Assemble and place the geocomposite drain against the surface to be backfilled according to the manufacturer's recommendations.

Splice geocomposite drains so the flow across the edges is continuous. Overlap the geotextile filter at least 3 inches in the direction of water flow. For vertical splices, overlap the geotextile filter in the direction backfill proceeds.

Connect the drainage core to the collector pipe or weep holes so the flow is continuous through the system. Extend the geotextile filter from the bottom of the drainage core around the collector pipe.

Backfill with structural backfill and compact according to Subsections 209.09 and 209.10.

605.06 Placing Geocomposite Pavement Edge Drain. Assemble the geocomposite pavement edge drain and outlet material according to the manufacturer's recommendations and place it in the trench. If the trench wall is irregular, smooth the trench wall or place a lift of sand between the geocomposite and the trench wall. Temporarily support the drain against the trench wall while backfilling.

If the trench is less than 18 inches wide, backfill the trench using sand. Backfilling and compacting in lifts are not required. Compact the sand by vibrating or tamping with a mechanical tamper.

If the trench is at least 18 inches wide, place and compact underdrain backfill or sand according to Section 209.

605.07 Acceptance. See Table 605-1 for sampling, testing, and acceptance requirements.

Material (except underdrain backfill) for underdrains, sheet drains, and edge drains will be evaluated under Subsections 106.02 and 106.03.

Underdrain backfill will be evaluated under Subsections 106.02 and 106.04.

Geocomposites will be evaluated under Subsections 106.02 and 106.03. Submit a production certification with each shipment of geocomposite that includes the name of the manufacturer, product name, style number, chemical composition of the core and encapsulating geotextile filaments or yarns, and other appropriate information to fully describe the geocomposite drain.

Installation of underdrains, sheet drains, and edge drains will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Geotextile filter will be evaluated under Section 207.

Outlet pipe will be evaluated under Section 602.

Measurement

605.08 Measure the Section 605 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring for a system, do not measure geotextile filters, geocomposites, collector pipes, backfill, and outlet pipes that are part of the system.

When measuring underdrain backfill and sand by the cubic yard, measure in place.

Payment

605.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 605 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 605-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Underdrain backfill (703.03)	Measured & tested for conformance (106.04 & 105)	Quality	–	Subsection 703.03	1 per aggregate type & source of material	Source of material	Yes	Before using in work	Not required if using Government -furnished source
Production									
Underdrain backfill (703.03)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes	4 hours	–

Section 606. — CORRUGATED METAL SPILLWAYS

Description

606.01 This work consists of providing and installing corrugated metal spillways.

Material

606.02 Conform to the following Section:

Metal pipe	707

Construction Requirements

606.03 Placing Corrugated Metal Spillways. Spillway, inlet, outlet, and connector dimensions and proportions may vary to allow the use of the manufacturer's standard jigs and templates.

Install spillway inlet assemblies as shown in the plans and consolidate the earth backfill by tamping.

Excavate and backfill according to Section 209.

Lay spillway outlet pipe according to Section 602. Anchor the spillway as shown in the plans.

606.04 Acceptance. Pipes, anchor assemblies, hardware, and other material provided to fabricate metal spillways will be evaluated under Subsections 106.02 and 106.03.

Construction of corrugated metal spillways will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Spillway inlet pipe will be evaluated under Section 602.

Measurement

606.05 Measure the Section 606 pay items listed in the bid schedule according to Subsection 109.02.

Payment

606.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 606 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 607. — CLEANING, RELAYING, AND REPAIRING EXISTING DRAINAGE STRUCTURES

Description

607.01 This work consists of cleaning, relaying, and repairing existing drainage and appurtenant structures.

Construction Requirements

607.02 Cleaning Drainage Structures in Place. Remove foreign material within the structure and accessories by approved methods.

Remove debris, vegetation, and earthen material that impedes inlet and outlet channel flow to the structure. Obtain approval from the CO before removing trees.

Dispose of removed material according to Subsection 203.07.

Regrade inlet and outlet channels at structures to provide positive drainage. Reshape inlet to direct flow into the structure entrance.

607.03 Relaying or Stockpiling Salvaged Pipe. Relay removed and cleaned pipe according to Section 602.

Salvage and stockpile pipe according to Subsection 203.04.

Replace damaged pipe and install according to Section 602. Dispose of damaged pipe according to Subsection 203.07.

607.04 Repairing Drainage Structures. Remove debris from structures designated to be repaired. Repair leaks and structural damage and replace missing or broken metalwork according to Sections 602 and 603.

607.05 Acceptance. Cleaning and repairing existing drainage structures will be evaluated under Subsection 106.02.

Relaying pipe will be evaluated under Section 602.

Repairing drainage structures will be evaluated under Sections 602 and 603.

Measurement

607.06 Measure the Section 607 pay items listed in the bid schedule according to Subsection 109.02.

Payment

607.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 607 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 608. — PAVED WATERWAYS

Description

608.01 This work consists of constructing paved waterways not contiguous to the traveled way.

Paved waterways are designated as follows:

Type 1 – Grouted rubble
Type 2 – Mortared rubble
Type 3 – Concrete and rubble
Type 4 – Concrete
Type 5 – Asphalt

Material

608.02 Conform to the following Subsections:

Soil and soil-aggregate materials	704.01
General mortar	701.05(a)
Neat hydraulic cement grout	701.04(a)(2)
Reinforcing steel	709.01
Rock for masonry structures (rubble)	705.03
Sand	703.14

Construction Requirements

608.03 General. Excavate and backfill according to Section 209. Place and compact the bedding material with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

Construct minor concrete according to Section 601.

Construct rubble masonry according to Section 620.

608.04 Grouted Rubble Paved Waterway (Type 1). Clean and wet the rubble to near saturation. Set rubble in a broken pattern with no continuous joint across the waterway or parallel to the flow line. Place rubble into the mortar bed with the flat faces up and the longest dimension at right angles to the flow line. Make the joints 1 to 2 inches wide.

Ram each piece of rubble until it is firm and true to the surface in grade, alignment, and cross-section. Remove and relay rubble having an irregular or uneven surface.

Fill the joints with sand to within 4 inches of the surface. Pour and broom grout into the joints until the grout is ½ inch below the surface of the rubble. Clean excess grout from the rubble surface.

608.05 Mortared Rubble Paved Waterway (Type 2). Clean and wet the rubble to near saturation. Set rubble in a broken pattern with no continuous joint across the waterway or parallel to the flow line. Place rubble into the mortar bed with the flat face up and the longest dimension parallel to the flow line. Make joints 1 to 2 inches wide.

Ram each piece of rubble until it is firm and true to the surface in grade, alignment, and cross-section. Remove and relay rubble having an irregular or uneven surface.

Fill joints to within ½ inch below the surface of the rubble. Clean excess mortar from the rubble surface.

608.06 Concrete and Rubble Paved Waterway (Type 3). Perform concrete work according to Section 601. Secure the reinforcing steel within the middle third of the depth of the concrete foundation if shown in the plans.

Clean and wet the rubble to near saturation. Embed rubble into the concrete foundation in a broken pattern with no continuous joint across the waterway or parallel to the flow line.

Make the joints 1 to 2 inches wide. Fill the joints with mortar to 1 inch below the surface of the rubble. Clean excess mortar from the rubble surface.

608.07 Concrete Paved Waterway (Type 4). Perform the work according to Section 601.

608.08 Asphalt Paved Waterway (Type 5). Perform the work according to Section 403, Type II. Clean and seal the cracks according to Section 414 before overlaying existing asphalt paved waterway.

608.09 Acceptance. See Table 608-1 for sampling, testing, and acceptance requirements.

Bedding material and sand will be evaluated under Subsections 106.02 and 106.04.

Material for grout and mortar will be evaluated under Subsections 106.02 and 106.03.

Mortar placement will be evaluated under Subsections 106.02 and 106.04.

Construction of paved waterways will be evaluated under Subsections 106.02 and 106.04.

Asphalt concrete will be evaluated under Section 403.

Cleaning and sealing cracks will be evaluated under Section 414.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Rubble masonry will be evaluated under Section 620.

Measurement

608.10 Measure the Section 608 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring paved waterways by the square yard, measure the width horizontally to include the total width. Measure the length parallel to the flow line.

When measuring paved waterways by the linear foot, measure along the flow line of the paved waterway.

Payment

608.11 The accepted quantities will be paid at the contract price per unit of measurement for the Section 608 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 608-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Bedding material (704.01)	Measured & tested for conformance (106.04 & 105)	Gradation	–	Subsection 704.01	1 per soil type & source of material	Source of material	Yes	Before using in work	Not required if using Government-furnished source
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Sand (703.14)	"	Gradation & deleterious material	–	AASHTO M 6	"	"	"	"	"
Production									
Bedding material (704.01)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes	4 hours	"
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Sand (703.14)	"	Gradation	–	AASHTO T 27 & T 11	"	"	"	"	"

Section 609. — CURB AND GUTTER

Description

609.01 This work consists of constructing or resetting curb, gutter, combination curb and gutter, and wheelstops.

Material

609.02 Conform to the following Subsections:

General mortar	701.05(a)
Reinforcing steel	709.01
Rock for masonry structures (stone curbing)	705.03
Sealants, fillers, and seals	712.01
Soil and soil-aggregate materials	704.01

Construction Requirements

609.03 General. Excavate and backfill according to Section 209. Place and compact the bedding material. Compact the bedding material with at least three passes of a lightweight mechanical tamper, roller, or vibratory system. Construct minor concrete according to Section 601.

609.04 Stone Curb. Do not use stone with visible drill marks on the exposed faces.

Conform to the dimensions of stone curb specified and the following:

(a) Type 1. Saw or point the top surface of vertical stone curb to an approximate true plane with no depression or projection on that surface of over ¼ inch. Pitch the front and back arris lines straight and true. Limit projections or depressions on the back surface to not exceed a batter of 1 inch horizontal to 3 inches vertical.

Saw, point, or smooth quarry split the front exposed face of the vertical stone curb and form to an approximately true plane. Limit projections or depressions on the remaining face distance to 1 inch or less from the plane of the exposed face.

Square the ends of vertical stone curb so when the sections are placed end to end, no space more than ½ inch shows for the full width of the top surface and for the entire exposed front face. The remainder of the end may break back no more than 4 inches from the plane of the joint. Cut the joints of circular or curved stone curb on radial lines.

Make stone curb segments at least 48 inches long, but the length may vary where a depressed or modified section of curb is required for driveways, crossings, or closures.

(b) Type 2 (sloped stone curb). Conform to the requirements of Type 1 stone curb, except as follows:

The maximum allowable projection or depression on a horizontal top surface is limited to ½ inch. On other exposed faces, the maximum allowable projection or depression is limited to 1 inch.

For unexposed surfaces, the maximum allowable projection or depression from a true plane on a 24-inch length is 3 inches.

The maximum allowable space showing on exposed faces between adjacent segments of slope stone curb is ¾ inch. Make slope stone curb segments at least 24 inches long.

Clean the curb material thoroughly and wet it immediately before setting. Set the curb in bedding material so the face and top lines are to line and grade. Make the joints ½ to 1 inch wide and fill the joints with mortar.

Complete the first 25 feet of curb to demonstrate the ability to build a curb conforming to these requirements. Do not continue construction until the 25-foot test section is approved.

Where a concrete pavement is constructed contiguous to the curb, construct the joints in the curb directly in line with the pavement expansion joints.

Make the curb joint ¾ inch wide and fill it with expansion joint filler of the same nominal thickness as the pavement joint. Fill voids between the joint filler and the curb with mortar.

609.05 Concrete Curb or Curb and Gutter. The curb or curb and gutter may be cast-in-place or slip-formed.

(a) Cast-in-place. Use forms that extend for the full depth of the concrete. Use curved forms for curb with a radius of 300 feet or less.

(1) Contraction joints. Construct at intervals no more than 10 feet. Use metal divider plates or form joints with a jointing tool or saw joints to a depth of ¼ to ⅓ the thickness of the concrete and about ⅛ inch wide. If the curb is constructed adjacent to or on concrete pavement, match the contraction joints in the pavement.

(2) Expansion joints. Form expansion joints at intervals of 60 feet using a ¾-inch thick preformed expansion joint filler. Where the curb is constructed adjacent to or on rigid pavement, match the expansion joints in the pavement.

Finish the concrete smooth and even with a wood float. Broom finish parallel to the curb line according to Subsection 552.12(c)(2). If an exposed aggregate finish is required, finish according to Subsection 552.12(c)(4). Leave forms in place for 24 hours or until the concrete has set sufficiently so the forms can be removed without harming the curb.

(b) Slip-formed. Use a self-propelled automatic curb machine or a paver with curb attachments. Use a machine that is heavy enough to obtain consolidation without the machine riding above the foundation.

Adjust the concrete aggregate gradation, if necessary, to produce a curb or curb and gutter that has well defined web marks of water on the surface. Remove and replace sections with craters larger than 3⁄16 -inch or other sections determined to be damaged or defective. Repairing surface craters and other defective sections by plastering is not allowed.

After the concrete has hardened sufficiently to allow sawing without damage, saw contraction joints according to Subsection 609.05(a)(1). Construct expansion joints according to Subsection 609.05(a)(2).

609.06 Asphalt Concrete Curb or Gutter. Where curb is constructed on a pavement, apply an asphalt tack coat according to Section 412 on the area under the curb.

Construct asphalt concrete curb according to Section 403, Type II. Use a self-propelled automatic curb machine or a paver with curb attachments that is heavy enough to compact a curb without riding above the foundation. Make the curb uniform in texture, shape, and density. Curb may be constructed by other means only in short sections or sections with short radii.

Construct gutters according to Section 403, Type II.

609.07 Bonding Concrete Curb to Surface. If bonding curb to asphalt pavement, thoroughly clean the pavement surface before placing the curb. Remove dust and loose material on the asphalt pavement.

Bond the extruded curb to the asphalt pavement using an approved adhesive or a two-component epoxy designed to bond curb to the pavement.

609.08 Resetting Stone Curb. Salvage the stone curb according to Subsection 203.04. Cut or fit the curb as necessary for installation. Replace lost, damaged, or destroyed curb. Reset the curb according to Subsection 609.04.

609.09 Wheelstops. Pin the wheelstops in place with two 36-inch sections of No. 6 reinforcing steel or ¾-inch steel rods. Reset wheelstops in the same manner.

609.10 Acceptance. See Table 609-1 for sampling, testing, and acceptance requirements.

Bedding material will be evaluated under Subsections 106.02 and 106.04.

Material for mortar will be evaluated under Subsections 106.02 and 106.03.

Mortar will be evaluated under Subsections 106.02 and 106.04.

Precast units (wheelstops) will be evaluated under Subsections 106.02 and 106.03.

Stone for stone curbing will be evaluated under Subsections 106.02 and 106.04.

Construction of curb, curb and gutter, gutter, and wheelstops will be evaluated under Subsections 106.02 and 106.04.

Asphalt concrete will be evaluated under Section 403.

Asphalt tack coat will be evaluated under Section 412.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Measurement

609.11 Measure the Section 609 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring curb or curb and gutter by the linear foot, do not deduct the length for drainage structures installed in the curb section or for driveway and accessibility ramp openings where the gutter is continuous across the opening.

Payment

609.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 609 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 609-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Bedding material (704.01)	Measured & tested for conformance (106.04 & 105)	Gradation	–	Subsection 704.01	1 per soil type & source of material	Source of material	Yes	Before using in work	Not required if using Government-furnished source
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Production									
Bedding material (704.01)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes	4 hours	–
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–

Section 610. — SIDEWALKS, PADS, AND MEDIANS

Description

610.01 This work consists of constructing sidewalks, pads, and medians.

Material

610.02 Conform to the following Subsections:

Concrete grid paving units	725.09(c)
Elastomeric joint sealant	712.01(a)(4)
Paving brick	725.08
Preformed expansion joint filler for concrete	712.01(b)(1)
Soil and soil-aggregate materials	704.01
Solid concrete interlocking paving units	725.09(f)

Construction Requirements

610.03 General. Excavate and backfill according to Section 209. Place bedding material in lifts no more than 4 inches in compacted thickness. Compact each lift with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

610.04 Concrete Sidewalks, Pads, and Medians. Construct minor concrete according to Section 601. Use forms extending the full depth of concrete.

(a) Joints. Construct joints perpendicular to the outside slab edges and other joints. Match the joints in adjacent curb or pavement. Tool and remove free mortar and concrete from joints.

(1) Expansion joints. Construct at intervals no more than 20 feet. Use ¾-inch thick preformed expansion joint filler for the full depth of the joints. If joints are sealed, use elastomeric joint sealant.

(2) Contraction joints. Construct at intervals no more than 10 feet. Form joints with a jointing tool or saw joints to a depth of ¼ to ⅓ the thickness of the concrete and about ⅛ inch wide.

(3) Construction joints. Form construction joints around appurtenances (such as manholes, utility poles, buildings, and bridges). Use ½-inch thick preformed expansion joint filler for the full depth of the joints. If joints are sealed, use elastomeric joint sealant.

(b) Finishes. Provide a sidewalk finish unless otherwise specified.

(1) Sidewalk finish. Conform to Subsection 552.12(c)(2).

(2) Exposed aggregate finish. Conform to Subsection 552.12(c)(4).

Use a ¼-inch radius edging tool on slab edges and joints. Cure the concrete according to Subsection 552.13. Protect the work for 72 hours.

610.05 Asphalt Concrete Sidewalks, Pads, and Medians. Perform the work according to Section 403, Type II.

610.06 Concrete Paving Unit and Paving Brick Sidewalks, Pads, and Medians. Lay units or bricks in successive courses on a prepared surface. Lay each course to grade. Relay courses that deviate from a straight line by more than 2 inches in 30 feet.

Sweep and inspect the surface before the bed sets. Remove and replace imperfect units or bricks.

Chock the joints flush with a dry mixture of 4 parts sand and 1 part cement by mass and carefully water the surface to saturate the joint filler.

610.07 Acceptance. See Table 610-1 for sampling, testing, and acceptance requirements.

Paving brick, concrete paving units, and joint filler and sealant will be evaluated under Subsections 106.02 and 106.03.

Construction of sidewalks, pads, and medians will be evaluated under Subsections 106.02 and 106.04.

Asphalt concrete will be evaluated under Section 403.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Measurement

610.08 Measure the Section 610 pay items listed in the bid schedule according to Subsection 109.02.

Payment

610.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 610 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 610-1
Sampling, Testing, and Acceptance Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Source									
Bedding material (704.01)	Measured & tested for conformance (106.04 & 105)	Gradation	–	Subsection 704.01	1 per soil type & source of material	Source of material	Yes	Before using in work	Not required if using Government -furnished source
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	"
Production									
Bedding material (704.01)	Measured & tested for conformance (106.04)	Gradation	–	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes	4 hours	–
		Liquid limit	–	AASHTO R 58 & T 89, Method A	"	"	"	"	–

Section 611. — WATER SYSTEMS

Description

611.01 This work consists of constructing or reconstructing water systems.

Material

611.02 Conform to the following Subsections:

Seamless copper water tube and fittings	707.16
Smooth wall polyethylene pipe	708.01(b)
Smooth wall polyvinyl chloride (PVC) pipe	708.06(c)
Soil and soil-aggregate materials	704.01
Steel pipe	717.06

Construction Requirements

611.03 General. Conform to the standards of APWA, AWWA, *International Building Code* and local agency plumbing and safety codes.

Obtain permits, arrange for inspections, and pay fees necessary to obtain water service.

Excavate according to Section 209. Place bedding for pipes according to Subsection 209.08.

Coordinate service interruptions with the user or owner of the waterline. Provide temporary waterlines to ensure a water supply is maintained. Connection work may be required during times other than normal working hours. Do not stop work on a connection until it is completed.

Dispose of disinfectant for water lines according to Subsection 107.01. Do not allow disinfectant to enter a body of water.

611.04 Backfilling. Backfill according to Subsection 209.09. Place backfill to a depth of 12 inches above the top of the pipe using a method that does not damage the pipe.

611.05 Acceptance. Material for water systems will be evaluated under Subsections 106.02 and 106.03.

Installation of water systems will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

611.06 Measure the Section 611 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring waterlines and encasement pipes by the linear foot, measure along the flow line including the length through tees, bends, valves, or other fixtures.

Payment

611.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 611 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for lump sum pay items will be prorated based on the price breakdown and total work completed under this Section.

Section 612. — SANITARY SEWER SYSTEMS

Description

612.01 This work consists of constructing or reconstructing sanitary sewer systems.

Material

612.02 Conform to the following Subsections:

Acrylonitrile-butadiene-styrene (ABS) pipe	708.08
Cast iron soil pipe and fittings	707.15
Detectable warning tape	725.11
Gaskets for plastic pipe	708.09
Precast concrete water and wastewater structures	725.09(e)
Smooth wall polyvinyl chloride (PVC) pipe	708.06(b)
Soil and soil-aggregate materials	704.01

Construction Requirements

612.03 General. Conform to the standards of APWA, AWWA, *International Building Code* and local agency plumbing and safety codes.

Obtain permits, arrange for inspections, and pay fees necessary to obtain sewerage service.

Excavate according to Section 209. Place bedding for pipes according to Subsection 209.08.

Coordinate service interruptions with the user or owner of the sewer line. Provide temporary sewer lines to ensure a sewer supply is maintained. Connection work may be required during times other than normal working hours. Do not stop work on a connection until it is completed.

Dispose of disinfectant for sewer lines according to Subsection 107.01. Do not allow disinfectant to enter a body of water.

612.04 Laying Sewer Lines. Inspect each joint and clean the pipe and bell before placing in the trench. Lay the sewer line from the lower end with the spigot ends pointing in the direction of flow. Fully support each length between joints and check for line and grade before placing the next length.

Check the gasket for proper positioning and shove sewer pipe into proper position where premolded watertight gaskets are used.

Position the pipe and fill the joint completely with joint sealer if poured joints are used. Allow the sealer to cool completely before removing the runner.

612.05 Backfilling. Backfill according to Subsection 209.09. Place backfill to a depth of 12 inches above the top of the pipe using a method that does not damage the pipe. Install continuous underground detectable warning tape during backfilling of trench for underground sewer-distribution piping. Locate below finished grade, directly over piping. Flush the lines with water to ensure they are unobstructed after backfilling.

Provide acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, at least 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector if tape is buried up to 30 inches deep; colored to comply with local practice or requirements of authorities having jurisdiction.

612.06 Acceptance. Material for sanitary sewer systems will be evaluated under Subsections 106.02 and 106.03.

Installation of sanitary sewer systems will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

612.07 Measure the Section 612 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring sewer lines by the linear foot, measure along the flow line including the length through valves, ells, tees, valve boxes, reducers, manholes, or other fixtures. Where two different sizes enter or exit a manhole, measure each size to the center of the manhole.

Payment

612.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 612 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for lump sum pay items will be prorated based on the price breakdown and total work completed under this Section.

Section 613. — SIMULATED STONE MASONRY SURFACE

Description

613.01 This work consists of constructing simulated stone masonry surfaces using concrete, staining, and grouting to simulate the texture and color of native stone masonry in a stone pattern.

Material

613.02 Conform to the following Subsections:

Neat hydraulic cement grout	701.04(a)(2)
Penetrating stain for concrete	719.05
Preformed expansion joint fillers	712.01(b)

Construction Requirements

613.03 Form Liner Fabrication. Take an impression of the stone shape, texture, and mortar joints from a designated location. Design form liners from the impressions according to the stone pattern shown in the plans. Submit detailed drawings of the form liner according to Subsection 104.06.

613.04 Test Wall. Before production work on the simulated stone masonry, construct a 36-inch-high by 24-inch-wide by 10-foot-long test wall according to Section 552 and this Section.

Cast the test wall on site using the same forming methods, procedures, form liner, texture configuration, expansion joint, concrete mixture, and stain application proposed for the production work. Demonstrate the quality and consistency of joint treatment, end treatment, top embossing methods, back treatment, and stain application on the test wall. If a test wall is rejected, construct a new test wall.

Start production structural concrete work after the test wall is approved. Start production stain application after the stain application on the test wall is approved. Dispose of the test wall after use.

613.05 Form Liner Installation. Provide a form liner that attaches easily to the forming system. Install the form liner so it does not compress more than ¼ inch during the concrete pour.

Attach the form liners to the form. Attach adjacent form liners to each other with less than a ⅛-inch seam. Do not repeat the form liner pattern between expansion joints or within 20-foot intervals, whichever is greater.

Form expansion joints at the intervals shown in the plans. Blend the butt joints into the pattern and the final concrete surface.

Coordinate the forms with wall ties. Place form tie holes in the high point of rustication or in the mortar joint.

Clean off build-up before reusing form liners. Visually inspect each liner for blemishes and tears. Repair the liner before installation.

613.06 Top Surface. Emboss the plastic concrete in the exposed top surface by stamping, tooling, troweling, hand shaping, or a combination thereof, to simulate the stone masonry texture and mortared joints. Match the side pattern of the formed mortared joints. After the free surface water evaporates and the finish embossing is complete, cure the concrete for 7 days according to Subsection 552.13(b). Do not use liquid membrane curing compounds.

613.07 Form Liner Removal. Within 24 hours after placing concrete, remove or break free the form liners without causing concrete surface deterioration or weakness in the substratum. Remove form tie material to a depth of at least 1 inch below the concrete face without spalling and damaging the concrete.

613.08 Preparation of Concrete Surface. Finish exposed formed concrete surfaces according to Subsection 552.14(b). Finish so that vertical seams, horizontal seams, and butt joint marks are not visible. Minimize grinding and chipping to avoid exposing aggregate.

Provide a completed surface free of blemishes, discolorations, surface voids, and conspicuous form marks. Make the finished texture and patterns continuous without visual disruption.

613.09 Stain Application. Age concrete, including patches, at least 30 days. Clean the surface of latency, dirt, dust, grease, and foreign material by approved methods.

Remove efflorescence with a pressure water wash. Do not sand blast surfaces that receive stain.

Correct surface irregularities created by the surface cleaning.

Maintain the concrete temperature between 40 and 85 °F when applying stain and for 48 hours after applying stain.

Stain exposed concrete surfaces. Use a stain application suitable to obtain the appearance of the native stone masonry. Use at least 3 colors of stains.

Provide protection and avoid over-spray and color overlap at boundaries between two color tones or between surfaces receiving color at different times.

Apply grout of a natural cement color to each form joint. Use sufficient grout so the over-spray of the stain is not visible. Give the form pattern grout joint the appearance of mortared joints in completed masonry.

Recoat areas inconsistent with the approved test wall.

Treat expansion joints with caulk, grout, or both to blend with the appearance of the adjacent stone or mortar joint.

613.10 Acceptance. Material for simulated stone masonry surface treatment will be evaluated under Subsections 106.02 and 106.03.

Installation of form liners will be evaluated under Subsections 106.02 and 106.04.

Application of stain to exposed concrete surfaces will be evaluated under Subsection 106.02.

Construction of the simulated stone masonry test wall will be evaluated under Subsection 106.02.

Construction of simulated stone masonry surfaces will be evaluated under Subsections 106.02 and 106.04.

Measurement

613.11 Measure the Section 613 pay items listed in the bid schedule according to Subsection 109.02.

Payment

613.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 613 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 614. — FLOWABLE BACKFILL

Description

614.01 This work consists of constructing flowable backfill of controlled low strength material.

Material

614.02 Conform to the following Subsections:

Chemical admixtures	711.03
Flowable backfill aggregate	703.15
Hydraulic cement	701.01
Pozzolans	701.03
Water for cementitious materials	725.01(a)

Construction Requirements

614.03 Composition of Mix. Design a well-graded, flowable, self-leveling mix. Design a mix with a 7-day compressive strength between 75 and 250 pounds per square inch according to ASTM D4832. Verify the mix design with trial batches prepared from the same sources proposed for the mix. Submit the following for approval at least 21 days before production:

(a) Type and source of aggregates;

(b) Type and source of cement;

(c) Type and source of pozzolans, if used in the mix;

(d) Type and supplier of admixtures, if used in the mix;

(e) Mix proportions;

(f) Commercial certifications for each material contained in the mix;

(g) Target values for water to cementitious material ratio and slump; and

(h) Compressive strength at 7 days.

614.04 General. Excavate and backfill according to Section 209.

Do not place flowable backfill in contact with aluminum or aluminum-coated structures.

Do not use flowable backfill above the top of subgrade.

614.05 Mixing and Placing Flowable Backfill. Mix flowable backfill by pugmill, rotary drum, or other approved mixer to obtain a uniform mix.

Place flowable backfill in a uniform manner that prevents voids or segregation in the backfill.

Maintain the temperature of flowable backfill to at least 50 °F at the time of placement. Protect the material from freezing for 24 hours after placement.

If backfilling around culverts and other structures, place flowable backfill so that the structure does not float or shift. Bring the backfill up evenly on all sides of the structure. Maintain correct alignment of structures by use of straps, soil anchors, or other approved methods of restraint.

If placing flowable backfill at or below an ambient temperature of 35 °F, perform the work according to Subsection 552.07(a).

Wait at least 4 hours before backfilling over flowable backfill.

614.06 Acceptance. Material for flowable backfill will be evaluated under Subsections 106.02 and 106.03, and 106.04 if tested for compressive strength according to ASTM D4832.

Construction of flowable backfill will be evaluated under Subsection 106.02.

Excavation and backfill will be evaluated under Section 209.

Measurement

614.07 Measure the Section 614 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring flowable backfill by the cubic yard, measure in the hauling vehicle.

Payment

614.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 614 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 615. — RESERVED

Section 616. — SLOPE PAVING

Description

616.01 This work consists of constructing slope paving.

Material

616.02 Conform to the following Section and Subsections:

Concrete masonry units	725.07
General mortar	701.05(a)
Geosynthetic material	714
Non-shrink grout	701.04(b)(1)
Paving brick	725.08
Sand	703.14
Solid concrete interlocking paving units	725.09(f)
Rock for Masonry Structures	705.03
Topsoil	713.01
Welded deformed steel wire reinforcement	709.01(j)

Construction Requirements

616.03 General. Excavate and backfill according to Section 209. Place and compact a sand lift with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

If shown in the plans, place geosynthetic material according to Subsection 207.04. Bury the ends of the geosynthetic material for anchorage. Pin the strips at 5-foot intervals to hold the geosynthetic material lap in place until slope paving is placed.

616.04 Concrete Slope Paving. Construct toe walls. Place welded deformed steel wire reinforcement at the center of the slab. Run the wire fabric continuously through the joints. Lap adjacent runs of wire fabric by at least 6 inches.

Construct minor concrete according to Section 601. Place slabs starting at the bottom of the slope. Construct horizontal joints parallel to the bottom of the slope and the vertical joints perpendicular to the horizontal joints. Construct cold joints without filler.

Finish the surface according to Subsection 552.12(c)(2). Use a ¼-inch radius edging tool on slab edges and joints.

616.05 Stone Masonry Paving. Perform stone masonry paving work according to Section 620. Start placing masonry block or rubble at the bottom of the slope. Place paving material on the sand lift with the flat face up and the longest dimension parallel to the bottom of the slope. Ram the masonry block or rubble into place.

Apply sufficient mortar on the exposed side to produce masonry block joints up to ½ inch wide and rubble joints up to 1 inch wide. Ram the masonry block or rubble into place so the mortar is within ½ inch of the surface. Do not allow mortar to protrude above the surface. Clean mortar stain from the surface.

616.06 Slope Paving with Concrete Masonry Units, Paving Brick, and Solid Concrete Interlocking Paving Units. Start placing units and bricks in a trench or against a suitable anchorage at the bottom of the slope. Lay each unit or brick on the slope and bed it firmly against adjoining blocks. Use non-shrink grout to fill misaligned joints or breaks at slope changes. Do not grout individual blocks to each other.

If using units or bricks with open cells, place topsoil loosely inside the cells, filling the cell openings. Do not place topsoil when the ground or topsoil is frozen, excessively wet, or in a condition detrimental to the work. Remove and dispose of clods and stones larger than 2 inches, stumps, roots, and other litter according to Subsections 203.05 and 203.07. If shown in the plans, establish turf according to Section 625.

616.07 Acceptance. Concrete masonry units, geosynthetic materials, non-shrink grout, mortar, paving brick, sand, solid concrete interlocking paving units, topsoil, and welded steel wire fabric will be evaluated under Subsections 106.02 and 106.03.

Slope paving construction will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Stone masonry will be evaluated under Section 620.

Turf establishment will be evaluated under Section 625.

Measurement

616.08 Measure the Section 616 pay items listed in the bid schedule according to Subsection 109.02.

Payment

616.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 616 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 617. — GUARDRAIL

Description

617.01 This work consists of constructing or modifying guardrail systems. This work also consists of removing, resetting, and raising guardrail systems.

Types and classes of metal beam guardrail are designated according to AASHTO M 180.

Material

617.02 Conform to the following Section:

Guardrail	724

Construction Requirements

617.03 Qualifications. At least 14 days before starting guardrail work, submit one of the following for the guardrail supervisor:

(a) Résumé describing at least 3 years' experience in guardrail installation;

(b) A certificate showing successful completion of the ATSSA Guardrail Installation Training; or

(c) A certificate showing successful completion of a state department of transportation guardrail installation training course.

617.04 General. Provide guardrail systems and terminals that are crashworthy.

If proprietary systems, terminals, or crash cushions are required, install according to the manufacturer's recommendations. Submit the installation manual, completed inspection checklists, and drawings from the manufacturer according to Subsection 104.06.

Construct minor concrete according to Section 601.

617.05 Post Installation. Complete adjacent earthwork, aggregate placement and other roadway surfaces to line and grade as applicable before installation of guardrail posts.

Do not damage adjacent pavement, subsurface utilities, or drainage features during post installation.

Posts may be installed by either drilling or driving. Ensure posts installed by drilling have sufficiently sized holes to allow thorough compaction of backfill around each post. Backfill post holes in 6-inch lifts with approved material. Tamp and compact each lift. Replace posts damaged during driving operations.

Install the posts plumb and at the location, spacing, and elevation as shown in the plans. If a post cannot be placed at its normal location due to a non-removable obstruction, an additional blockout may be added as approved. If the post cannot be offset with the addition of a blockout, the following options are allowed as approved: the post-in-rock detail, the long span detail, or the omission of a post as shown in the plans.

Use post lengths shown in the plans. Do not change the post lengths or spacings in terminals or structure transitions.

Treat field cuts for wood posts with two coats of preservative. Do not place field cuts in contact with the ground.

617.06 Rail Element Installation. Do not modify specified hole diameters or slot dimensions.

(a) Steel rail. Shop bend curved guardrail with a radius of 150 feet or less.

Install rail elements in a smooth continuous line with the laps in the direction of traffic flow. Use bolts that extend at least ¼ inch, but no more than 1 inch beyond the nuts.

Coat scrapes on galvanized surfaces that expose the base metal with two coats of zinc-oxide coating material.

(b) Steel-backed timber and log rail. Treat field cuts with two coats of preservative.

617.07 Terminal Systems, Anchorage Systems, and Structure Transitions. Do not connect the guardrail to cast-in-place anchors until the concrete has cured 7 days. Install end anchor cables without slack.

617.08 Guardrail Construction Exposed to Traffic. If a roadway is open to traffic during construction, complete guardrail installations within 5 days from the day the structure, pavement, shoulder, or whichever is the controlling item of work is sufficiently completed to allow guardrail installation. In areas where guardrail construction is not restricted by other construction, complete removal of existing guardrail and construct new guardrail within 48 hours of starting work.

Delineate unfinished sections of guardrail installation or follow an approved method of protecting traffic from the unfinished guardrail elements.

Schedule guardrail installation so work is finished before work suspension or other extended periods of time.

617.09 Removing and Resetting Guardrail. Salvage the existing rail elements, posts, and appurtenances according to Subsection 203.04. Do not salvage posts that are set in concrete. Remove and dispose of material not used in resetting guardrail according to Subsections 203.05 and 203.07.

Backfill holes resulting from the removal of guardrail posts and anchors with approved material. Reset guardrail to the height shown in the plans. Replace guardrail, posts, and hardware damaged during removal, storage, or resetting.

617.10 Raising Guardrail. Salvage the existing rail elements and appurtenances according to Subsection 203.04. Dispose of damaged material according to Subsection 203.07.

Replace or reset posts as needed. Backfill holes resulting from the removal or raising of guardrail posts and anchors with approved material. Raise guardrail to the height shown in the plans. Replace rail elements, posts, and hardware damaged during the removal and raising.

617.11 Acceptance. Material for guardrail will be evaluated under Subsections 106.02 and 106.03.

Construction of guardrail will be evaluated under Subsections 106.02 and 106.04.

Minor concrete will be evaluated under Section 601.

Measurement

617.12 Measure the Section 617 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure removing and resetting guardrail and raising guardrail including reset terminal sections.

Measure replacement posts (except replacement posts for posts damaged by construction operations) used in raising guardrail or removing and resetting guardrail.

Payment

617.13 The accepted quantities will be paid at the contract price per unit of measurement for the Section 617 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 618. — CONCRETE BARRIERS

Description

618.01 This work consists of constructing concrete barrier systems. This work also consists of removing and resetting concrete barrier systems.

Material

618.02 Conform to the following Subsections:

Backer rod	712.01(f)
Guardrail hardware	724.04
Joint sealants and crack fillers	712.01(a)
Precast concrete units and accessories	725.09
Preformed expansion joint fillers	712.01(b)
Reinforcing steel	709.01

Construction Requirements

618.03 General. Excavate and backfill according to Section 209.

Construct barriers that are crashworthy.

Construct temporary terminal sections and crash cushions according to Section 635.

618.04 Concrete Barriers. Concrete barriers may be cast-in-place, slip-formed, or precast according to Section 552 or Section 578. Finish the sides and top according to Subsection 552.14(a).

(a) Cast-in-place. Tool or saw cut contraction joints ¼ inch wide and 2 inches deep at 20-foot intervals. Saw cut after the concrete has set sufficiently, but before shrinkage cracking occurs. Decrease the depth of the saw cut at the edge adjacent to the pavement to prevent pavement damage.

Place ¾-inch preformed expansion joint filler in construction joints. Cut the joint filler to fit the cross-sectional area at structures and barrier construction joints. Tool construction joint edges. Seal joints according to Subsection 501.11.

(b) Slip-formed. Do not contact extruded concrete surface as it leaves the slip-form machine, except to remove offsets and fins by light troweling.

Adjust the operation to correct conditions causing surface blemishes larger than ½ inch. Do not use water on the completed barrier to correct imperfections.

(c) Precast. Precast barriers in section lengths. Prepare the barrier foundation so it does not vary over ¼ inch when a 10-foot metal straightedge is laid along the centerline of the barrier. Align the joints and connect adjacent sections.

Use cast-in-place barrier where transitions, split barriers, or gaps shorter than 10 feet require it. At each joint between precast and cast-in-place barrier, provide hardware in the cast-in-place section to tie its end to the abutting precast section.

618.05 Removing and Resetting. Salvage the existing concrete barrier, terminal sections, and appurtenances according to Subsection 203.04. Reset concrete barrier and terminal sections according to Subsections 618.03 and 618.04. Replace concrete barrier, terminal sections, and hardware damaged during removal, storage, or resetting.

618.06 Acceptance. Material for concrete barrier (except concrete and reinforcing steel) will be evaluated under Subsections 106.02 and 106.03.

Construction of concrete barriers will be evaluated under Subsections 106.02 and 106.04.

Concrete will be evaluated under Section 552.

Excavation and backfill will be evaluated under Section 209.

Reinforcing steel will be evaluated under Section 554.

Temporary terminal sections and crash cushions will be evaluated under Section 635.

Measurement

618.07 Measure the Section 618 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Measure concrete barrier excluding terminal sections.

Measure reset concrete barrier in the relocated position including terminal sections.

Payment

618.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 618 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 619. — FENCES, GATES, CATTLE GUARDS, AND BOLLARDS

Description

619.01 This work consists of constructing, and removing and resetting fences, gates, cattle guards, and bollards.

Material

619.02 Conform to the following Section and Subsection:

Fencing and mesh fabrics	710
Neat hydraulic cement grout	701.04(a)(2)

Construction Requirements

619.03 General. Clear along the fence line. Remove and dispose of trees, brush, logs, upturned stumps, roots of downed trees, rubbish, and debris according to Subsections 203.05 and 203.07.

Grubbing is not required, except where short and abrupt changes in the ground contour require removal of stumps to properly grade the fence line. Remove or cut stumps according to Subsection 201.04(b).

Perform clearing and leveling with minimum disturbance to the terrain outside the fence line.

Schedule the fence installation, provide temporary fence, or other adequate means to prevent traffic (such as pedestrian, livestock, and vehicular) from entering the project right-of-way, easements, or adjoining properties.

At bridges, cattle underpasses, and culverts, connect new fence to structure to allow free passage of livestock under or through the structure.

Construct cast-in-place concrete according to Section 601, where required.

Construct precast concrete according to Section 578, where required.

619.04 Fences and Gates.

(a) Chain link fence and gates.

(1) Posts. Space posts at no more than 10-foot intervals. Measure the post spacing interval horizontally. Set posts vertically.

Where solid rock is encountered without overburden, drill line post holes at least 14 inches deep. Drill end, corner, gate, and pull posts at least 20 inches deep in the solid rock. Make the hole width or diameter at least 1 inch greater than the post width or diameter. Cut the post to the required length before installation or drill the hole deep enough to set the post at the required height. Set and plumb the post and fill the hole with grout. Thoroughly work the neat hydraulic cement grout into the hole to eliminate voids. Crown the grout to drain water away from the post.

Where solid rock is covered with soil or loose rock overburden, set posts to the plan depth or to the minimum depth into the solid rock as specified above, whichever is less. If solid rock is encountered before the plan depth, grout the portion of the post in solid rock and backfill the post hole from the solid rock to the top of the ground with concrete.

Provide end, gate, corner, and pull posts with adjacent brace posts as shown in the plans. A change in the fence alignment of 20 degrees or more is considered a corner.

(2) Top rail. Install top rails through the loop caps of the line posts, forming a continuous brace from end-to-end of each stretch of fence. Join lengths of top rail with sleeve-type couplings. Securely fasten top rails to terminal posts by pressed steel fittings or other approved means.

(3) Tension wire. Attach tension wire to end, gate, corner, or pull posts by bands and clamps. Thread the top tension wire through the line post loop caps or hold in open slots to limit vertical movement. Tie or attach the bottom tension wire to the bottom of the line posts by ties or clamps to prevent vertical movement. Apply sufficient tension to avoid excess sag between posts. On the top tension wire, provide one turnbuckle or ratchet take-up in each run of fence.

(4) Fence fabric. For fences placed on the right-of-way, place fence fabric on the post face away from the highway. On curved alignment, place the fence fabric on the post face on the outside of the curve. For residential fences and fences off the right-of-way, place fence fabric on the post face designated by the CO.

Place the fabric approximately 1 inch above the ground and on a straight line between posts. Excavate high points of the ground to maintain grade. Do not fill in depressions without prior approval.

Stretch the fabric taut and securely fasten the fabric to the posts. Do not stretch using a motor vehicle. Use stretcher bars and fabric bands to fasten to end, gate, corner, and pull posts or weave the fabric into the fastening loops of roll-formed posts.

Fasten fabric to line posts using wire ties, metal bands, or other approved method. Fasten the top and bottom edge of the fabric with tie wires or hog rings to the top rail or tension wires as applicable.

Join rolls of fabric by weaving a single strand into the ends of the rolls to form a continuous mesh.

(b) Gates. Fasten fabric to the end bars of the gate frame by stretcher bars and fabric bands. Fasten fabric to the top and bottom bars of the gate frame by tie wires similar to the method specified for fence fabric or by other approved standard methods.

Thoroughly clean welded connections on gate frames where the smelter coating has been burned with a wire brush. Remove traces of the welding flux and loose or cracked smelter. Coat the cleaned areas with two coats of zinc-oxide coating material according to Section 563.

Provide a concrete footing for the drop-bar locking device on double metal gates. Make a hole to receive the locking bar to the depth specified by the manufacturer of the locking device.

Hinge each single gate to prevent removal of the gate without tools. Set the gate in an approximately horizontal plane. Set the gate so it swings freely inward and outward and fastens securely in its latch holder, or in the case of double gates, in its latch holder and gate stops. Set double gates on their respective hinge pintles to provide a common horizontal plane in which each single gate swings. Set gates to swing open at least 90 degrees in each direction.

(c) Wire fences and gates.

(1) Posts. Excavate holes for posts, footings, and anchors as shown in the plans. Space posts at intervals shown for the type of fence being installed. Measure post spacing interval parallel to the existing ground slope. Set posts in a vertical position. Backfill post holes in 6-inch lifts. Tamp and compact each lift.

Wood posts may be driven in place if the method of driving does not damage the post. Metal posts may be driven. Set metal corner, gate, end, and pull posts in concrete.

Where solid rock is encountered without overburden, drill line post holes at least 14 inches deep and end, corner, gate, and pull posts at least 20 inches deep in the solid rock. Make the hole width or diameter at least 1 inch greater than the post width or diameter. Cut the post to the required length before installation or drill the hole deep enough to set the post at the required height. Set and plumb the post and fill the hole with grout. Thoroughly work the grout into the hole to eliminate voids. Crown the grout to drain water away from the post. Metal posts set in this manner do not require anchor plates and concrete footings.

Where solid rock is covered with soil or loose rock overburden, set posts to the plan depth or to the minimum depth into the solid rock as specified above, whichever is less. If the depth of overburden is greater than 12 inches, use an anchor plate on steel line posts and backfill steel end, corner, gate, and pull posts with concrete from the solid rock to top of the ground. If the depth of overburden is 12 inches or less, anchor plates and concrete backfill are not required. Grout the portion of the post in solid rock.

Install corner posts at changes in alignment of 30 degrees or more. Where new fence joins an existing fence, set end or corner posts and attach as approved.

(2) Braces. Limit fence runs to no more than 650 feet between adjacent corner braces, gate braces, end braces, or line braces. Install line braces at uniform intervals so the distance between any two braces is 650 feet or less. Construct braces before placing the fence fabric and wires on posts.

(a) Metal braces. Provide corner posts and pull posts with two braces, one each direction from the post in the main fence line. Provide end posts and gate posts with one brace in the line of the fence. Attach metal braces to the metal end, corner, pull, and gate posts as shown in the plans.

(b) Wood braces. Tap the posts to receive the braces. Anchor the brace to the post with three 16d nails or a ⅜- by 4-inch dowel. Install brace wires as shown and twist together until the entire assembly is taut and firm. Lightly notch the posts to position the brace wire. Drive three staples at each notch to secure wire.

(3) Barbed wire, smooth wire, and woven wire. Place barbed wire, smooth wire, and woven wire on the side of the post facing away from the highway. On curved alignment, place the barbed wire, smooth wire, and the woven wire on the post face on the outside of the curve. Tightly stretch and fasten barbed wire, smooth wire, and woven wire to the posts.

Apply tension according to the manufacturer's recommendations using a mechanical stretcher or other device designed for such use. Evenly distribute the pull over the longitudinal wires in the woven wire so no more than 50 percent of the original depth of the tension curves is removed. Do not use a motor vehicle to stretch the wire.

Splicing of barbed wire, smooth wire, and woven wire between posts is allowed provided no more than two splices, spaced at least 50 feet apart, occur in a run of fence. Use wrap or telephone type splices for the longitudinal woven wire and barbed and smooth wire with each end wrapped around the other wire for at least six complete turns.

(4) Fastening barbed wire, smooth wire, and woven wire. End the woven wire, smooth wire, and barbed wire at each end, corner, gate, and pull post. Wrap each line of barbed wire, smooth wire, and each longitudinal wire of the woven wire around the post and then itself with at least four turns. Where wood posts are used, staple the wires tightly to the posts.

At line posts, fasten the woven wire to the post at top and bottom and at intermediate points no more than 12 inches apart. Fasten each strand of barbed wire and smooth wire to each line post. Use wire ties or clamps to fasten the wires to metal posts. Securely splice tie wires to the fence on both sides of the post so there are two loops behind the post and one loop in front. On wood line posts, drive U-shaped staples diagonally across the wood grain so that both points do not enter between the same grain. In depressions where wire uplift occurs, drive staples with points slightly upward. On level ground and over knolls, slope the points slightly downward. Drive the staples just short of actual contact with the wires to allow free longitudinal movement of those lines and to prevent damage to the protective coating.

At grade depressions, alignment angles, and other locations where stresses tending to pull posts from the ground or out of alignment are created, snub or guy the wire fence. Attach the guy wire to each strand of barbed wire and smooth wire, and to the top and bottom wires of woven wire to maintain the entire fence in its normal shape. Attach the guy wire to a deadman anchor buried no more than 24 inches in the ground or to an approved anchor at a point that best serves to resist the pull of the wire fence. If necessary to guy the fence in solid rock, grout the guy wire in a hole 2 inches in diameter and 10 inches deep. Deadman may also be fastened to posts. Place the deadman anchors at locations as directed.

Where required, install vertical cinch stays as shown in the plans. Twist the wire to allow weaving into the horizontal fence wires to provide rigid spacing. Weave barbed wires and smooth wires and the top, middle, and bottom wire of the woven wire as applicable, into the cinch stay.

Where existing fence intersects the new fence, cut the existing fence material or, splice in kind new material as necessary, and fasten each longitudinal wire of the woven wire and each strand of the barbed wire and smooth wire to a new end post in line with or immediately adjacent to the new fence line.

(5) Gates.

(a) Wire gates. Construct wire gates of the same material as the fence and as shown. Provide a taut and well-aligned closure of the opening, that can be readily opened and closed by hand.

(b) Metal gates. Install metal gates and fittings to gate posts previously set. Firmly attach the fittings to the posts and gates. Hinge each single gate to prevent removal of the gate without

tools. Set the gate in a horizontal plane. Set the gate so it swings freely inward and outward and fastens securely in its latch holder, or in the case of double gates, in its latch holder and gate stops. Set double gates and their respective pintles to provide a common horizontal plane in which each single gate swings. Set gates to swing open at least 90 degrees in each direction.

For double gates, provide a drop-bar locking device with a concrete footing 12 inches in diameter and 12 inches deep. Crown the top of the footing and make a hole to receive the locking bar. Make the diameter and depth of the hole in the footing as specified by the manufacturer of the locking device.

(c) Wood gates. Install wood gates similar to metal gates and as shown in the plans.

619.05 Grounding Fences. Where an electric line crosses the fence line, ground the fence. Drive an 8-foot long, ½-inch minimum diameter galvanized steel rod into the ground under the fence directly below the point of crossing. Drive the rod vertically until the top is 6 inches below the ground surface. Connect the grounding rod to each fence element with a ¼-inch diameter solid copper conductor or equivalent. Either braze the connections or fasten with noncorrosive clamps.

Where an electric line runs parallel or nearly parallel to and above the fence, ground the fence at each end or gate post or at intervals no more than 1600 feet.

Where vertical penetration of the grounding rod cannot be accomplished, use an equivalent horizontal grounding system.

619.06 Remove and Reset Fence and Gate. Salvage the existing fence and gate according to Subsection 203.04. If posts are set in concrete, remove concrete from old post and reset in new concrete. Replace fence and gate material damaged beyond reuse.

Reset to approximately the same condition as the original. Firmly reset posts on new alignment. Space posts and attach the horizontal members or wires to posts the same as the original fence and gate. Provide and use new material to fasten members or wires to posts.

619.07 Temporary Fence. If necessary, construct temporary fence to keep traffic (such as pedestrian, livestock, and vehicular) off the project. Maintain the temporary fence during construction of the project or until the fence is directed to be removed. Dispose of temporary fence according to Subsection 203.07.

619.08 Cattle Guards.

(a) Excavating and backfilling. Excavate and backfill according to Section 209. Excavate foundation to depth with sufficient space for proper installation of formwork.

If the cattle guard is to be installed on new embankment, construct the embankment according to Section 204 before excavating for the footing.

(b) Concrete foundation. Concrete cattle guard foundations may be cast-in-place or precast. If placing cattle guard in cast-in-place concrete, set cattle guard units in the foundation concrete before it hardens.

Finish stringer bearings to allow full bearing under each stringer. Firmly seat cattle guard on the concrete to prevent rocking.

(c) Cattle guard. Provide cattle guards with HS-20 loading rating according to AASHTO, *LRFD Bridge Design Specifications*. Provide suitable cleanouts. Submit drawings according to Subsection 104.06.

Fabricate cattle guards according to Section 555. Assemble and place cattle guards as shown in the plans. Securely fasten the cattle guard to the foundation. Fasten the metal wings as shown in the plans. Connect fences and gates as shown in the plans. Weld according to AASHTO/AWS, *Bridge Welding Code D1.5 (D1.5M)*.

(d) Coating. Coat according to Section 563. Apply one shop coat to metal parts. Apply two additional coats in either the shop or in the field.

619.09 Bollards. Drill holes for bollards. Set posts plumb, backfill with approved material, and compact.

619.10 Acceptance. Material for fences, gates, cattle guards, and bollards will be evaluated under Subsections 106.02 and 106.03.

Construction of fences, gates, cattle guards, and bollards will be evaluated under Subsections 106.02 and 106.04.

Coatings will be evaluated under Section 563.

Embankment for cattle guard will be evaluated under Section 204.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Precast elements will be evaluated under Section 578.

Steel structures will be evaluated under Section 555.

Measurement

619.11 Measure the Section 619 pay items listed in the bid schedule according to Subsection 109.02.

Payment

619.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 619 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 620. — STONE MASONRY

Description

620.01 This work consists of constructing or rehabilitating stone masonry structures and the stone masonry portions of composite structures.

620.02 Definitions.

(a) Dimensioned masonry. Stones are cut in two or more dimensions and laid in a broken-course pattern in mortar.

(b) Class A masonry. Stones are shaped, dressed to within ¼ inch of true line, and laid in mortar.

(c) Class B masonry. Stones are shaped, dressed to within ¾ inch of true line, and laid in mortar.

(d) Rubble masonry. Stones vary in size and shape, are roughly dressed, and laid in random courses in mortar.

Material

620.03 Conform to the following Subsections:

General mortar	701.05(a)
Neat hydraulic cement grout	701.04(a)(2)
Preformed expansion joint fillers	712.01(b)
Reinforcing steel	709.01
Rock for masonry structures	705.03

Construction Requirements

620.04 General. Submit stone samples for approval representing the range of colors and sizes to be used 14 days before starting work. When no dimensions are shown in the plans, provide the rocks in the sizes and face areas necessary to produce the general characteristics and appearance shown in the plans.

Keep an adequate inventory of stone on the site to provide a variety of stones. Mix new stone with existing stone to produce a uniform pattern and color.

Do not use rock with depressions or projections that might weaken it or prevent it from being properly bedded.

Excavate and backfill according to Section 209.

Construct minor concrete according to Section 601.

620.05 Dressing Rock. Remove thin or weak portions of rock. Dress face rock bed and joint lines to a maximum variation from true line as shown in Table 620-1.

Table 620-1
Maximum Variation from True Line

Class	Distance
Dimensioned	Reasonably true
Class A	¼ in
Class B	¾ in
Rubble	1½ in

(a) Bed surfaces. Dress face rock bed surfaces normal to the face to a depth of 3 inches. Beyond that point, do not exceed 1 inch departure from normal per 12 inches for dimensioned masonry or 2 inches departure from normal per 12 inches for other classes.

(b) Joint surfaces. For dimensioned masonry, dress face rock joint surfaces normal to the bed surface. For other classes of masonry, dress face rock joint surfaces to form an angle with the bed surface of at least 45 degrees.

Dress face rock joint surfaces normal to the face to a depth of 2 inches. Beyond that point, do not exceed 1 inch departure from normal per 12 inches.

Do not round corners at the meeting of the bed and joint lines more than the radii shown in Table 620-2.

Table 620-2
Masonry Rock Rounding

Class	Radius
Dimensioned	No rounding
Class A	No rounding
Class B	1 in maximum
Rubble	1½ in maximum

(c) Arch ring rock joint surfaces. Dress ring rock joint surfaces radial to the arch or normal to the front face to a depth of 3 inches. Beyond that point, do not exceed ¾ inch departure from the radial or normal per 12 inches.

Dress the back surface adjacent to the arch barrel concrete parallel to the front face and normal to the intrados to a depth of 6 inches. If concrete is placed after the masonry is constructed, vary adjacent ring stones at least 6 inches in depth.

(d) Finish for exposed faces. Remove drill or quarry marks from exposed faces. Pitch face stones to the line along beds and joints. Finish the exposed faces as shown in the plans.

(1) Fine pointed. Make point depressions approximately ⅜ inch apart. Limit surface variations to no more than ⅛ inch from the pitch line.

(2) Medium pointed. Make point depressions approximately ⅝ inch apart. Limit surface variations to no more than ¼ inch from the pitch line.

(3) Coarse pointed. Make point depressions approximately 1⅛ inches apart. Limit surface variations to no more than ⅜ inch from the pitch line.

(4) Split or seam face. Provide a smooth appearance, without tool marks, depressions below the pitch line, or projections exceeding ¾ inch beyond the pitch line.

(5) Rock faced. Provide an irregular projecting surface without tool marks, concave surfaces below the pitch line, and projections beyond the specified pitch line. For example, the specification "1.50 R.F." means no projections 1½ inches beyond the pitch line. Where a *variable rock face* is specified, uniformly distribute stones of the same height of projection.

620.06 Placing Stone. Do not place stone masonry when the ambient temperature is below 32 °F.

Clean stones and moisten before placing. Use hand tools to clean the exposed faces of the stones of mortar if removing and resetting stone masonry. Clean and moisten the bed. Clean the bearing surface and moisten before spreading the mortar bed on footings.

Level the cross beds for vertical walls. Lay beds for battered walls from level to normal to the batter line of the face of the wall.

Place stone to provide a consistent pattern and color. Lay stones with the longest face horizontal and the exposed face parallel to the masonry face.

Construct masonry joints to the thicknesses shown in Table 620-3 for face stones. Construct arch ring stone joints on the faces and soffits between ¼ inch and 1½ inches thick, but make the bed of each course of a uniform thickness throughout. Construct head joints vertically in dimensioned masonry. Construct head joints in other masonry classes at angles with the vertical from 0 to 45 degrees.

Maintain completed masonry at a temperature above 40 °F for 24 hours after construction.

Remove stones loosened after the mortar has taken initial set, clean off the mortar, and relay the stone with fresh mortar.

Table 620-3
Masonry Joint Thicknesses

Class	Bed Joint, inch	Head Joints, inch
Dimensioned	⅜ to 1	¾ to 1
Class A	½ to 2	½ to 1½
Class B	½ to 2	½ to 2
Rubble	½ to 2½	½ to 2½

620.07 Pointing.

(a) Pointing new joints. Crown the joint mortar slightly on top surfaces to provide drainage.

If raked joints are required, squarely rake mortar in exposed face joints and beds to the required depth. Slightly rake the mortar where weather joints are required. Do not leave the mortar flush with the stone faces.

Clean stone faces of mortar stains while the mortar is fresh. After the mortar sets, clean stone faces again using wire brushes and acid. Protect masonry during hot or dry weather by keeping it moist for at least 3 days after the work is completed.

(b) Repointing joints. Remove loose mortar from joints using a small mason’s chisel, small pneumatically-power chisel, or other approved raking tool. Do not use power saws or grinders. If power equipment is used, demonstrate proficiency to the CO before removing mortar from the structure. Remove mortar to a depth of two and one-half times the width of the joint. Remove dirt or vegetation with a wire brush or other approved tools. Clean joint of loose fragments and dust with pressurized air or water.

Construct a 36-inch test section of joint along the structure for approval before continuing with work. Approved test section may be incorporated in the work. Moisten adjacent stone before filling the joint. Do not place mortar to a depth greater than two and one-half times the joint width. Place mortar in layers of approximately ¼ inch for joints deeper than ⅛ inch. Add successive layers once mortar has attained thumb-print hardness. Tool the final layer to match the approved joint appearance.

Clean excess mortar and stain from stone masonry using a bristle brush after the mortar has dried, but before the initial set. Do not use chemicals for cleaning. Protect masonry during hot or dry weather by keeping it moist for at least 3 days after the work is completed.

620.08 Constructing Walls. Construct an L-shaped test section of wall at least 5 feet high and 8 feet long; showing examples of face wall, top wall, method of turning corners, and method of forming joints. Do not construct masonry other than the foundation masonry before the test section is approved.

Set face stones to produce the effect demonstrated in the approved test section. Do not extend bed joints in an unbroken line through more than five stones and head joints through more than two stones. Bond each face stone with contiguous face stones at least 6 inches longitudinally and 2 inches vertically. Do not allow the corners of four stones to be adjacent to each other.

Do not bunch small stones or stones of the same size, color, or texture. Construct walls using stones decreasing in size from the bottom to the top. Use large stones in corners.

(a) Headers. Distribute headers uniformly throughout the walls of structures to form at least 20 percent of the faces.

(b) Backing. Construct the backing out of large stones. Bond the individual stones composing the backing and heart with the stones in the face wall and with each other. Fill openings and interstices in the backing with mortar or with spalls surrounded by mortar.

(c) Coping. Finish with coping if shown in the plans. If copings are not required, finish the top of the wall with stones wide enough to cover the top of the wall from 1.5 to 5 feet in length, and of random heights, with a minimum height of 6 inches. Lay stones so that the cap course is an integral part of the wall. Pitch the top of the capstones to align in both vertical and horizontal planes.

(d) Parapet walls. Use stones squared and pitched to line and with heads dressed in the ends of parapet walls and in exposed angles and corners. Interlock spreaders with as many headers as possible. Extend headers through the entire wall thickness. Interlock both the headers and stretchers in the two faces of the wall. Use headers and stretchers to comprise a majority of the wall volume. Fill openings and interstices with mortar or with spalls surrounded by mortar.

(e) Weep holes. Place weep holes at the lowest points where free outlets can be obtained. Space holes no more than 10 feet apart.

620.09 Facing for Concrete.

(a) Stone placed before concrete. Make the back of the masonry uneven. Pack voids in the back of the masonry with grout.

Use No. 4 reinforcing steel bent into an elongated letter "*S*" to anchor the stone. Embed each anchor in a mortar bed to within 2 inches from the face of the stones. Project the other end about 10 inches into the concrete backing. Space the anchors 18 inches apart both horizontally and vertically.

Clean the back masonry surface of dirt, loose material, and mortar drippings after the mortar has attained sufficient strength. Wash surfaces with pressurized water before placing concrete.

(b) Concrete placed before stone. Set galvanized metal anchor slots flush with the projected face of concrete. Set the slots vertically at maximum horizontal spacings of 24 inches. Use foam filled slots to prevent filling with concrete.

Fit the metal anchors in the slots at a maximum vertical spacing of 24 inches. Extend the anchors to within 2 inches of the face of the stones.

If the shape of the concrete face is unsuitable for the use of metal slots, use 9-gauge galvanized iron wire ties at a rate of 6 ties per square yard of exposed surface.

Keep the concrete face continuously wet for 2 hours preceding the placing of the stone and fill interstices with mortar or with spalls surrounded by mortar.

620.10 Constructing Arches. Submit drawings for falsework according to Section 562. Stratify arch ring stones parallel to the radial joint and stratify other stones parallel to the beds.

Lay out a full-size template of the arch ring showing face dimensions of each ring stone and thickness of joints. Do not shape or dress ring stones until falsework drawings have been approved. Do not place ring stones until all ring stones have been shaped and dressed.

Construct arch centering according to the drawings. Provide suitable wedges for adjusting the elevation of the forms.

Set arch ring stones and hold in place with wedges until the joints are packed with mortar. If required, support centering with jacks to prevent settlement during masonry placement. Lower the centering gradually and symmetrically to avoid overstresses in the arch. Ensure the arch is self-supporting before installing coping or other features.

Strike the centers of filled spandrel arches before constructing the spandrel walls to avoid jamming of the expansion joints. Place the backfill so the ring is uniformly and symmetrically loaded.

620.11 Guardwall. Use rubble masonry. Construct cast-in-place concrete corewalls according to Section 601 and precast concrete corewalls according to Section 578.

Construct a 25-foot test section of guardwall. Do not construct additional guardwall until the test section is approved.

Construct the guardwall true and uniform along its length with no stone projecting more than 1½ inches beyond the face of the guardwall. Construct masonry beds and joints for face stones to the thicknesses shown in Table 620-1. Rake the joints and beds to a depth of 2 inches on the front and top sides and to a depth of 1½ inches on the back.

Use a one-piece capstone for the full width of the guardwall for at least 25 percent of the total length. Use a two-piece capstone with the joint within 4 inches of the guardwall center for the remaining length.

Place stones (including the capstones) randomly to avoid a pattern. Lay stones to reflect the width of the expansion joints. Do not leave a gap or a mortar edge at the expansion joint. Use various size stones to coin or key the corners of the guardwall.

620.12 Acceptance. Rock for masonry structures will be evaluated under Subsections 106.02 and 106.04.

Material for mortar will be evaluated under Subsections 106.02 and 106.03.

Mortar placement will be evaluated under Subsection 106.02.

Construction or rehabilitation of stone masonry will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Minor concrete will be evaluated under Section 601.

Precast elements will be evaluated under Section 578.

Measurement

620.13 Measure the Section 620 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring stone masonry by the cubic yard, measure in the structure.

When measuring stone masonry guardwall by the linear foot, measure along the gutter line including terminal sections.

When measuring remove and reset stone masonry by the cubic yard, measure in the structure after resetting.

When measuring repointing of stone masonry by the linear foot, measure along the centerline of joint.

Do not measure test wall sections not incorporated in the work.

Payment

620.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 620 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for lump sum pay items will be prorated based on total work completed under this Section.

Section 621. — MONUMENTS AND MARKERS

Description

621.01 This work consists of constructing and reestablishing monuments and markers.

Construction Requirements

621.02 Monuments and Markers. Reestablish or locate permanent points according to Subsection 107.01 and Section 152. Excavate and backfill according to Section 209. Monuments may be cast-in-place according to Section 601 or precast according to Section 578. Set each monument and marker vertically at the required location and elevation such that the monument remains stable horizontally and vertically.

Unless otherwise specified, install markers or monuments that are commercially available and typical for the area and application. Mark the monuments with durable markings that identify the monument uniquely and unambiguously.

621.03 Acceptance. Material (except concrete) for monuments and markers will be evaluated under Subsections 106.02 and 106.03.

Construction of monuments and markers will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Location of permanent points will be evaluated under Sections 107 and 152.

Minor concrete will be evaluated under Section 601.

Precast elements will be evaluated under Section 578.

Survey work will be evaluated under Section 152.

Measurement

621.04 Measure the Section 621 pay items listed in the bid schedule according to Subsection 109.02.

Payment

621.05 The accepted quantities will be paid at the contract price per unit of measurement for the Section 621 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 622. — RENTAL EQUIPMENT

Description

622.01 This work consists of providing and operating equipment for construction work ordered and not otherwise provided for under the contract.

Construction Requirements

622.02 Rental Equipment. The CO will order in writing rental equipment for use on the project. Submit the model number and serial number for each piece of equipment before use. Make equipment available for inspection and approval before use.

Provide an operator who is skilled in running the rental equipment. Provide equipment with auxiliary attachments necessary to complete the ordered work. Maintain the equipment in good working order.

Obtain approval of the length of workday and workweek before starting work. Keep daily records of the number of operating hours for each piece of equipment. Submit records with pay notes within 24 hours of the work being performed.

622.03 Acceptance. Rental equipment work will be evaluated under Subsections 106.02 and 106.04.

Measurement

622.04 Measure the Section 622 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

Do not measure inoperable equipment or equipment dependent upon another piece of inoperable equipment.

Payment

622.05 The accepted quantities will be paid at the contract price per unit of measurement for the Section 622 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 623. — GENERAL LABOR

Description

623.01 This work consists of providing laborers for construction work, as well as specialized laborers for technical and professional services ordered and not otherwise provided. This work also includes providing associated equipment and hand tools needed to complete the work.

Construction Requirements

623.02 General. The CO will order in writing labor and specialized labor to complete work and services on the project. Provide competent workers to perform the work.

Obtain approval of the length of workday and workweek before starting work. Keep daily records of the number of hours worked. Submit records with pay notes within 24 hours of the work being performed.

623.03 Specialized Labor. Perform special labor services as follows:

(a) Survey services. Provide personnel, equipment, and materials, and perform work according to Section 152.

Survey services include performing both field survey and associated office work. The ordered work may consist of mapping and construction survey and staking. Work may include, but is not limited to, boundary surveys, setting permanent monuments and markers, preparing legal descriptions and exhibits, topographic mapping, taking cross-sections, setting construction stakes and finish grade stakes, or other miscellaneous survey and staking activities.

(b) Technical services. Provide qualified engineering personnel experienced in highway construction and design, that can perform in a timely and accurate manner.

Provide personnel with at least 2 years' recent job experience in the type of highway design and construction provided for under the contract. Provide the names and relevant experience of personnel. Provide supporting tools and equipment.

Technical services include both field work and associated office work. The ordered work may consist of, but is not limited to, conducting field investigations, engineering work, drafting, performing calculations, or other miscellaneous engineering activities.

Submit calculations, notes, and supporting documentation generated to complete the work.

623.04 Acceptance. General labor work will be evaluated under Subsection 106.02.

Technical services will be evaluated under Subsections 106.02 and 106.04.

Survey services will be evaluated under Section 152.

Measurement

623.05 Measure the Section 623 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring survey services by the hour, measure survey services by the crew hour regardless of crew size. Measure time spent in performing calculations, plotting cross-sections, or processing computer or other data.

When measuring technical services by the hour, measure time spent in performing calculations, drafting, plotting cross-sections, or processing computer or other data.

Do not measure time for transportation of laborers and special laborers to and from the project site.

Payment

623.06 The accepted quantities will be paid at the contract price per unit of measurement for the Section 623 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 624. — TOPSOIL

Description

624.01 This work consists of providing and placing topsoil and placing conserved topsoil.

Material

624.02 Conform to the following Subsection:

Topsoil	713.01

Construction Requirements

624.03 General. Provide at least 7 days' notice before the start of topsoil placement. Do not place topsoil when the ground or topsoil is frozen, excessively wet, or otherwise in a condition detrimental to the work. Use topsoil conserved according to Subsection 204.05 before providing topsoil. Keep the roadway surfaces clean during hauling and spreading operations.

624.04 Preparing Areas. Shape slopes and disturbed areas to be covered with topsoil. Disk or scarify slopes 1V:3H or flatter to a depth of 4 inches perpendicular to the natural flow of water.

624.05 Placing Topsoil. Spread topsoil to a depth that after settlement, provides the required depth. Break clods and lumps with harrows, disks, or other equipment to provide a uniform textured soil. Remove and dispose of clods and stones larger than 2 inches, stumps, roots, and other litter according to Subsections 203.05 and 203.07.

Construct longitudinal depressions at least 2 inches deep perpendicular to the natural flow of water without overly compacting the topsoil surface.

624.06 Acceptance. Material for provided topsoil will be evaluated under Subsections 106.02 and 106.03.

Material for conserved topsoil will be evaluated under Subsection 106.02.

Placing topsoil will be evaluated under Subsections 106.02 and 106.04.

Measurement

624.07 Measure the Section 624 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring providing and placing topsoil by the cubic yard, measure in the hauling vehicle.

When measuring providing and placing topsoil by the acre, measure on the ground surface.

When measuring placing conserved topsoil by the cubic yard, measure in the hauling vehicle.

When measuring placing conserved topsoil by the acre, measure on the ground surface.

Payment

624.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 624 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 625. — TURF ESTABLISHMENT

Description

625.01 This work consists of soil preparation, watering, fertilizing, seeding, and mulching.

Material

625.02 Conform to the following Subsections:

Agricultural limestone	713.02
Fertilizer	713.03
Mulch	713.05
Seed	713.04
Tackifiers	713.11
Water for vegetation	725.01(b)

Construction Requirements

625.03 General. Within 14 days after completion and approval of finished slopes and ditches, apply turf establishment to those portions of the site. Do not seed during windy weather or when the ground is excessively wet, frozen, snow covered, extremely dry, cloddy, hard pan, or not friable.

625.04 Preparing Seedbed. Remove weeds, sticks, stones 2 inches in diameter and larger, and other debris detrimental to application, growth, or maintenance of the turf.

Cultivate the seeding area to a minimum depth of 4 inches and prepare a firm, but friable seedbed before seeding. Do not cultivate aggregate-topsoil courses that were previously dry seeded according to Section 313.

Minimize soil compaction of seedbed.

625.05 Watering. Moisten seeding areas before seeding and maintain the moisture until turf is established or until final acceptance.

625.06 Fertilizing. Apply fertilizer by the following methods:

(a) Dry method. Incorporate the fertilizer into the upper portion of the seedbed before seeding.

(b) Hydraulic method. Add fertilizer to the slurry and mix before adding seed. Apply the seed and fertilizer in one application.

625.07 Seeding. Apply seed by the following methods:

(a) Dry method. Apply the seed with approved power-driven seeders, drills, or other mechanical equipment. Hand-operated seeding methods are satisfactory on areas inaccessible to mechanical equipment.

(b) Hydraulic method. Use hydraulic-type equipment that can provide a uniform application using water as the carrying agent. Add a tracer material consisting of either wood or grass cellulose fiber mulch to the water. Apply the tracer material at a rate of 400 pounds per acre to provide visible evidence of uniform application. Add the seed to the water slurry no more than 30 minutes before application. Seed by hand areas inaccessible to seeding equipment.

625.08 Mulching. If wood chips are used, do not import without approval. Apply mulch within 48 hours after seeding by the following methods:

(a) Dry method. Spread mulch material, except wood and grass cellulose fibers, by a mulch spreader utilizing forced air to blow the mulch material onto the seeded area. Apply straw mulch at a rate of 4000 pounds per acre. Anchor the mulch material with an approved tackifier or approved mechanical method. Do not mark or deface structures, pavements, utilities, or plant growth with tackifier.

(b) Hydraulic method. Apply mulch in a separate application from the seed using hydraulic-type equipment according to Subsection 625.07(b).

Apply wood fiber or grass straw cellulose fiber mulch at a rate of 2000 pounds per acre.

Apply bonded fiber matrix hydraulic mulch at a minimum rate of 3000 pounds per acre or as specified by the manufacturer. Apply so no hole in the matrix is greater than 0.04 inch. Apply so that no gaps exist between the matrix and the soil.

Mulch by hand areas inaccessible to mulching equipment.

625.09 Protecting and Caring for Seeded Areas. Protect and care for seeded areas including watering when needed. Repair or apply supplemental applications of seed, mulch, fertilizer, and water as many times as needed until vegetation is established. Vegetation is considered established when one of the following is attained:

(a) A uniform perennial vegetative cover with a density of 70 percent of the native background vegetative cover (percent vegetative cover before ground disturbance); or

(b) A uniform perennial vegetative cover with the density required by permits.

625.10 Acceptance. Material for turf establishment will be evaluated under Subsections 106.02 and 106.03.

Placing of turf establishment will be evaluated under Subsections 106.02 and 106.04.

Measurement

625.11 Measure the Section 625 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring turf establishment and supplemental applications by the acre, measure on the ground surface.

When measuring water by volume or mass, measure in the hauling vehicle or by metering.

Payment

625.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 625 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments will be paid as follows:

(a) 75 percent of the pay item amount will be paid after initial seeding and mulching.

(b) The remaining 25 percent of the pay item amount price will be paid after the final acceptance.

Section 626. — PLANTS, TREES, SHRUBS, VINES, AND GROUND COVERS

Description

626.01 This work consists of providing and planting trees, shrubs, vines, groundcovers, and other plants.

Material

626.02 Conform to the following Subsections:

Fertilizer	713.03
Miscellaneous planting material	713.08
Mulch	713.05
Plant material	713.06
Topsoil	713.01
Water for vegetation	725.01(b)

Construction Requirements

626.03 General. Do not plant in frozen ground, when snow covers the ground, or when the soil is saturated, extremely dry, cloddy, hard pan, not friable, or is otherwise unsatisfactory for planting.

Provide stock with a live and fibrous root system. Do not provide container-grown stock that is pot-bound, has a top system out of proportion (larger) than the size of the container, has rooting media that does not hold together when plant is removed from the container, or has roots growing out of the container.

Dig out transplants by gently removing the root ball. Ball and burlap the root ball before moving the transplant. Ensure the attached soil root ball diameter is at least two-thirds the size of the branch spread.

Transplant shrubs and small trees after plants have gone dormant. Harvest stakes from dormant plants.

Do not salvage trees or shrubs within 15 feet of a stream bank.

Tag each plant or groups of plants with a weatherproof tag showing species name and date of delivery.

Install plants received on site within 7 days.

626.04 Delivery. Notify the CO at least 30 days before delivery of material to allow the CO the opportunity to select material at the source. Submit commercial certifications and complete written information concerning the source of supply for plant material at least 14 days before delivery of plants to the project.

626.05 Protection and Temporary Storage. Package plants to provide protection against weather and breakage during transit. Tie and cover plants to prevent wind damage and dehydration when transporting by open vehicle. Pack and ventilate plants to prevent sweating when transporting by closed vehicle. Keep bare root plants below 35 °F during transport.

Keep growing media moist. Protect bark, branches, and root systems from damage. Replace damaged plants including plants with cracked or crushed root balls.

Protect plants not scheduled for immediate planting as follows:

(a) Keep bare root plants below 35 °F;

(b) Protect plants from over-exposure to sunlight and keep moist;

(c) Protect plants from animals and insects; and

(d) Hold salvaged woody species no more than 7 days.

626.06 Excavation for Plant Pits and Beds. At least 14 days before planting, submit planting locations and methods of planting for approval. Mark planting locations with stakes or flagging. Remove sod, weeds, roots, and other unsuitable material from the planting site. Excavate plant pits as follows:

(a) Width of excavation.

(1) For root spread or ball diameters up to 48 inches, excavate the pits circular in outline to the root spread plus 24 inches.

(2) For root spread or ball diameters over 48 inches, excavate one and one-half times the root spread.

(b) Depth of excavation. Excavate the pits to a depth that allows at least 6 inches of backfill under the roots or balls or excavate the pits to the following depths, whichever is deeper:

(1) Deciduous trees.

(a) Under 1½-inch caliper	24 inches deep
(b) Over 1½-inch caliper	36 inches deep

(2) Deciduous and evergreen shrubs.

(a) Under 2 feet height	12 inches deep
(b) Over 2 feet height	24 inches deep

(3) Evergreen trees.

(a) Under 5 feet height	8 inches plus ball height
(b) Over 5 feet height	12 inches plus ball height

(4) Vines and groundcovers. Double the size of the pot.

Loosen soil at the sidewalls and bottom of the plant pit to a depth of 6 inches before setting the plant.

Do not leave planting holes open overnight.

626.07 Setting Plants. Do not plant material until inspected and approved. Prepare a backfill mixture of 4 parts topsoil, loam, or selected soil to one part peat moss. Place backfill mixture in the bottom of the plant pit. Set plants approximately plumb and at the same level or slightly lower than the depth at which they were grown in the nursery or collected in the field. Set plants as follows:

(a) Bare root stock. Place bare rooted plants in the center of the plant pit with the roots properly spread in a natural position. Work backfill mixture around and over the roots, tamp as hole is being filled, and water thoroughly.

(b) Balled and burlapped stock. Handle and move plants by the ball. Place balled and burlapped plants in the prepared pits on tamped backfill mixture. Score the root ball to a depth of 1 inch along the entire side equally on 4 sides. Backfill around the plant ball to one-half of the depth of the ball. Tamp and thoroughly water. Cut the burlap and remove it from the upper half of the ball or loosen the burlap and fold it back. If wire baskets are used cut the wire from the upper half of the basket. Backfill the remainder of the plant with backfill mixture.

(c) Container-grown stock. Remove the container immediately before planting. Place plants in the prepared pits on tamped backfill mixture. Backfill the remainder of the plant with backfill mixture and tamp.

(d) Live stakes. Use a planting bar or other tool to plant live stakes in fine to medium textured soils. Make planting hole at least 24 inches deep and place one live stake in each hole. Place live stakes with the basal end pointed downward and in contact with the water table and with buds pointing upwards and the tip extending at least 5 to 7 inches above the soil surface. Backfill planting hole with topsoil and tamp soil around stake to ensure good soil to stem contact.

(e) Plugs. Plant plugs slightly beneath the level of the soil grade. Place soil around the plug, tamp, and water thoroughly.

626.08 Fertilizing. Fertilize using one of the following methods:

(a) Mix the fertilizer with the backfill mixture when it is prepared.

(b) Spread the fertilizer uniformly around the pit area of individual plants or over shrub beds. Cultivate the fertilizer into the top 2 inches of the backfill mixture.

626.09 Watering. Construct 4-inch-deep water basins around trees and 3-inch-deep water basins around shrubs. Make the diameter of the basin equal to that of the plant pit.

Water plants during and immediately after planting until final acceptance, and throughout the plant establishment period. Saturate the soil around each plant at each watering.

626.10 Guying and Staking. If guying and staking is specified, guy deciduous trees just below the first lateral branch and guy evergreen trees halfway up the height of the tree.

626.11 Pruning. Prune before or immediately after planting to preserve the natural character of each plant. Use experienced personnel to perform the pruning. Use accepted horticultural practices. Paint cuts over ¾ inch in diameter with tree wound dressing.

626.12 Mulching. Remove weeds and other live vegetation from pit and water basin areas around individual plants and from entire shrub beds. If wood chips are used, do not import without approval.

Place mulch within 24 hours after planting.

626.13 Plant Establishment Period. The plant establishment period starts after all plantings have been completed. The plant establishment period ends at 1-year after all plantings have been completed or final inspection, whichever occurs later. Employ necessary means to preserve the plants in a healthy growing condition during the plant establishment period. Water, weed, prune, adjust guys and stakes, and protect from animals, insects, and disease during the plant establishment period. At the end of the plant establishment period, remove guys and stakes.

An inspection of the plant material will be made 14 days before the end of the plant establishment period to identify dead, dying, or diseased plants for removal and replacement. During the following planting season, remove and replace identified plants. A final inspection of all plant material within 15 days after completion of all replacement planting will be the basis for final acceptance.

626.14 Acceptance. Material for plants, trees, shrubs, vines, and groundcovers (including fertilizer, mulch, and topsoil) will be evaluated under Subsections 106.02 and 106.03.

Planting of plants, trees, shrubs, vines, and groundcovers will be evaluated under Subsections 106.02 and 106.04.

Measurement

626.15 Measure the Section 626 pay items listed in the bid schedule according to Subsection 109.02.

Payment

626.16 The accepted quantities will be paid at the contract price per unit of measurement for the Section 626 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments will be paid as follows:

(a) 75 percent of the pay item amount will be paid after initial planting.

(b) The remaining 25 percent of the pay item amount price will be paid after the final acceptance.

Section 627. — SOD

Description

627.01 This work consists of providing and placing living sod of perennial turf-forming grasses.

Material

627.02 Conform to the following Subsections:

Agricultural limestone	713.02
Fertilizer	713.03
Pegs for sod	713.10
Sod	713.09
Water for vegetation	725.01(b)

Construction Requirements

627.03 General. Move and place sod during dry weather and on dry, unfrozen ground.

Avoid erosion when watering.

627.04 Delivery. Provide at least 3 days' notice before cutting sod. Obtain approval of the sod in its original position before cutting. Do not deliver sod until the soil is prepared.

627.05 Preparing the Soil. Clear and grade the surface. Cultivate, disk, harrow, or otherwise loosen the grade to a depth of at least 4 inches. Finish the surface to a smoothness comparable to hand raking. Remove surface stones not passing a 1-inch sieve. Remove sticks, stumps, and other surface debris that interfere with sod placement or subsequent growth.

Place topsoil according to Section 624 as shown in the plans.

Apply fertilizer and agricultural limestone uniformly over the sodding area. Mechanical spreaders or blower equipment may be used. Disk or till the fertilizer and limestone into the soil to a depth of 4 inches.

Moisten the prepared soil.

627.06 Placing Sod. Place sod within 24 hours after cutting or within 5 days after cutting if the sod is stored in moist stacks, grass-to-grass and roots-to-roots. Protect sod against drying and from freezing.

(a) Solid sod. Place sod perpendicular to drainage flows. Place sections of solid sod edge to edge with staggered joints. Plug openings with sod or fill openings with acceptable loamy seeded topsoil. Roll or tamp sod to eliminate air pockets and provide an even surface. On slopes 1V:2H or steeper and in channels, peg sod on 24-inch centers after rolling or tamping. Drive pegs flush with the sod bed surface.

(b) Spot sod. Place sod blocks. Roll or tamp the blocks into the soil until the sod surfaces are slightly below the surrounding ground surface.

Blend final grades with existing adjacent areas. Leave the entire area drainable and without abrupt changes in slope.

627.07 Maintaining Sodded Areas. Water sod to a depth of 4 inches after placing and keep moist.

Protect newly sodded areas using approved methods. Do not allow vehicles or equipment on newly sodded areas.

Mow sodded areas and repair or replace sodded areas that are damaged or fail to show a uniform growth of grass. Maintain sodded areas and replace nonliving sod until final acceptance of the project.

627.08 Acceptance. Material for sod (including lime and fertilizer) will be evaluated under Subsections 106.02 and 106.03.

Placing sod will be evaluated under Subsections 106.02 and 106.04.

Topsoil will be evaluated under Section 624.

Measurement

627.09 Measure the Section 627 pay items listed in the bid schedule according to Subsection 109.02.

Payment

627.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 627 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments will be paid as follows:

(a) 75 percent of the pay item amount will be paid after initial placement of sod.

(b) The remaining 25 percent of the pay item amount price will be paid after the final acceptance.

Section 628. — TEMPORARY STREAM DIVERSIONS

Description

628.01 This work consists of constructing, maintaining, and removing temporary stream diversions.

Material

628.02 Conform to the following Subsections:

Floating turbidity curtains	713.21
Gravel bags	713.13
Plastic lining	713.22
Rock for riprap	705.02
Sandbags	713.14
Sediment filter bags	713.19
Temporary culvert pipe	713.15

Construction Requirements

628.03 Submittals. At least 14 days before starting stream diversion work, submit the following according to Subsection 104.06:

(a) Drawings and written narrative showing the type, size, location, elevation, and method of installation and removal for the stream diversion, and means of access to waterways;

(b) A Fish and Aquatic Life Removal and Passage Plan. Include applicable Federal, state, and local permits and approvals;

(c) Sequence and schedule for the following:

(1) Installing and removing the diversion;

(2) Removal of water from the work area;

(3) Accessing the waterways; and

(4) Fish and aquatic life removal from the work area.

(d) Best management practices used to ensure minimization of erosion and turbidity;

(e) Description of all construction stages;

(f) A list of on-site backup materials and equipment for emergency use; and

(g) Capacity calculations and hydraulic profile in an approved hydraulic modeling software.

628.04 General. Provide a stream diversion system for expected flow during in-water work activities that accommodates at least a 2-year peak flood event. Additional flow capacity may be required when in-water work activities occur during higher flow periods. Divert sufficient flow to sustain fish and aquatic life downstream. Do not constrict flow such that fluctuations in water depth, flow volume, and velocity cause erosion upstream or downstream of the project.

628.05 Diverting Stream Flow. Use materials that are non-erosive for the expected flows.

Maintain and control water flow downstream of the isolated work area for the duration of the diversion. Inspect and clean diversions of debris or sediment accumulation daily or according to an approved schedule.

If required, install floating turbidity curtains within a body of water to minimize the migration of sediment laden water out of the construction area.

Divert the stream using one of the following methods and according to Section 107:

(a) In-stream diversion. Place diversion berm, working from upstream end to downstream end. Maintain at least half-width channel flow. Minimize disturbance of channel bed. Minor quantities of in-stream material can be moved to help seal and secure diversion structures.

(b) Diversion channel. Excavate, stabilize, maintain, and operate the stream diversion channel to carry the diverted stream flow. Stockpile excavated materials in areas outside of the floodplain. Excavate the diversion channel with barriers installed at both ends of the diversion channel so stream flow does not prematurely enter the diversion channel.

Line the entire length and width of the diversion channel with plastic liner or riprap according to Section 251. If plastic liner does not span the channel from bank to bank, place seams perpendicular to the flow and place upstream sections overlapping at least 18 inches of the downstream section. Lay plastic liner flat on the channel in direct contact with the soil without any void spaces. Remove sharp objects to avoid puncturing the plastic liner. Ensure that the liner is secured at the upstream end of the channel and along the channel before removing barriers and diverting stream flow.

(c) Temporary culvert pipe diversion. Size and locate culvert pipe to minimize potential erosion. Stabilize the upstream and downstream ends of the culvert pipe to minimize erosion. Install the culvert pipe according to Section 602, and build the upstream flow barrier, followed by the downstream flow barrier.

(d) Bypass pumping diversion. Install the upstream barrier first, followed by the downstream barrier. Suspend the intake above the channel bottom to prevent sediment from entering the intake. Place a mesh screen over the intake with a minimum mesh size of $^{3}/_{32}$ inch. Enclose the intake with a secondary screen box 3 feet on each side if velocities at the intake are greater than 0.4 feet per second. Stabilize the discharge point at the downstream end to avoid erosion. Have spare pumps on site in the event of pump failures or higher than expected flow rates. Place the pump on firm ground with secondary containment measures.

Remove water from the isolated work area as necessary to perform the work. Dispose of water according to Federal, state, and local rules and regulations. Do not discharge sediment laden water directly or indirectly to wetlands or waters. Pump water from the isolated work area to a temporary storage and treatment site or into upland areas and allow water to infiltrate. Control erosion at the discharge point.

628.06 Removal of Stream Diversions. Upon completion of in-water work activities, restore isolated work area to match original or planned contours. Slowly restore stream flow to prevent loss of surface water downstream. Ensure isolated work area is stabilized and streambed material is washed down to remove dirt and fine sediment before stream flow is restored to prevent sudden releases of suspended sediment. Maintain sufficient stream flow downstream of the project to prevent stranding of aquatic life.

Remove temporary flow barriers and diversion structures. Restore existing stream bank and floodplain topography, including restoring areas used for stream diversion to match original or planned contours.

628.07 Acceptance. Material for stream diversions will be evaluated under Subsections 106.02 and 106.03.

Construction, maintenance, and removal of stream diversions will be evaluated under Subsections 106.02 and 106.04.

Culvert pipe will be evaluated under Section 602.

Riprap will be evaluated under Section 251.

Measurement

628.08 Measure the Section 628 pay items listed in the bid schedule according to Subsection 109.02.

Payment

628.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 628 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for temporary stream diversions by the lump sum will be paid as follows:

(a) 50 percent of the pay item amount will be paid after installation.

(b) The remaining portion of the pay item amount will be paid after the temporary stream diversions are removed from the project.

Section 629. — ROLLED EROSION CONTROL PRODUCTS AND CELLULAR CONFINEMENT SYSTEMS

Description

629.01 This work consists of constructing and installing RECP and cellular confinement systems.

629.02 Definitions.

(a) Mulch control netting. A planar woven natural fiber or extruded geosynthetic mesh used as a temporary degradable RECP to anchor loose fiber mulches.

(b) Open weave textile. A temporary degradable RECP composed of processed natural or polymer yarns woven into a matrix, used to provide erosion control and facilitate vegetation establishment.

(c) Erosion control blanket. A temporary degradable RECP composed of processed natural or polymer fibers mechanically, structurally, or chemically bound together to form a continuous matrix, used to provide erosion control and facilitate vegetation establishment.

(d) Turf reinforcement mat. A permanent non-degradable RECP designed for critical hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation.

Material

629.03 Conform to the following Subsections:

Cellular confinement systems	713.07
Rolled erosion control products	713.17
Topsoil	713.01
Turf reinforcement mats	713.18

Construction Requirements

629.04 General. Make the soil surface stable, firm, and free of rocks and other obstructions. Install RECP and cellular confinement systems according to the manufacturer's recommendations and to the following minimum guidelines. Apply turf establishment according to Section 625.

In areas to be mowed soon after installation, use temporary RECP consisting of rapidly degrading netting with a functional longevity of 3 months or less.

629.05 Netting or Open Weave Textile (RECP, Types 1.A, 2.A, and 3.A). Apply mulch according to Subsection 625.08(a). Immediately after mulching, install netting or open weave textile according to Subsection 629.06.

629.06 Erosion Control Blanket, Open Weave Textile, and Turf Reinforcement Mat (RECP, Types 1.B, 1.C, 1.D, 2.B, 2.C, 2.D, 3.B, 4.A, 4.B, 5.A, 5.B, 5.C, 5.D, 5.E, and 5.F). Unless soil in-filling is required, complete turf establishment work before installing RECP.

If soil in-filling is required, first install RECP. Then apply seed and lightly brush or rake ¼ to ¾ inch of topsoil into the voids in the RECP leaving only the top netting exposed.

Unroll the RECP parallel to the primary direction of flow and place it in direct contact with soil surface. Do not stretch or allow RECP to bridge over surface inconsistencies. Overlap edges of adjacent RECP by 3 to 4 inches or according to the plans. Use fasteners according to the plans and use enough fasteners to prevent seam separation. Overlap roll ends of joining RECP 6 inches or according to the plans in the direction of flow.

(a) Slope installations. At the top of slope, anchor the RECP by one of the following methods:

(1) Fasteners. Install the RECP 36 inches over the shoulder of the slope onto flat final grade. Secure with a single row of fasteners on 12-inch centers or according to the plans.

(2) Anchor trench. Construct a 6- by 6-inch trench. Extend the upslope terminal end of the RECP 36 inches past the trench. Use fasteners on 12-inch centers to fasten the RECP into the trench or according to the plans. Backfill the trench and compact the soil. Secure the terminal end with a single row of fasteners on 12-inch centers and cover the end with soil. Apply turf establishment.

(3) Check slot. Install two rows of staples 4 inches apart on 4-inch centers across the top edge of the RECP. Drive fasteners flush with soil surface.

Securely fasten RECP to the soil by installing fasteners at a minimum rate of 1.5 per square yard.

(b) Channel installations. At the start of the channel, construct a full width anchor trench according to Subsection 629.06(a)(2). Construct additional anchor trenches or check slots at intervals along the channel reach and at the channel end according to Subsection 629.06(a)(2) or (a)(3) and the manufacturer's installation guidelines.

Securely fasten RECP to the soil by installing staples at a minimum rate of 2 per square yard. Significantly higher anchor rates may be necessary in sandy, loose, or wet soils and in severe applications.

Repair damaged areas immediately by restoring soil to finished grade, reapplying turf establishment, and replacing the RECP.

629.07 Cellular Confinement Systems. Excavate to the depth of the cellular confinement system and smooth and compact the slope. Install the top of the system flush or lower than the adjacent slope. Expand the geocell down the slope. Connect adjacent geocell sections with hog rings or staples in every other cell.

Anchor the system with wooden stakes across the top at every other cell. Repeat the anchoring pattern in every tenth row and in the bottom row. Drive stakes to a minimum embedment of 12 inches below the base of the cellular confinement layer.

Backfill the cells with material as shown in the plans. Compact the material within each cell. Apply turf establishment according to Section 625, where shown in the plans.

629.08 Acceptance. Material for RECP and cellular confinement system will be evaluated under Subsections 106.02 and 106.03.

Installation of RECP and cellular confinement systems will be evaluated under Subsections 106.02 and 106.04.

Material for topsoil will be evaluated under Subsection 106.02.

Placing topsoil will be evaluated under Subsections 106.02 and 106.04.

Turf establishment will be evaluated under Section 625.

Measurement

629.09 Measure the Section 629 pay items listed in the bid schedule according to Subsection 109.02.

Payment

629.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 629 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 630. — RESERVED

Section 631. — RESERVED

Section 632. — LOCATING UTILITIES

Description

632.01 This work consists of locating, marking, and providing a record of existing underground utilities.

Construction Requirements

632.02 General. Follow the requirements of FAR Clause 52.236-3 Site Investigation and Conditions Affecting the Work. The locations of existing utilities shown in the plans are approximate.

Locate, protect, and repair utilities according to Section 107.

632.03 Locating Utility. Use appropriate means to locate utilities including, but not limited to, geophysical prospective techniques, and electromagnetic, sonic, or other energy field devices to establish alignment of utilities where applicable. Thread a traceable duct rod through non-metallic utility pipes to locate them.

Locate the utility by perpendicular trench or test pits, if approved. Excavate to the assumed depth using hand tools as needed to avoid disturbing utilities. If excavating within roadway pavements where traffic is being maintained, excavate by air-vacuum methods or equivalent, keeping the area of disturbance to a minimum. Uncover the utility sufficiently to make accurate measurements. Restore test pit or trenched areas to their original condition. Excavate and backfill according to Section 209.

If a conflict exists, cooperate with the utility owner according to Section 107.

632.04 Reporting. Submit a report of the utility locate within 48 hours. In the report, describe each utility found, the locating methods utilized, plan and profile mapping of the utility, photographs, and recommendations for mitigation or relocation.

632.05 Marking. Mark the utility location by flags or paint. Maintain the markings for the duration of the project.

632.06 Acceptance. Locating utilities will be evaluated under Subsection 106.02.

Excavation and backfill will be evaluated under Section 209.

Measurement

632.07 Measure the Section 632 pay items listed in the bid schedule according to Subsection 109.02.

Payment

632.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 632 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for lump sum pay items will be prorated based on total work completed under this Section.

Section 633. — PERMANENT TRAFFIC CONTROL

Description

633.01 This work consists of installing and removing and resetting permanent traffic control devices.

Material

633.02 Conform to the MUTCD and the following Section:

Traffic signing and marking material	718

Construction Requirements

633.03 General. Provide and install permanent traffic control devices according to the MUTCD and as shown in the plans. Provide traffic control devices that are crashworthy. Current state-approved permanent traffic control devices may be used if approved. Install permanent traffic control devices according to the manufacturer’s recommendations.

Sign locations may be changed to fit field conditions as approved. Determine sign support lengths at time of staking.

633.04 Sign Posts. Install sign posts plumb and according to the manufacturer’s recommendations.

Drive sign posts with a suitable driving head or set posts in drilled or punched holes. Backfill and compact sign post holes with suitable material in 6-inch lifts until no visible evidence of further consolidation. Excavate, construct, and backfill concrete footings according to Section 601.

633.05 Sign Panels. Mount sign panels with the legend horizontal.

Use oversized bolt heads and neoprene or nylon washers for fastening plastic sign panels.

Use antitheft fasteners. Cover exposed fasteners on the sign panel face with material matching the background of the panel.

Turn sign panels 3 degrees away from the road in the direction of travel to reduce specular glare (mirror reflection).

Cover the sign face with an opaque material if a sign message is not applicable. Maintain the covering in good condition until the message becomes applicable. Do not use adhesive tape on the sign face.

633.06 Delineators and Object Markers. Attach delineators and object markers to posts according to the manufacturer’s recommendations or as specified.

633.07 Rumble and Mumble Strips. Construct rumble and mumble strips within 2 inches of the specified alignment. Ensure that indentations conform to the specified dimensions within ¼ inch in length and ¼ inch in width and that the depth of the indentation is within the range of ½ inch to ⅝ inch.

Dispose of excess material according to Subsection 203.07.

633.08 Metal Frame Road Closure Gates. Construct concrete foundations according to Section 601. Fabricate gates according to Section 555. Assemble and install gates as shown in the plans. Submit drawings according to Subsection 104.06.

Coat according to Section 563. Provide and install signs, retroreflective sheeting, and object markers as shown in the plans.

633.09 Removing and Resetting Permanent Traffic Control Devices. Salvage existing traffic control devices according to Subsection 203.04. Reset as necessary. Replace traffic control devices damaged during removal, storage, and resetting.

633.10 Acceptance. Material for permanent traffic control devices will be evaluated under Subsections 106.02 and 106.03.

Installation of permanent traffic control devices will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Steel structures will be evaluated under Section 555.

Minor concrete will be evaluated under Section 601.

Measurement

633.11 Measure the Section 633 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring sign panels by the square foot, measure front face. Measure each sign panel in a multiple configuration.

When measuring sign systems by the square foot, measure front face of each sign panel.

When measuring sign systems by the each, measure each system as one regardless of the number of sign panels.

When measuring removing and resetting permanent traffic control devices, measure after they are reset.

When measuring rumble or mumble strips by the linear foot or mile, measure the length of rumble or mumble strip constructed parallel to the roadway centerline. Do not subtract for gaps in rumble or mumble strips.

Do not measure signs, retroreflective sheeting, and object markers installed on road closure gates.

Do not measure supports for sign systems.

Payment

633.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 633 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 634. — PERMANENT PAVEMENT MARKINGS

Description

634.01 This work consists of applying markings and markers on finished pavement.

Pavement markings are designated as follows:

Type A – Solventborne pavement markings
Type B – Waterborne pavement markings
Type C – High-build waterborne pavement markings
Type D – Epoxy pavement markings
Type H – Thermoplastic pavement markings
Type J – Preformed pavement marking tape
Type L – Methyl methacrylate pavement markings

Material

634.02 Conform to the MUTCD and the following Section:

Traffic signing and marking material	718

Construction Requirements

634.03 General. Where existing and final marking locations are identical, stake the limits of existing markings before starting pavement work.

Submit manufacturer's SDS and product data sheets at least 7 days before applying markings. A field demonstration may be required to verify the adequacy of the material.

Ship marking material containers plainly marked with the following information as appropriate for the material being provided:

(a) Manufacturer's name and address;

(b) Name of product;

(c) Lot and batch numbers;

(d) Color;

(e) Net mass and volume of contents;

(f) Date of manufacture;

(g) Date of expiration;

(h) Statement of contents;

(i) Mixing proportions (if mixing of components is required); and

(j) Safety information.

Establish marking patterns and locations according to the MUTCD and as shown in the plans.

In curve widening areas, establish the edge line markings at the limits of the traveled way and the centerline markings equal distance between the edge lines.

Remove loose particles, dirt, tar, grease, and other deleterious material from the surface to be marked. Where markings are placed on rigid pavement less than 1-year old, clean the pavement of laitance and curing compounds.

Remove temporary markings the same day permanent markings are applied. Remove temporary and conflicting makings according to Subsection 635.14 before applying permanent markings.

Wait at least 14 days before applying markings on new asphalt pavements or new asphalt surface treatments. Apply markings to a clean, dry surface and according to the manufacturer's recommendations. Produce markings that are clean-cut and uniform in appearance by day and night.

Current state-approved marking material may be used if approved.

Apply glass beads at the rate, type, and timing according to the manufacturer's recommendations and immediately following marking application to ensure adhesion.

Protect markings from traffic until dried to a no-tracking condition. Remove tracking marks, spilled marking material, markings in unauthorized areas, and defective markings.

634.04 Solventborne Pavement Markings (Type A). Apply markings when pavement and air temperatures are at 35 °F and rising. Do not heat the markings above 120 °F. Spray markings to a 15-mil minimum wet film thickness or at a rate of 107 square feet per gallon.

On new asphalt pavements or new asphalt surface treatments, apply two coats of markings and glass beads. Apply second coat after first coat is track free.

634.05 Waterborne Pavement Markings (Type B). Apply markings when pavement and air temperatures are 50 °F and rising.

Do not heat the markings above 120 °F. Spray markings at a 15-mil minimum wet film thickness or at a rate of 107 square feet per gallon.

On new asphalt pavements or new asphalt surface treatments, apply two coats.

634.06 High-Build Waterborne Pavement Markings (Type C). Apply markings when pavement and air temperatures are 50 °F and rising.

Spray markings at 25-mil minimum wet film thickness or at a rate of 71 square feet per gallon.

634.07 Epoxy Pavement Markings (Type D). Apply epoxy when pavement and air temperatures are 35 °F and rising. Heat components according to the manufacturer's recommendations. Apply to a 25-mil minimum dry film thickness or at a rate of 71 square feet per gallon.

634.08 Thermoplastic Pavement Markings (Type H). Apply thermoplastic when pavement and air temperatures are 50 °F and rising. Heat thermoplastic according to the manufacturer's recommendations.

Apply an epoxy resin primer and sealer according to the thermoplastic manufacturer's recommendations if placing markings on pavements more than 2-years old, oxidized, or having exposed aggregates. Allow the primer and sealer to dry.

For edge lines, apply thermoplastic to a 60-mil dry film thickness. For other lines, apply thermoplastic to a 90-mil dry film thickness.

634.09 Preformed Pavement Marking Tape (Type J). Use preformed marking tape containing retroreflective beads. Install to form a durable, weather resistant bond to the pavement. Apply preformed markings according to the manufacturer's recommendations.

634.10 Methyl Methacrylate Pavement Markings (Type L). Apply a two-component methyl methacrylate marking at a minimum thickness of 60 mils for longitudinal markings and 120 mils for transverse markings and symbols. Apply markings when pavement and air temperatures are between 40 °F and 105 °F. Apply according to the manufacturer's recommendations.

634.11 Pavement Markers. Install raised and recessed pavement markers when the pavement and air temperatures are 50 °F and rising. Apply pavement markers with an epoxy resin adhesive according to the manufacturer's recommendations when the pavement is dry. Space the markers according to the MUTCD and as shown in the plans.

634.12 Acceptance. Material for permanent pavement markings and markers will be evaluated under Subsections 106.02 and 106.03.

Applying permanent pavement markings and markers will be evaluated under Subsections 106.02 and 106.04.

Measurement

634.13 Measure the Section 634 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When two coats of markings are required, measure each coat.

When measuring pavement markings by the linear foot or mile, measure the length of line applied along the centerline of each line applied regardless of color. Measure broken and dotted pavement lines from end to end of the line including gaps. Measure solid pavement lines from end to end of each continuous line. Measure line quantities based on a 4-inch-wide line. For line widths greater than 4 inches, adjust the measured length of line in the ratio of the required width to 4 inches.

When measuring pavement markings by the square foot, measure the number of square feet of line, symbol, or letter marking based on the marking area shown in the plans. If not shown, measure the area of each marking in place to the nearest square foot.

Payment

634.14 The accepted quantities will be paid at the contract price per unit of measurement for the Section 634 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 635. — TEMPORARY TRAFFIC CONTROL

Description

635.01 This work consists of providing, installing, maintaining, relocating, and removing temporary traffic control devices and services as ordered for the control and protection of public traffic through the project.

Advance warning arrow board, barricade, and warning light types are designated in the MUTCD.

Material

635.02 Conform to the MUTCD and the following Section and Subsections:

Emulsified asphalt	702.02
Temporary plastic fence	710.08
Traffic signing and marking material	718

Construction Requirements

635.03 Qualifications. At least 30 days before starting work, submit the following for approval:

(a) Flaggers. Appropriate certifications from ATSSA, the National Safety Council, a state department of transportation, or other approved organization;

(b) Pilot car operators. Appropriate certifications; and

(c) TCS. Certifications according to Subsection 156.02.

635.04 General. Provide, install, and maintain temporary traffic control devices adjacent to and within the project according to the MUTCD, temporary traffic control plan, and Section 156. Install and maintain traffic control devices as follows:

(a) Provide and install temporary traffic control devices before the start of construction operations.

(b) Install only those temporary traffic control devices needed for each stage or phase.

(c) Relocate temporary traffic control devices as necessary.

(d) Immediately replace devices that are lost, stolen, destroyed, or inoperative.

(e) Provide and maintain temporary traffic control devices that meet the *acceptable* standard described in ATSSA, *Quality Guidelines for Work Zone Traffic Control Devices*. Modify the ATSSA standards as follows:

(1) Repair or remove and replace *marginal* devices within 48 hours.

(2) Repair or remove and replace *unacceptable* devices immediately.

(f) Remove temporary traffic control devices upon contract completion or when approved.

(g) Provide crashworthy temporary traffic control devices.

635.05 Barricades. Use barricades of the type and size specified.

635.06 Cones and Tubular Markers. Use cones or tubular markers of the height specified.

635.07 Construction Signs. Install posts according to Subsection 633.04. Portable sign supports may be used instead of sign posts if approved. Submit ballasting for approval. Do not install sign supports on sidewalks, bicycle facilities, or areas designated for pedestrian or bicycle traffic.

Remove or completely cover unnecessary signs.

Use crashworthy posts within the traversable area adjacent to traffic.

635.08 Drums. Use plastic drums that are at least 36 inches high and at least 18 inches in diameter.

635.09 Traffic Control Supervisor. Perform services described in Subsection 156.08.

635.10 Flaggers. Use certified flaggers according to Subsection 635.03. Do not use flags alone.

635.11 Pilot Cars. Use certified pilot car operators according to Subsection 635.03. Mount a high-intensity, rotating, flashing, or oscillating light on the roof of the pilot car.

635.12 Portable Traffic Barriers. Use temporary barriers that are crashworthy. Lifting holes no larger than 4 inches or lifting loops are allowed. Mount white or yellow retroreflectors, as applicable, to the top or side of the barrier on 25-foot centers. Mount the retroreflectors at a uniform height at least 24 inches above the road surface. Flexible barrier delineators or barrier delineation tape may be used instead of retroreflectors if approved.

635.13 Temporary Guardrail. Construct temporary guardrail according to Section 617.

Mount white or yellow retroreflectors, as applicable, to the top or side of the guardrail on 25-foot centers. Mount the retroreflectors at a uniform height at least 24 inches above the road surface.

635.14 Temporary Pavement Markings and Delineation. Before opening a pavement surface to traffic, remove conflicting pavement markings. Make the removal pattern uneven to not perpetuate the outline of the removed pavement markings. Lightly coat removal areas on asphalt surfaces with emulsified asphalt.

Place and maintain temporary pavement markings that are neat, crack free, true, straight, and unbroken.

If temporary signs and pavement markers are substituted for temporary pavement markings, install temporary signs and pavement markers as shown in the plans.

For temporary pavement markings, use the following:

(a) Preformed retroreflective tape. Apply according to the manufacturer's recommendations. Remove loose preformed retroreflective tape before placing additional pavement lifts.

(b) Pavement markers. Do not use pavement markers during seasonal suspensions. If chip seals, slurry seals, or tack coats are used after marker placement, protect the markers with an approved protective cover, and remove it after the asphalt material is sprayed. Install according to the manufacturer's recommendations.

(c) Traffic paint. Do not apply traffic paint to the final surface. Apply traffic paint as the temporary pavement marking if no work will be performed on the project for at least 30 days. Apply waterborne traffic paint according to Section 634.

Remove temporary pavement markings before placing additional pavement lifts or permanent pavement markings unless approved. Remove temporary markers after 14 days and apply permanent pavement markings unless approved.

635.15 Warning Lights. Use warning lights of the types shown in the plans or according to the MUTCD. Install warning lights with a minimum mounting height of 30 inches to the bottom of the lens. Secure lights to the top of the traffic control device they are supplementing. Use batteries recommended by the light manufacturer. Mount large batteries below windshield height and preferably on the ground. Replace batteries when they no longer provide satisfactory performance.

Use Type C steady-burn warning lights for delineation on barricades or drums. Use Type A low-intensity flashing warning lights on the first 2 barricades or drums in the merging or shifting taper series. Use Type B high-intensity flashing warning lights on the first two advance warning signs.

635.16 Shadow Vehicle. Use a 19,800±990 pound shadow vehicle equipped with a truck-mounted attenuator attached to the rear of the vehicle, an exterior flashing yellow dome light, and an arrow board.

Use the shadow vehicle to provide physical protection to workers from traffic approaching from the rear during moving operations.

If using a shadow vehicle, submit a plan for using a shadow vehicle and associated lane closures to traffic.

635.17 Pavement Patch. Use an approved hot asphalt mix or commercially available cold asphalt mix to repair potholes and rough spots in the traveled way before reopening travel lanes to traffic. If cold asphalt mix is used, remove and replace with approved hot asphalt mix before placing succeeding hot asphalt lifts.

635.18 Crash Cushions. Use a crashworthy temporary crash cushion according to the manufacturer's recommendations.

635.19 Traffic Signal System. Provide the names and telephone numbers of at least two emergency contacts who can be reached 24 hours a day, and who are available to arrive on site within 4 hours of notification to repair or replace malfunctioning temporary signal equipment. In addition, provide emergency flaggers who can be reached 24 hours a day, and who are available to perform traffic control operations within the timeframes specified below until the temporary signal system is operable.

If the traffic signal malfunctions during construction operations, immediately start traffic control operations using flaggers until the system is returned to normal signal operation. Complete traffic signal repairs within 6 hours of the malfunction.

If the traffic signal malfunctions during a period when no construction activity is taking place, start traffic control operations using flaggers as soon as possible, but no later than 2 hours after the initial notification.

Continue temporary flagging operations until the system is returned to normal signal operation. Complete traffic signal repairs within 12 hours of notification.

635.20 Temporary Plastic Fence. Use temporary plastic fence according to Section 619.

635.21 Portable Rumble Strip. Before placing portable rumble strips, clean the roadway free of dust, sand, and other materials that may cause slippage. Use portable rumble strips that can be installed without adhesives or bolts and have a minimum weight of 105 pounds, and a non-slip textured surface on the rumble strip face.

635.22 Steel Plates. Use 1-inch or thicker steel plates that can safely carry traffic. Secure the plates to the pavement to prevent movement.

635.23 Advance Warning Arrow Board. Conform to the MUTCD.

635.24 Portable Changeable Message Sign. Ensure that the portable changeable message sign (PCMS) display panel is raised to a fully upright position and is fully visible to motorists. Reduce the intensity of the lights when using PCMS at night. Use approved messages. Limit messages to two phases unless approved. Use a display time for each phase between 2 and 3 seconds.

635.25 Acceptance. Material for temporary traffic control devices will be evaluated under Subsections 106.02 and 106.03.

Vehicles for pilot cars and shadow vehicles will be evaluated under Subsections 106.02 and 106.04.

Placement of temporary traffic control devices will be evaluated under Subsections 106.02 and 106.04.

Temporary traffic control services will be evaluated under Subsection 106.02.

Temporary guardrail will be evaluated under Section 617.

Temporary plastic fence will be evaluated under Section 619.

Waterborne traffic paint will be evaluated under Section 634.

Measurement

635.26 Measure the Section 635 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

When measuring temporary traffic control pay items, measure only one time even if relocated or replaced.

When measuring barricades by the linear foot, measure barricades by the width.

When measuring construction signs by the square foot, measure front face sign panel. Do not measure posts and temporary supports.

When measuring moving portable traffic barriers, do not measure movement of portable traffic barriers for work access or the convenience of the Contractor.

When measuring temporary pavement markings by the linear foot or mile, measure along the centerline of the roadway. Measure temporary pavement markings as a single measurement, inclusive of all markings, from end to end regardless of color, material type, or number of lines. Do not deduct for standard gaps between stripes.

When measuring temporary pavement markings by the square foot, measure the number of square feet of symbols or letter markings based on the marking area shown in the plans or, if not shown, the area of each marking measured in place to the nearest square foot.

Measure temporary pavement markers used at the option of the Contractor instead of temporary pavement markings as equivalent temporary pavement markings and not as temporary pavement markers.

When measuring pavement marking removal, measure the actual line removed. Do not measure gaps.

When measuring moving crash cushion by the each, do not measure movement of crash cushion for work access or the convenience of the Contractor.

When measuring replacement barrels or cartridges for crash cushions by the each, measure barrels or cartridges damaged by public traffic.

Measure flaggers for each hour a person is performing the work. Do not measure time required to set up and take down required signage.

Do not measure flagging performed by the Traffic Control Supervisor.

Do not measure flaggers used in place of a malfunctioning or inoperable temporary signal system.

Payment

635.27 The accepted quantities will be paid at the contract price per unit of measurement for the Section 635 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

(a) Progress payments for temporary traffic control devices and markings will be paid as follows:

(1) 50 percent of the pay item amount will be paid after installation.

(2) An additional 25 percent of the pay item amount will be paid after 50 percent of the total work is completed in the contract.

(3) The remaining portion of the pay item amount will be paid after the temporary traffic control devices and markings are removed from the project.

(b) Progress payments for temporary traffic control by the lump sum will be paid as follows:

(1) 25 percent of the pay item amount will be paid after initial construction signs are in place and needed devices onsite for use.

(2) An additional 65 percent of the pay item amount will be prorated based on total work completed in the contract.

(3) The remaining portion of the pay item amount will be paid after the construction signs and devices are no longer needed and have been removed from the project.

(c) Progress payments for pay items paid for by the hour, or day, will be paid at 100 percent of the pay item amount.

Section 636. — TRAFFIC SIGNAL, TRAFFIC COUNTER, LIGHTING, AND ELECTRICAL SYSTEMS

Description

636.01 This work consists of installing, modifying, relocating, or removing traffic signals, traffic counter, flashing beacons, highway lighting, sign illumination, communication conduits, and electrical systems or provisions for future systems.

Material

636.02 Conform to the following Subsections:

Backer rod	712.01(f)
Electrical material	721.01
Joint sealant and crack fillers	712.01(a)
Lighting material	721.02
Underground precast concrete utility structures	725.09(d)

Construction Requirements

636.03 Regulations and Codes. Provide material and workmanship conforming to the standards of the National Electrical Code (NEC), local safety code, UL, NEMA, Insulated Cable Engineers Association (ICEA), and IMSA.

Obtain permits, arrange for inspections, and pay fees necessary to obtain electrical service.

Provide luminaires with crashworthy supports.

Notify the CO, local traffic enforcement agency, utility companies, or railroad company at least 7 days before operational shutdown to coordinate connections or disconnections to an existing utility or system.

636.04 General. At least 14 days before starting system installation work, submit a list of proposed equipment and material according to Subsection 104.06. Include the manufacturer's name, size, and identification number of each item. Supplement the list with drawings and wiring diagrams showing locations and details of equipment and wiring.

Obtain approval for the exact location of the systems.

Remove structures and obstructions according to Section 203. Salvage material that meets requirements for reuse in the work. Excavate and backfill according to Section 209. Construct minor concrete according to Section 601. Install signs according to Section 633.

If roadways are to remain open to traffic, maintain the existing systems in operation until final connection to the modified circuit to minimize traffic disruptions.

636.05 Conduit. Cut conduit so the ends are smooth. Connect conduit sections with couplings to butt the ends of both conduits squarely against each other inside the couplings. Provide a metal expansion and deflection fitting where conduit crosses a structural expansion joint.

Install conduits continuous between outlets with at least couplings to allow pulling conductors. End conduit with bell fittings or bushings. Provide pull wires for conduits designated for future cable installation.

Remove and replace crushed, deformed, or damaged conduit. Maintain conduits clean and dry and protect ends of conduit with plugs, caps, or fittings.

Size pull boxes to provide for termination of the conduit and connection of the conductors.

636.06 Traffic Signal and Lighting Systems. Provide systems conforming to the MUTCD or state adopted supplements to the MUTCD for the state in which the system is located. Design systems to operate according to IMSA or NEMA or both.

636.07 Traffic Counter and Traffic Counter Components. Obtain approval of traffic counter and traffic counter components before installation.

Mount a fan inside the cabinet and position to direct the majority of airflow over the traffic counter and modem. Mount a fan thermostat at the top of the cabinet and minimize its interference with other cabinet components. Run the fan until the cabinet temperature decreases 20 degrees below the turn-on temperature.

Before powering-on equipment within the cabinet provide a copy of the following:

(a) Voltages for solar power supplies; and

(b) Telephone number, IP address, or both, for communication devices.

If using solar-powered panels, include a minimum 20-watt solar panel (that can produce at least 36 watt hours per day) and a minimum 12-volt, C100 36-ampere-hour, gel type battery that can power the cabinet electrical components for at least 25 days.

Frame the solar panel with bronze anodized extruded aluminum. Mount a weatherproof connection on the back of the solar panel to connect the output cable to the solar panel cable. Ensure all cell modules have been approved for application in NEC Class I, Division 2, Group D hazardous location.

Mount and orient the cabinet to provide an unobstructed, direct line of sight to the roadways that contain count station and vehicle detection equipment when cabinet door is opened. Install traffic counter and communications devices inside cabinet.

Identify and label loop wires inside each pull box in which the loop wires enter. Maintain consistent wiring identification and labeling when entering the cabinet and with connection to the traffic counter. Use water resistant material for wiring identification and labeling. Obtain approval for loop wire assignments at all locations.

636.08 Rectangular Rapid-Flashing Beacons. Provide and install rectangular rapid-flashing beacons according to the MUTCD.

636.09 Traffic Loop. Do not install loops when the pavement is wet. Saw cut, wire, and seal loop wires on the same day. Do not allow vehicular traffic to pass over an open saw cut unless protected.

Wet cut clean, smooth, well-defined, ⅜-inch wide saw cuts at a depth to allow 2 to 2½ inches of cover without damaging the adjacent pavement. Drill 1½-inch diameter loop corners matching the saw cut depth. For the lead-in channel, saw clean, smooth, well-defined, $^{5}/_{8}$-inch-wide cuts providing a minimum cover of 2 inches. Ensure saw cuts are straight with less than ½-inch error in a 10-foot line. Saw cut the lead-in to the pull box as close as possible to the edge of pavement. Thoroughly clean the saw cut of foreign material with compressed air and water blasting. Dry the joint with compressed air.

Install the loop wire in one continuous length at the bottom of the cut using a $^{3}/_{16}$- to ¼-inch thick rounded, smooth wood paddle. Install without kinks, curls, or other damage to the wire or its insulation. Replace damaged wires. Hold the loop wire in place with 1-inch lengths of ½-inch backer rod spaced at 2-foot intervals.

For the number of loop wire turns, conform to Table 636-1.

Table 636-1
Required Number of Loop Wire Turns

Required Number of Loop Wire Turns	Number of Turns
≤ 200	3
>200 to 500	4
>500 to 700	5

If the loop wire crosses a crack or joint, use a plastic sleeve that extends 4 inches on each side of the crack or joint. Provide extra loop wire in the sleeve for joint expansion and contraction.

Twist the loop lead-in wires 6 twists per foot from the loop to the pull box. Do not twist different loop pairs together. Color code the wires of each loop using colored vinyl electrical tape for identification of separate loops inside each pull box, as shown in Table 636-2. Coil 18 inches of lead-in slack in the pull box for each loop.

Table 636-2
Loop Labeling Convention

Loop	# of Identifiers	Color
Loop 1	1	Red
Loop 2	1	White
Loop 3	1	Green
Loop 4	1	Blue
Loop 5	2	Red
Loop 6	2	White
Loop 7	2	Green
Loop 8	2	Blue

Before applying sealant, test the loop and lead-in for continuity and resistance by applying a 1000-volt megohmmeter between each end of the loop lead-in and the nearest reliable electrical ground. If no available ground exists, establish a ground for the measurement. Record the location and megohmmeter readings and submit readings and test equipment data to the CO. Replace the loop if the insulation resistance measure to earth ground is greater than 100 megohms at 500 volts direct current, the inductance is less than 50 microhenries or more than 800 microhenries, wire resistance is less than 1.75 ohms per 700 feet, or the loop quality factor is less than 5 at 50 kilohertz. Install inductive loops with dedicated saw cuts and separate PVC conduits for each sensor lead-in cable from the edge of pavement to the first pull box.

Apply sealant to the saw cuts with the backer rods in place. Do not produce air bubbles when applying sealant. Remove excess sealant and finish level with the pavement. Follow the manufacturer's recommendations for sufficient time for the sealant to harden before allowing traffic to cross the loops.

Repeat the resistance and continuity test after sealant is applied. Report the second test for comparison with the first test report.

Preformed inductive loops with 3 to 5 turns of #14 AWG cable with an insulation of XLPE (cross-linked polyethylene) encased in PVC pipe may be used as an alternative for use in new construction.

Loop dimensions and spacing, based on lane width are shown in Table 636-3.

Table 636-3
Loop Dimensions and Spacing

Lane Width, feet	Loop Dimension, feet	Spacing to Centerline, feet
12	6 x 6	3
11	5 x 5	3
10	5 x 5	2.5

636.10 Testing and Demonstration Period for Traffic Counters. Before energizing portions of the system, demonstrate that the conductor system is clear and free of short circuits, open circuits, and unintentional grounds. Repair or replace faulty circuits.

After energizing the system, demonstrate that all electrical components work properly. Repair or replace faulty electrical components.

Conduct an on-site verification test according to ASTM E2300, Type I-2 with a 10 percent tolerance. For each loop tested, provide two human observers to count for the minimum duration of 15 minutes and at least 50 vehicles. If the test would likely last greater than 30 minutes to attain the 50-vehicle threshold, then test vehicles driven over the loops being tested should be considered. Conduct the test at an approved date and time.

Upon completion of construction at a location as shown in the plans the site will be placed in full scale operation for a 30-day demonstration period. Repair defects or complete necessary adjustments during the demonstration period. If failures occur during this demonstration period, perform repairs within 2 days. If necessary repairs are not completed within 3 days of notification, stop the demonstration period and resume only after such repairs and replacement of materials have been made, inspected, and approved.

636.11 Warranties, Guarantees, and Instruction Sheets. If installations are permanent, deliver the manufacturer's warranties, guarantees, instruction sheets, and parts lists at the final inspection.

Within each cabinet, store one laminated copy of the cabinet wiring diagram and the field wiring diagram showing loops, pull boxes, and conduit runs inside two one-gallon re-sealable storage bags, one inside the other. Provide an electronic copy of each document to the CO.

636.12 Relocations. Use material equivalent to existing material, unless present codes require different or improved material. Existing material may be salvaged and reused if material and installation methods used meet the requirements of applicable codes and ordinances.

636.13 Acceptance. Material for traffic signal, traffic counter, lighting and electrical systems will be evaluated under Subsections 106.02 and 106.03.

Installation of traffic signal, traffic counter, lighting and electrical systems will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Installation of signs will be evaluated under Section 633.

Minor concrete will be evaluated under Section 601.

Removal of structures and obstructions will be evaluated under Section 203.

Measurement

636.14 Measure the Section 636 pay items listed in the bid schedule according to Subsection 109.02 and the following as applicable:

For relocations, do not measure additional line or connections necessary to place the fixture at the new location.

Payment

636.15 The accepted quantities will be paid at the contract price per unit of measurement for the Section 636 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for lump sum pay items will be prorated based on total work completed under this Section.

Section 637. — FACILITIES AND SERVICES

Description

637.01 This work consists of providing, installing, maintaining, and removing facilities and services for the exclusive use of Government personnel.

Construction Requirements

637.02 General. Provide the facilities and services starting no later than 14 days before starting on-site construction activities and ending no sooner than 21 days after on-site construction activities have concluded for all contract work. Provide notice for removal or termination date for facilities and services.

Submit a list of facilities, proposed facility locations, services, furnishings, and equipment for approval before committing to or signing any agreements or leases for these items.

Comply with applicable ordinances, safety codes, rules, and regulations.

If facilities or services become defective, are damaged, stolen, or for other reasons do not function as intended; repair or provide a replacement within 8 hours after being notified. Repairs and replacements are subject to approval.

Pay bills, including taxes and fees, for facilities and services by the payment due date.

Remove facilities and services when directed.

637.03 Facilities. Perform site work to accommodate the placement or construction of facilities. Conform to Subsection 107.10(d).

Provide and maintain facilities according to Tables 637-1 and 637-2. If not otherwise specified, provide furnishings of standard size, character, and condition for their function. Provide batteries and light bulbs necessary for the provided furnishings.

Provide safe, secure, sanitary, weatherproof buildings or trailers in good condition. Provide services according to Subsection 637.04.

Restore the ground to its original condition upon removal of facilities.

(a) Field office. Provide one of the following:

(1) Office trailer. Provide a portable office trailer. Locate the office trailer on or adjacent to the project site, or as directed. Locate the trailer so that it can be accessed 24 hours a day, 7 days a week. Provide exterior lighting to illuminate the area surrounding the Government field office at night. Equip the lights with photocell sensor devices and motion detectors to activate the lights.

(2) Commercial office space. Provide office space at a commercial development adjacent to or near the project site.

(b) Residential housing. If the unit is part of a larger building, separate units with partitions and provide separate outside doors with locks.

Table 637-1
Minimum Requirements for Field Facilities and Associated Services

Property	Field Office, Each	Residential Housing, Each
Floor space, square feet	400	880
Locking outside door, deadbolt with 2 sets of keys	1	1
Steps with slip-proof tread and handrails	✓(1)	✓(1)
Windows with locks	2	3
Total window area, square feet	30	60
Ceiling height, 7 feet	✓	✓
Rooms including toilet room	4	5(2)
Room size, except toilet room, square feet	100	100
Closet, 45-cubic foot	–	2
Shelves, 12-inch depth, square feet	12	12
Electrical lighting	✓	✓
Heat and air conditioning, maintain temperature of 72±7 °F(3)	✓	✓
Adequate electrical outlets	✓	✓
Surge protectors	3	3
Adequate electricity (120 and 240 V, 60 cycle as applicable)	✓	✓
Adequate potable water supply	✓	✓
Drinking water cooler with water supply	✓	–
Sink with faucets for both hot and cold water	✓	✓
Adequate hot and cold water supply	–	✓
Shower/bath facilities	–	✓
Parking for three vehicles on gravel, or paved surface	✓	✓
6-foot-high chain link fence with gate around building and parking area	✓	–

(1) As required by local code.
(2) Includes two bedrooms.
(3) If window air conditioning is provided, provide a separate unit for each room

Table 637-2
Minimum Facility Furnishings

Property	Field Office, Each	Residential Housing, Each
Table, wood or like, 96 inches L x 30 inches W x 30 inches H	3	–
File cabinet, 2-drawer, fire resistant, metal, with lock and keys	1	–
File cabinet, 4-drawer, metal	1	–
Desk, wood or like, 60 inches L x 30 inches W x 30 inches H(1)	2	–
Desk lamp(1)	2	–
Office chair(1)	5	–
Storage cabinet, 72 inches L x 36 inches W x 18 inches H	1	–
Fire extinguisher	1	2
Refrigerator, 18-cubic foot	1	1
Range and oven, standard 36-inch	–	1
Microwave oven, 1.1 cubic foot, 1100 watt	1	1
Kitchen table with 4 chairs, wood or like, 60 inches L x 36 inches W x 30 inches H, minimum	–	1 set
Sofa, 90 inches L x 38 inches W x 34 inches H, minimum	–	1
Coffee table, 36 inches L x 18 inches W x 16 inches H, minimum	–	1
Recliner chair	–	2
End table, 28 inches L x 17 inches W x 20 inches H, minimum	–	3
Table lamp, 26 inches H, minimum	–	3
Queen bed with frame, mattress, and box spring as necessary	–	2
Nightstand, 20 inches L x 20 inches W x 25 inches H, minimum	–	4
Nightstand lamp, 26 inches H, minimum	–	4
Dresser, six-drawer, wood or like	–	2
Television, 40-inch	–	✓
Laundry (washer and dryer)	–	✓
Vacuum cleaner, bagless, 12amp	–	✓

(1) Meet accepted industry standards for ergonomics.

(c) Storage facility. Provide a storage facility with a minimum floor space of 100 square feet, that is secure, enclosed, covered, and protected from the elements. Secure the storage facility with a padlock or other approved device. Provide keys, lock combinations, or gate codes necessary for entry to the CO. Provide one of the following:

(1) Stand-alone facility. Provide a stand-alone structure or storage container located adjacent to the Government field office, or as directed. Position the facility, or make improvements to the site, so that vehicles can park within 50 feet of the facility for loading and unloading.

(2) Commercial facility. Provide a drive-up storage facility at a commercial development located within 15 roadway miles of the project.

(d) Vehicle. Provide a light duty, 4x4 wheel drive, gasoline powered pickup truck which is 7 model years old or newer and with less than 65,000 miles. Deliver the vehicle to the project site, field office, or alternate location as directed. Do not include branding, stickers, or advertisements on the vehicle. Maintain the vehicle to provide safety and reasonable comfort for the operator with all factory equipment in working order. Provide fuel and perform required maintenance on the vehicle, including regular cleanings.

Provide and maintain current vehicle registration and collision and comprehensive insurance. Secure vehicle insurance according to State and Local rules and regulations.

Equip the vehicle with tools, equipment, and a roadside emergency kit. Store equipment in a suitable container within the vehicle. Include the following:

(1) Automotive strobe light, amber;

(2) Full-size spare tire and jack;

(3) Jumper cables;

(4) Flares and reflective triangles;

(5) Fire extinguisher;

(6) First aid kit;

(7) Basic tool kit or multitool;

(8) Duct tape;

(9) Blanket;

(10) Flashlight with extra batteries;

(11) Shovel;

(12) Axe or pulaski; and

(13) Ice scraper and snow brush.

637.04 Services. Provide utilities and services necessary to operate field offices and residential housing facilities according to Table 637-3 and the following.

(a) Electricity. Provide electrical service from the local utility. Obtain approval to use generators if electricity cannot be provided to the facility by the utility.

(b) Water. Provide continuous potable water supply.

(c) Natural gas, propane, or heating oil. Provide service from a local utility or provider if required for appliances and furnishings.

(d) Sewer. Provide service from the local utility if required.

(e) Portable toilet. Provide portable toilets if sewer or septic hookups are unavailable for field office trailers. Provide one portable toilet with weekly service and cleanings. Locate portable toilet adjacent to the field office, as directed. Provide hand sanitizer and toilet paper. Provide a padlock if requested.

(f) Trash and waste disposal. Provide trash and waste disposal service weekly.

(g) Drinking water. Provide a bottled water dispenser, that can cool and dispense chilled water. Provide purified drinking water for use with the water dispenser.

(h) Snow removal. Perform snow removal if directed. Plow parking areas and access roads to the provided facilities. Shovel sidewalks and walkways.

(i) Landscape maintenance. Perform landscape maintenance if directed.

(j) Pest control. Perform pest control if directed.

(k) High-speed internet. Provide dedicated commercial high-speed internet service with no bandwidth limitations, data caps, or throttling that meets the following:

(1) Fiber Optic Service (FIOS), Cable Internet Service, or Digital Subscriber Line (DSL), with minimum speeds of:

(a) Download speed of 25,000 kilobits per second;

(b) Upload speed of 10,000 kilobits per second;

(2) Equipped with a modem and a router with a firewall or a router and a firewall appliance;

(3) Router with Internet Protocol Version 6 (IPv6) capability, Wi-Fi Protected Access II (WPA2) or higher encryption, Simple Network Management Protocol (SNMP) Monitoring, Dynamic Host Configuration Protocol (DHCP), and at least Category 6 Registered Jack 45 (RJ45) LAN office drop cables; and

(4) Supports simultaneous internet access of at least 3 workstations connected by Category 6 Registered Jack 45 (RJ45) LAN office drop cables.

If the required service options are not available, alternate internet access service options, including Satellite Internet, a dedicated Transmission System 1 Line (T1), or mobile hotspot (MiFi) may be submitted for approval.

(l) Telephone. Provide telephone if directed. Provide local and long-distance telephone service. Provide two cordless telephones with the following capabilities:

(1) Touch tone, speaker phone, speed dial, hold button, and conference calling features; and

(2) One digital telephone answering machine or voicemail service that can answer, record, store, and play back telephone messages and has storage capacity of at least 30 minutes in length.

(m) Television. Provide cable or satellite television service.

Table 637-3
Services Provided for Facilities

Service	Field Office, Each	Residential Housing, Each
Electricity (120 and 240 V, 60 cycle as applicable)	✓	✓
Water	✓	✓
Natural gas, propane, and heating oil(1)	✓	✓
Sewer(1)	✓	✓
Portable toilet(2)	✓	–
Trash and waste disposal	✓	✓
Drinking water	✓	–
Snow removal(3)	✓	✓
Landscape maintenance(3)	✓	✓
Pest control(3)	✓	✓
High-speed internet	✓	✓
Telephone	✓	✓
Television	–	✓

(1) If required for provided appliances or furnishings.
(2) If indoor flush toilets are not available.
(3) Provide service if directed.

637.05 Acceptance. Facilities and services will be evaluated under Subsections 106.02 and 106.04.

Measurement

637.06 Measure the Section 637 pay items listed in the bid schedule according to Subsection 109.02.

Payment

637.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 637 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for facilities and services by the lump sum or by the each will be paid as follows:

(a) 75 percent of the pay item amount will be paid after installation and acceptance for occupancy.

(b) The remaining portion of the pay item amount will be paid after the facilities and services are removed.

DIVISION 700
MATERIAL

Section 701. — CEMENTITIOUS MATERIAL

701.01 Hydraulic Cement. Do not mix cement brands or types.

(a) Portland cement. Conform to AASHTO M 85.

(b) Blended hydraulic cement. Conform to AASHTO M 240.

701.02 Reserved.

701.03 Pozzolans.

(a) Fly ash. Conform to AASHTO M 295, Class C, Class F, or Class N. Available alkalies as equivalent Sodium Oxide (Na_2O)	1.5 percent maximum
(b) Slag cement. Conform to AASHTO M 302, Grade 100 or Grade 120. Total alkalies as equivalent Na_2O	1.0 percent maximum
(c) Silica fume (microsilica). Conform to AASHTO M 307. Total alkalies as equivalent Na_2O	1.0 percent maximum
(d) High-reactivity pozzolans. Conform to AASHTO M 321. Total alkalies as equivalent Na_2O	1.0 percent maximum

701.04 Grout.

(a) Neat hydraulic cement grout.

(1) Ground anchors, micropiles, and soil nails. Provide a pumpable mixture of portland cement, sand, water, and admixtures. Use hydraulic cement conforming to Subsection 701.01. If sand is added, provide sand conforming to Subsection 703.01. Provide water conforming to Subsection 725.01(a). Provide the minimum water content necessary for placement and a maximum water to cementitious material ratio of 0.45 by mass.

Chemical admixtures that control bleed or retard set may be used provided the additives conform to Subsection 711.03 and are mixed according to the manufacturer's recommendations. Do not use admixtures containing more than trace (from impurities, not as an intended constituent) quantities of chlorides, fluorides, aluminum, zinc, or nitrates.

The maximum water-soluble chloride ion content of the grout is 0.06 percent by mass of cement when tested according to ASTM C1218.

Provide grout conforming to the following minimum compressive strengths:

(a) Ground anchors	3500 psi at 7 days
(b) Micropiles	2500 psi at 7 days and 5000 psi at 28 days

(c) Soil nails	1500 psi in 3 days and 3000 psi in 28 days

(2) Miscellaneous applications. Provide a grout consisting of a mixture of hydraulic cement, water, and admixtures. Do not exceed a water to cementitious material ratio of 0.44. Do not exceed 20 percent of the cement by mass if fly ash is used. Admixtures to reduce water content, improve the flowability, control bleeding, or control shrinkage may be added according to the manufacturer's recommendations. Provide admixtures free of chlorides, fluorides, sulphites, and nitrates.

(b) Non-shrink grout. Conform to ASTM C1107 and the following as specified:

(1) Provide a minimum compressive strength of 5000 pounds per square inch in 3 days.

(2) Provide a minimum compressive strength of 3000 pounds per square inch in 3 days.

(c) Grout for post-tensioned structures. Conform to the requirements of the PTI, *Guide Specification for Grouting of Post-Tensioned Structures*.

701.05 Mortar.

(a) General mortar. Conform to ASTM C270. Use masonry cement Type M or S according to ASTM C91.

(b) Packaged repair mortar. Conform to ASTM C928, Type R1 and the following:

(1) Relative dynamic modulus of elasticity, ASTM C666, Method A	95 percent minimum
(2) Drying shrinkage, ASTM C157, except as modified by ASTM C882	0.07 percent maximum

(c) Latex-modified mortar. Conform to ASTM C1438, Type II.

Section 702. — ASPHALT MATERIAL AND ADDITIVES

702.01 Asphalt Binder. Conform to AASHTO M 226, AASHTO M 320, or AASHTO M 332.

702.02 Emulsified Asphalt. Conform to AASHTO M 140 or AASHTO M 208.

(a) Polymer-modified cationic emulsified asphalt for chip seals. Conform to AASHTO M 316.

(b) Polymer-modified emulsified asphalt for micro surfacing. Conform to ISSA A143, except use AASHTO T 59, Section 7, Emulsified Asphalt Residue by Evaporation to determine percent residue.

(c) Penetrating emulsified asphalt for prime coat. Test according to AASHTO T 59, except as modified by Table 702-1.

Table 702-1
Penetrating Emulsion for Prime Coat

Property	Minimum	Maximum
Requirements for Emulsion		
Viscosity, saybolt furol at 122 °F, sec	15	150
Settlement, 24 hours, %	–	1
Residue by evaporation, %	62	–
Requirements for Residue		
Penetration, 77 °F, 100 g, 5 sec, AASHTO T 49	40	200

(d) Engineered emulsion. Conform to the following:

(1) Residue by distillation — 60 minimum

(2) Sieve test — 0.10 maximum

(3) Test on residue from distillation:

(a) Penetration, 77 °F, 100g, 5s percent — Target from mix design ±25

(b) Ductility, 77 °F, 5 cm/min, cm — 40 minimum

(e) Polymer-modified emulsified asphalt membrane. Conform to Table 702-2. Follow AASHTO T 59 test method except where noted.

Table 702-2
Polymer-Modified Emulsified Asphalt Membrane for Ultrathin Bonded Wearing Course

Property	Minimum	Maximum
Requirements for Emulsion		
Viscosity, saybolt furol at 77°F, sec	20	100
Storage stability, 24-hour, %(1)	-	1
Particle charge test	positive	-
Sieve test, %(2)	-	0.05
Residue by evaporation, %	63	-
Requirements for Residue		
Penetration, 77°F, 100 g, 5 sec AASHTO T 49	60	150
Elastic recovery, %, 50°F, 20 cm elongation, 5 cm/min, AASHTO T 301	58	-
Ash content, AASHTO T 111	-	1

(1) After standing undisturbed for 24 hours, the surface shows no white, milky colored substance, but is a smooth homogeneous color throughout.
(2) Use distilled water in all wetting and washing operations rather than a sodium oleate solution (two percent).

702.03 Hot-Applied Asphalt Aggregate-Filled Mastic. Conform to ASTM D8260.

702.04 Asphalt Mastic. Conform to AASHTO M 243.

702.05 Antistrip Additive. Conform to the following:

(a) Type 1. Provide commercially produced, heat stable liquid products that when added to an asphalt have the chemical and physical properties to prevent separation of the asphalt from aggregates.

(b) Type 2. Provide cement conforming to Subsection 701.01 or fly ash conforming to Subsection 701.03(a).

(c) Type 3. Provide lime conforming to AASHTO M 303.

Section 703. — AGGREGATE

703.01 Fine Aggregate for Concrete. Provide sand conforming to AASHTO M 6, Class B, except as modified or supplemented by the following:

(a) Material passing No. 200 sieve, AASHTO T 11	3.0 percent maximum

(b) ASR. Test the aggregate for alkali silica reaction and conform to one of the following:

(1) ASR, ASTM C1260 after casting	0.10 percent maximum at 16 days
(2) ASR, ASTM C1260	0.11 percent to 0.20 percent at 16 days after casting
Include one of the following examinations:	
(a) Petrographic examination of aggregates, ASTM C295, performed within 1 year from time of submittal	Favorable report for use
(b) Petrographic examination of hardened concrete, ASTM C856, performed on ASTM C1260 specimens after test	Favorable report for use
(c) Examinations according to AASHTO R 80 for field performance history, limiting the alkali content of the concrete, or using supplementary cementitious materials or blended cements	Favorable study results or adequate prevention levels achieved
(3) ASR with cementitious after casting material, ASTM C1567, performed on approved mix design mass percent combinations. Do not use lithium compounds as mitigation measures.	0.10 percent maximum at 16 days
(4) ASR, ASTM C1293	less than 0.04 percent at 12 months
(5) ASR with cementitious material, ASTM C1293, performed on approved mix design mass percent combinations.	less than 0.04 percent at 24 months

For lightweight fine aggregate, conform to AASHTO M 195.

703.02 Coarse Aggregate for Concrete. Conform to AASHTO M 80, Class A, except as modified or supplemented by the following:

(a) Los Angeles abrasion, AASHTO T 96	40 percent maximum
(b) Grading, AASHTO M 43	All sizes
(c) ASR	Subsection 703.01(b)

For bridge decks or surface courses, do not use aggregates known to polish or carbonate aggregates containing less than 25 percent by mass of insoluble residue as determined by ASTM D3042.

For lightweight coarse aggregate, conform to AASHTO M 195.

703.03 Underdrain Backfill. Provide aggregate for the following installations.

(a) Underdrain pipe with geotextile. Provide aggregate backfill conforming to AASHTO M 80, Class E and AASHTO M 43, Size Number 3, 4, 5, 57, 67, or 7.

(b) Underdrain pipe without geotextile. Provide aggregate backfill conforming to AASHTO M 6, except the soundness test is not required.

703.04 Reserved.

703.05 Subbase, Base, and Surface Course Aggregate.

(a) General. Provide hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

(1) Los Angeles abrasion, AASHTO T 96	35 percent maximum
(2) Soundness of aggregate using sodium sulfate AASHTO T 104, 5 cycles	
(a) Coarse aggregate	12 percent loss maximum
(b) Fine aggregate	12 percent loss maximum
(3) Durability index (coarse), AASHTO T 210	35 minimum
(4) Durability index (fine), AASHTO T 210	35 minimum
(5) Fractured faces, AASHTO T 335 (one or more)	70 percent minimum
(6) Without organic matter and lumps or balls of clay.	

(b) Subbase or base course aggregate. In addition to Subsection 703.05(a), conform to the following:

(1) Gradation	Table 703-1
(2) Liquid limit, AASHTO R 58 and AASHTO T 89	25 maximum

Table 703-1
Target Value Ranges for Subbase, Base, and Surface Course Gradation

Sieve size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)							
	Grading Designation[1]							
	Subbase		Base			Surface		
	A	B	C	D	E	F	G	H
2½ in	100	–	–	–	–	–	–	–
2 in	97 to 100	100	100	–	–	–	–	–
1½ in	–	97 to 100	–	–	–	–	–	–
1 in	65 to 79	–	80 to 100	100	100	–	100	–
¾ in	–	–	64 to 94	86 to 100	86 to 100	100	–	100
½ in	45 to 59	–	–	–	–	–	70 to 80	–
⅜ in	–	–	40 to 69	51 to 82	51 to 82	62 to 90	–	–
No. 4	28 to 42	40 to 60	31 to 54	36 to 64	36 to 64	36 to 74	40 to 50	41 to 71
No. 10	–	–	–	–	–	–	25 to 40	–
No. 40	9 to 17	–	–	12 to 26	12 to 26	12 to 26	15 to 25	12 to 28
No. 200	4.0 to 8.0	4.0 to 12.0	4.0 to 7.0	4.0 to 7.0	10 max[2]	4.0 to 7.0	8.0 to 14.0	9.0 to 16.0

(1) Contractor specified target values. See Table 703-2 for allowable deviations.
(2) Statistical procedures do not apply.

(c) Surface course aggregate. In addition to Subsection 703.05(a), conform to the following:

(1) Gradation — Table 703-1

(2) Liquid limit, AASHTO R 58 and T 89, Method A — 35 maximum

(3) Plasticity index, AASHTO T 90

(a) Grading G — 10±3

(b) Grading H — 8±4

Table 703-2
Allowable Deviation
Based on Target Value for Aggregates

Percent by Mass Passing		Allowable Deviation
Minimum	Maximum	
90.0	100	(1)
70.1	89.9	4
60.1	70.0	5
55.1	60.0	6
45.1	55.0	7
40.1	45.0	6
30.1	40.0	5
21.1	30.0	4
8.1	21.0	3
0	8.0	2

(1) Statistical procedures do not apply.

703.06 Crushed Aggregate. Provide hard, durable particles or fragments of crushed stone or gravel conforming to the size and quality requirements for crushed aggregate material normally used locally in the construction and maintenance of highways by Federal or state agencies. Provide crushed aggregate with a maximum size of 1 inch as determined by AASHTO T 27 and AASHTO T 11. Provide well-graded crushed aggregate, free of organic matter, lumps or balls of clay, and other deleterious material.

703.07 Asphalt Concrete Aggregate. Provide hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

(a) Los Angeles abrasion, AASHTO T 96	35 percent maximum
(b) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles):	
(1) Coarse aggregate	12 percent loss maximum
(2) Fine aggregate	12 percent loss maximum
(b) Fractured faces, AASHTO T 335 (one or more)	90 percent minimum
(c) Fine aggregate angularity, AASHTO T 304, Method A	40.0 percent minimum
(d) Flat and elongated particles, ASTM D4791 (1:5 ratio, plus ⅜-inch sieve, calculated by mass, weighted average)	10 percent maximum
(e) Sand equivalent, AASHTO T 176, Alternative Method No. 2, Reference Method	45 minimum
(f) Gradation.	See Table 703-3

For the surface course, do not use aggregates known to polish or carbonate aggregates containing less than 25 percent by mass of insoluble residue when tested according to ASTM D3042.

Table 703–3
Asphalt Concrete Aggregate Gradation

Sieve Size	Nominal Maximum Aggregate Size – Percent Passing(1)									
	Grading Designation(2)									
	1 inch		¾ inch		½ inch		⅜ inch		No. 4	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1½ in	100	–	–	–	–	–	–	–	–	–
1 in	90	100	100	–	–	–	–	–	–	–
¾ in	–	90	90	100	100	–	–	–	–	–
½ in	–	–	–	90	90	100	100	–	–	–
⅜ in	–	–	–	–	–	90	90	100	100	–
No. 4	–	–	–	–	–	–	–	90	95	100
No. 8	19	45	23	49	28	58	32	67	70	80
No. 16	–	–	–	–	–	–	–	–	–	–
No. 30	–	–	–	–	–	–	–	–	–	–
No. 50	–	–	–	–	–	–	–	–	–	–
No. 200	1.0	7.0	2.0	8.0	2.0	10.0	2.0	10.0	4.0	10.0

(1) Size, grade and combine the aggregate fractions in mix proportions that result in a composite blend conforming to the specified gradation. Nominal maximum size is one sieve size greater than the first sieve to retain more than 10 percent of the combined aggregate. Test according to AASHTO T 27 and AASHTO T 11

(2) Contractor specified target values. Provide target values for all sieves designated in Table 703-3. See Table 703-2 for allowable deviations.

703.08 Open-Graded Asphalt Friction Course Aggregate. Provide hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

(a) Los Angeles abrasion, AASHTO T 96	35 percent maximum
(b) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	
(1) Coarse aggregate	12 percent loss maximum
(2) Fine aggregate	12 percent loss maximum
(c) Fractured faces, AASHTO T 335 (two or more)	75 percent minimum
(d) Gradation	Table 703-4

Table 703-4
Target Value Ranges for
Open-Graded Friction Course Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)	
	Grading Designation(1)	
	A	B
½ in	–	100
⅜ in	100	95 to 100
No. 4	30 to 45	50 to 70
No. 8	5 to 15	5 to 15
No. 200	2.0 to 5.0	2.0 to 5.0

(1) Contractor specified target values. See Table 703-2 for allowable deviations.

703.09 Chip Seal Aggregate. Provide hard durable particles or fragments of crushed gravel, crushed stone, crushed slag, or lightweight aggregates. Use only one type of aggregate on the surface treatment. Conform to the following:

(a) Gradation	Table 703-5
(b) Clay lumps and friable particles, AASHTO T 112	1.0 percent maximum
(c) Flat and elongated particles, ASTM D4791 (1:3 ratio, plus ⅜-inch sieve, calculated by mass, weighted average)	10 percent maximum
(d) Fractured faces, AASHTO T 335 (one or more)	90 percent minimum
(e) Los Angeles abrasion, AASHTO T 96	40 percent maximum
(f) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss maximum

Table 703-5
Target Value Ranges for
Single and Double Course Chip Seal Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)			
	Grading Designation[(1)]			
	A	B	C	D
1 in	100			
¾ in	90 to 100	100		
½ in	0 to 35	90 to 100	100	
⅜ in	0 to 12	0 to 35	85 to 100	100
No. 4	–	0 to 12	0 to 35	85 to 100
No. 8	–	–	0 to 8	0 to 23
No. 200[(2)]	0.0 to 1.0	0.0 to 1.0	0.0 to 1.0	0.0 to 1.0

(1) Contractor specified target values. See Table 703-2 for allowable deviations.
(2) The allowable deviation is (plus or minus) 0.5.

703.10 Slurry Seal and Micro Surfacing Aggregate. Provide hard durable particles or fragments of crushed gravel or crushed stone.

(a) Slurry seal aggregate. Conform to ISSA A105 and the following:

(1) Gradation	Table 703-6
(2) Los Angeles abrasion, AASHTO T 96, Grading D	35 percent maximum
(3) Sand equivalent, AASHTO T 176, Alternate Method No. 2, Reference Method	45 minimum
(4) Soundness of aggregate using sodium sulfate fine, AASHTO T 104 (5 cycles)	15 percent loss maximum

(b) Micro surfacing aggregate. Conform to ISSA A143 and the following:

(1) Gradation	Table 703-6
(2) Los Angeles abrasion, AASHTO T 96, Grading D	30 percent maximum
(3) Sand equivalent AASHTO T 176, Alternate Method No. 2, Reference Method	65 minimum
(4) Soundness of aggregate using sodium sulfate fine, AASHTO T 104 (5 cycles)	15 percent loss maximum

Table 703-6
Micro Surfacing and Slurry Seal Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)		
	Grading Designation		
	I	II	III
⅜ in	–	100	100
No. 4	100	90 to 100	70 to 90
No. 8	90 to 100	65 to 90	45 to 70
No. 16	65 to 90	45 to 70	28 to 50
No. 30	40 to 65	30 to 50	19 to 34
No. 50	25 to 42	18 to 30	12 to 25
No. 100	15 to 30	10 to 21	7 to 18
No. 200	10.0 to 20.0	5.0 to 15.0	5.0 to 15.0

703.11 Reserved.

703.12 Blotter. Provide sound durable particles of gravel or crushed stone conforming to the following:

(a) Material passing ⅜-inch sieve, AASHTO T 27 100 percent

(b) Liquid limit, AASHTO R 58 and T 89, Method A 25 maximum

(c) Without organic matter and clay balls.

703.13 Aggregate for Aggregate-Topsoil Course. Conform to AASHTO M 80, Class E and AASHTO M 43, Size Number 57.

703.14 Sand. Provide clean material conforming to AASHTO M 6, Class B.

703.15 Flowable Backfill Aggregate. Provide hard, clean, durable, nonplastic, nonorganic, nonreactive aggregate conforming to Table 703-7.

Table 703-7
Flowable Backfill Aggregate

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
1 in	100
No. 200	0.0 to 10.0

703.16 Shotcrete Aggregate. Provide hard, clean, durable, nonplastic, nonorganic, nonreactive aggregate conforming to the following:

(a) Fine aggregate. Conform to AASHTO M 6, Class B, except as modified or supplemented by the following:

(1) Material passing No. 200 sieve, AASHTO T — 3.0 percent maximum

(2) Sand equivalent value, AASHTO T 176, Alternate Method No. 2, Reference Method — 75 minimum

(3) ASR — Subsection 703.01(b)

(b) Coarse aggregate. Conform to AASHTO M 80, Class A, except as modified or supplemented by the following:

(1) Los Angeles abrasion, AASHTO T 96 — 40 percent maximum

(2) ASR — Subsection 703.01(b)

(c) Gradation. Combine fine and coarse aggregates to meet the designated gradation in Table 703-8.

Table 703-8
Shotcrete Gradation Limits for Combined Aggregates

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11) Grading Designation	
	A	B
½ in	–	100
⅜ in	100	90 to 100
No. 4	95 to 100	70 to 85
No. 8	80 to 98	50 to 70
No. 16	50 to 85	35 to 55
No. 30	25 to 60	20 to 35
No. 50	10 to 30	8 to 20
No. 100	2.0 to 10.0	2.0 to 10.0

703.17 Granular Rock Backdrain. Provide hard, durable, crushed, rock conforming to the following:

(a) Los Angeles abrasion, AASHTO T 96 — 50 percent maximum

(b) Apparent specific gravity, AASHTO T 85 — 2.50 minimum

(c) Absorption, AASHTO T 85 — 4.0 percent maximum

(d) Durability index (coarse), AASHTO T 210 — 50 minimum

(e) Gradation — Table 703-9

(f) Fractured faces, AASHTO T 335 (one or more) — 90 percent minimum

Table 703-9
Granular Rock Backdrain Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
6 in	100
4 in	0 to 25
No. 200	0.0 to 5.0

703.18 Ultrathin Bonded Wearing Aggregate. Provide hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

(a) Los Angeles abrasion, AASHTO T 96 — 35 percent maximum

(b) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)

(1) Coarse aggregate — 12 percent loss, maximum

(2) Fine aggregate — 12 percent loss, maximum

(c) Flat and elongated particles, ASTM D4791, 1:3 ratio, plus ⅜-inch sieve, calculated by mass, weighted average — 25 percent maximum

(d) Fractured faces, AASHTO T 335 (two or more) — 90 percent minimum

(e) Sand equivalent value, AASHTO T 176, Alternate Method No. 2, Reference Method — 45 minimum

(f) Gradation — Table 703-10

Table 703-10
Target Value Ranges for
Ultrathin Bonded Wearing Course Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
½ in	100
⅜ in	85 to 100
No. 4	22 to 40
No. 8	19 to 32
No. 16	15 to 23
No. 30	10 to 18
No. 50	8 to 13
No. 100	6 to 10
No. 200	4 to 7

703.19 Polyester Polymer Concrete Aggregate. Provide aggregate for PPC conforming to the following:

(a) Use natural sand for the fine aggregate.

(b) Crushed particles retained on the No. 8 sieve, AASHTO T 335	45 percent maximum
(c) Aggregate absorption (weighted average), AASHTO T 84 and T 85	1 percent maximum
(d) Aggregate moisture content, AASHTO T 255	less than 50 percent of aggregate absorption
(e) Gradation	Table 703-11

Table 703-11
Polyester Polymer Concrete Aggregate
Gradation Limits

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
3/8 in	100
No. 4	62 to 85
No. 8	45 to 67
No. 16	29 to 50
No. 30	16 to 36
No. 50	5 to 20
No. 100	0 to 7
No. 200	0 to 3

703.20 Geosynthetic Reinforced Soil Open-graded Backfill. Provide hard, crushed, durable particles or fragments of rock or gravel conforming to the following:

(a) Gradation	AASHTO M 43, size number 6, 67, 68, 7, 78, 8, or 89
(b) Fractured faces AASHTO T 335 (two or more)	75 percent minimum
(c) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	15 percent loss maximum
(d) Los Angeles abrasion, AASHTO T 96	50 percent maximum

Section 704. — SOIL

704.01 Soil and Soil-aggregate Materials. Provide suitable materials conforming to Table 704-1.

Table 704-1
Soil Gradation and Classification Requirements

<table>
<tr><th rowspan="2">Gradation and Classification Requirements</th><th colspan="7">Material Designation</th></tr>
<tr><th>Foundation Fill</th><th>Bedding Material</th><th>Common Backfill</th><th>RSS Backfill</th><th>Plastic Pipe Backfill</th><th>Structural Backfill</th><th>Unclassified Borrow</th></tr>
<tr><td>Maximum particle size, in</td><td>2</td><td>½</td><td>3</td><td colspan="2">1½</td><td>3</td><td>24</td></tr>
<tr><td>Soil classification, AASHTO M 145</td><td>A-1-a</td><td>–</td><td>A-1
A-2
A-3</td><td colspan="2">A-1
A-2-4
A-2-5
A-3</td><td>–</td><td>A-1
A-3
A-2-4</td></tr>
<tr><td>Material passing No. 200 sieve, AASHTO T 27 & T 11</td><td>6.0 maximum</td><td>10 maximum</td><td>–</td><td colspan="2">–</td><td>5.0 maximum</td><td>–</td></tr>
<tr><td>Plasticity index, AASHTO T 90</td><td>–</td><td>–</td><td>–</td><td colspan="2">–</td><td>6 maximum</td><td>–</td></tr>
<tr><td>Other Requirements</td><td>–</td><td>–</td><td>Well-graded</td><td colspan="2">Well-graded</td><td>–</td><td>–</td></tr>
</table>

704.02 Select Borrow. Provide a suitable, well-graded material conforming to the following:

(a) Gradation — Table 704-2

(b) Liquid limit, AASHTO T 89, Method A — 30 maximum

Table 704-2
Select Borrow Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
3 in	100
1 in	70 to 100
No. 4	30 to 70
No. 200	0.0 to 5.0

704.03 Select Granular Backfill.

(a) General. Provide suitable, sound, durable, granular material conforming to the following:

(1) Gradation	Table 704-3
(2) Angle of internal friction on the portion passing the No. 10 sieve, AASHTO T 236	34 degree minimum

AASHTO T 236 is not required for material with more than 40 percent retained on the No. 4 sieve. If required, compact samples to 95 percent of the maximum density at +/-2 percent of the optimum moisture content determined according to AASHTO T 99, method A or B without oversized material corrections. Perform testing at confining stresses of 1, 2, 4, and 8 kips per square foot.

(3) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	15 percent loss maximum
(4) Plasticity index, AASHTO T 90	6 maximum
(5) Los Angeles abrasion, AASHTO T 96	50 percent maximum

Table 704-3
Select Granular Backfill Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)	
	Backfill with Geosynthetic Reinforcement	Backfill with Metallic Reinforcement
4 in	–	100
1½ in	100	–
No. 40	0 to 60	0 to 60
No. 200	0.0 to 15.0	0.0 to 15.0

(b) MSE walls with metallic reinforcements. Conform to Subsection 704.03(a) and the following:

(1) Resistivity, AASHTO T 288	3000 Ω centimeter minimum
(2) pH, AASHTO T 289	5.0 to 10.0
(3) Sulfate content, AASHTO T 290	200 ppm maximum
(4) Chloride content, AASHTO T 291	100 ppm maximum

Tests for sulfate and chloride content are not required if resistivity is greater than 5000 ohm centimeters.

(c) MSE walls with geosynthetic reinforcements. Conform to Subsections 704.03(a) and 704.03(b)(2).

Section 705. — ROCK

705.01 Gabion and Revet Mattress Rock. Provide angular stone from a rock quarry or cut that is hard, durable, free of organic and other unsuitable material, and resistant to weathering and water action. Do not use crushed river rock or rock with rounded surfaces. Conform to the following:

(a) Durability index (coarse), AASHTO T 210	50 minimum
(b) Density of a filled basket	100 lb/ft^3 minimum

(c) Gradation. Provide rock with breadth and thickness at least one-third its length.

(1) Baskets 1 foot or greater in the vertical dimension.

(a) Maximum dimension	8 inches
(b) Minimum dimension	4 inches

(2) Baskets less than 1 foot in the vertical dimension.

(a) Maximum dimension	6 inches
(b) Minimum dimension	3 inches

(d) Los Angeles abrasion, AASHTO T 96	50 percent maximum

705.02 Rock for Riprap. Provide hard, durable, angular rock that is resistant to weathering and water action, and free of organic and other unsuitable material. Angular rock is characterized by sharp, clean edges at the intersections of relatively flat surfaces. Do not use shale, rock with shale seams, or other fissile or fissured rock that may break into smaller pieces in the process of handling and placing. Conform to the following:

(a) Apparent specific gravity, AASHTO T 85	2.40 minimum
(b) Absorption, AASHTO T 85	4.0 percent maximum
(c) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss maximum
(d) Los Angeles abrasion, AASHTO T 96	50 percent maximum
(e) Rock particle intermediate dimension (width) and minimum dimension (thickness)	⅓ longest dimension (length) minimum
(f) Gradation, FLH T 521	Table 705-1

Table 705-1
Gradation Requirements for Riprap(1)

Class	Percent of Rock Equal or Smaller by Count, DX	Range of Intermediate Dimensions, inches(2)	Range of Rock Mass, pounds(3)
1	100	9 to 15	59 to 270
	85	7 to 11	28 to 110
	50	5 to 8	10 to 42
	15	3 to 6	2 to 18
2	100	15 to 21	270 to 750
	85	11 to 15	110 to 270
	50	8 to 11	42 to 110
	15	6 to 8	10 to 42
3	100	21 to 27	750 to 1600
	85	15 to 19	270 to 560
	50	11 to 14	110 to 220
	15	8 to 10	42 to 81
4	100	27 to 33	1600 to 2900
	85	19 to 23	560 to 990
	50	14 to 17	220 to 400
	15	9 to 12	59 to 140
5	100	33 to 39	2900 to 4850
	85	23 to 28	990 to 1800
	50	17 to 20	400 to 650
	15	11 to 15	110 to 270
6	100	39 to 45	4850 to 7400
	85	28 to 32	1800 to 2650
	50	20 to 23	650 to 990
	15	13 to 17	180 to 400
7	100	45 to 54	7400 to 12,800
	85	32 to 38	2650 to 4450
	50	23 to 28	990 to 1800
	15	15 to 20	270 to 650
8	100	54 to 66	12,800 to 23,400
	85	38 to 47	4450 to 8450
	50	28 to 35	1800 to 3500
	15	19 to 25	560 to 250
9	100	66 to 78	23,400 to 38,600
	85	47 to 55	8450 to 13,500
	50	35 to 41	3500 to 5600
	15	22 to 30	870 to 2200
10	100	78 to 90	38,600 to 59,300
	85	55 to 64	13,500 to 21,300
	50	41 to 48	5600 to 9000
	15	26 to 36	1450 to 3800

(1) Gradation includes spalls and rock fragments to provide a stable, dense mass.
(2) The intermediate dimension is the longest straight-line distance across the rock that is perpendicular to the rock’s longest axis on the rock face with the largest projection plane.
(3) Rock mass is based on a specific gravity of 2.65 and 85 percent of the cubic volume as calculated using the intermediate dimension.

705.03 Rock for Masonry Structures. Provide sound, durable rock of the texture and color specified. Provide rock without reeds, rifts, seams, laminations, and minerals that may cause discoloration or deterioration from weathering.

Unless otherwise specified, provide rock fragments with the following dimensions:

(a) Minimum thickness	5 inches
(b) Minimum width	12 inches or 1½ times the thickness, whichever is greater
(c) Minimum length	1½ times the width
(d) Rocks with volume ≥1 cubic foot	50 percent minimum

When headers are required, provide headers with lengths at least the width of bed of the widest adjacent stretcher plus 12 inches.

705.04 Rock for Special Rock Embankments. Provide angular rock that is hard, durable, resistant to abrasion and weathering, and that is free of weak cleavages that may cause the rock to disintegrate during handling and placing.

(a) Mechanically-placed embankments. Provide rock conforming to Table 705-2.

Table 705-2
Range of Mechanically-Placed Rock

Percent of Rock Fragments by Mass	Range of Intermediate Dimensions, inches(1)	Range of Rock Mass, pounds(2)
50	> 29	> 2000
50	10 to 29	90 to 2000

(1) The intermediate dimension is the longest straight-line distance across the rock that is perpendicular to the rock's longest axis on the rock face with the largest projection plane.
(2) Rock mass is based on a specific gravity of 2.65.

(b) Hand-placed embankments. Provide rock conforming to Table 705-3.

Table 705-3
Range of Hand-Placed Rock

Percent of Rock Fragments by Mass	Range of Intermediate Dimensions, inches(1)	Range of Rock Mass, pounds(2)
75	> 14	> 165
25	10 to 14	90 to 165

(1) The intermediate dimension is the longest straight-line distance across the rock that is perpendicular to the rock's longest axis on the rock face with the largest projection plane.
(2) Rock mass is based on a specific gravity of 2.65.

705.05 Rock for Buttresses.

(a) General. Provide angular rock that is hard, durable, free of organic and other unsuitable material, and resistant to weathering and water action. Conform to the following:

(1) Rock breadth and thickness	At least one-third of the rock length
(2) Apparent specific gravity, AASHTO T 85	2.40 minimum
(3) Absorption, AASHTO T 85	4.0 percent maximum
(4) Durability index (coarse), AASHTO T 210	52 minimum

(b) Mechanically-placed buttresses. In addition to Subsection 705.05(a), provide rock conforming to Table 705-2.

(c) Hand-placed buttresses. In addition to Subsection 705.05(a), provide rock conforming to Table 705-3.

705.06 Rock for Rockeries. Provide hard, angular, and durable rock that consists of a solid mass without open fractures, foliation, or other planes of weakness that are generally cubical, tabular, or rectangular in shape. Do not provide crushed river rock or rock with rounded surfaces. Conform to the following:

(a) Apparent specific gravity, AASHTO T 85	2.50 minimum
(b) Absorption, AASHTO T 85	4.0 percent maximum
(c) Los Angeles abrasion, AASHTO T 96	50 percent maximum
(d) Durability index (coarse), AASHTO T 210	52 minimum
(e) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles)	12 percent loss maximum
(f) Size and shape	
(1) Rock length	See plans
(2) Rock breadth and thickness	At least one-third of rock length
(3) Rock dimension	18 in minimum
(4) Cap rock mass	200 lb minimum

705.07 Rock Mulch. Provide hard, durable native rock that is resistant to weathering and free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Maximum particle size	6 in
(b) Minimum particle size	2 in

(c) Apparent specific gravity, AASHTO T 85 — 2.40 minimum

(d) Absorption, AASHTO T 85 — 4.0 percent maximum

(e) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles) — 12 percent loss maximum

(f) Los Angeles abrasion, AASHTO T 96 — 50 percent maximum

705.08 Filter Rock. Provide hard, durable, angular rock that is resistant to weathering and water action and free of organic or other unsuitable material. Angular rock is characterized by sharp, clean edges at the intersections of relatively flat surfaces. Do not use shale, rock with shale seams, or other fissile or fissured rock that may break into smaller pieces in the process of handling and placing. Conform to the following:

(a) Apparent specific gravity, AASHTO T 85 — 2.40 minimum

(b) Absorption, AASHTO T 85 — 4.0 percent maximum

(c) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles) — 12 percent loss maximum

(d) Los Angeles abrasion, AASHTO T 96 — 50 percent maximum

(e) Rock particle intermediate dimension (width) and minimum dimension (thickness) — ⅓ longest dimension (length) minimum

(f) Gradation — Table 705-4

Table 705-4
Gradation Requirements for Filter Rock

Percent of Rock by Mass	Range of Intermediate Dimensions, inches(1)	Range of Rock Mass, pounds(2)
20	6 to 8	21 to 49
30	5 to 6	12 to 21
40	3 to 5	2.6 to 12
10	2 to 3	0.8 to 2.6

(1) The intermediate dimension is the longest straight-line distance across the rock that is perpendicular to the rock's longest axis on the rock face with the largest projection plane.
(2) Rock mass is based on a specific gravity of 2.65.

705.09 Wall Facing Fill. Provide hard, durable, angular, or fractured rock without organic or other unsuitable material. Do not use shale, rock with shale seams, or other fissile or fissured rock that may break into smaller pieces in the process of handling and placing. Conform to the following:

(a) Gradation. Provide rock with width and thickness at least one-third its length with a 6-inch maximum dimension. Ensure that 95 percent of wall facing fill particles minimum dimension exceeds welded wire facing opening with remaining 5 percent exceeding one-half of the welded wire facing opening.

(b) Soundness of aggregate using sodium sulfate, AASHTO T 104 (5 cycles) — 15 percent loss maximum

(c) Los Angeles abrasion, AASHTO T 96	50 percent maximum

(d) A minimum of 75 percent of individual particles exhibit an angular, rough, or broken surface either naturally occurring or created by crushing, blasting, or other means. The surface is well defined by sharp natural angles or fractured edges and consist of one half or more of the projected area, when viewed normal to that face.

Section 706. — CONCRETE PIPE

706.01 Non-Reinforced Concrete Pipe. Conform to AASHTO M 86 for the diameters and strength classes specified.

706.02 Reinforced Concrete Pipe. Conform to AASHTO M 170 for the diameters and strength classes specified. For precast reinforced concrete end sections, conform to cited specifications to the extent they apply.

706.03 Perforated Concrete Pipe. Conform to AASHTO M 175, Type 1 or Type 2 and AASHTO M 86 for the diameters and strength classes specified.

706.04 Reinforced Arch-Shaped Concrete Pipe. Conform to AASHTO M 206 for the diameters and strength classes specified.

706.05 Reinforced Elliptically-Shaped Concrete Pipe. Conform to AASHTO M 207 for the diameters, placement design (horizontal or vertical), and strength classes specified.

706.06 Reinforced D-Load Concrete Pipe. Conform to AASHTO M 242 for the diameters specified.

706.07 Precast Reinforced Concrete Box Sections. Conform to ASTM C1577 for the design earth cover, size, and the circumferential reinforcement area specified. Meet the design requirements for AASHTO, *LRFD Bridge Design Specifications* with HL-93 live load. Clearly mark the following information on the inner surface of each box section by indentation, waterproof paint, or other approved means:

(a) Box span and rise;

(b) Date of manufacture;

(c) Name of manufacturer;

(d) Submittal number; and

(e) Date certified by manufacturer.

706.08 Gaskets for Concrete Pipe.

(a) Elastomeric seals. Conform to ASTM C1619, Class C.

(b) Resilient connectors. Conform to ASTM C923.

706.09 Supplemental Concrete Pipe Ties. Conform to ASTM A307 or ASTM F1554 and galvanize tie hardware.

Section 707. — METAL PIPE

707.01 Ductile Iron Culvert Pipe. Conform to ASTM A716 for the sizes specified.

707.02 Metallic-Coated Corrugated Steel Pipe. Provide pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections) and coupling bands conforming to AASHTO M 36 and either AASHTO M 218, AASHTO M 274, or AASHTO M 289 for the dimensions, classification type, and thicknesses specified.

Fabricate underdrain pipe from steel sheets with a minimum thickness of 0.052 inch. Use any class of perforation specified in AASHTO M 36.

707.03 Aluminum-Alloy Corrugated Pipe. Provide pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections) and coupling bands conforming to AASHTO M 196 for the dimensions, classification type, and thicknesses specified.

Fabricate underdrain pipe from aluminum sheets with a minimum thickness of 0.048 inch. Use any class of perforation.

707.04 Asphalt-Coated Pipe. Provide pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections), and coupling bands conforming to this Section as applicable for the kinds of pipes to be coated.

Coat the pipe with asphalt material conforming to AASHTO M 190 for the type of coating specified. Coat special sections (such as elbows, branch connections, and end sections) and coupling bands according to AASHTO M 190. Coat flared end sections with an asphalt coating conforming to AASHTO M 190, Type A or a field applied asphalt mastic coating conforming to AASHTO M 243.

707.05 Steel Structural Plate Structures. Provide structures and assembly fasteners for connecting plates conforming to AASHTO M 167 for the sizes and types specified.

707.06 Aluminum-Alloy Structural Plate Structures. Provide structures and assembly fasteners for connecting plates conforming to AASHTO M 219 for the sizes and types specified.

707.07 Asphalt-Coated Structural Plate Structures. Provide structures conforming to either Subsection 707.05 or 707.06 as applicable. Coat with an asphalt coating conforming to AASHTO M 190, Type A or a field applied asphalt mastic coating conforming to AASHTO M 243.

If the asphalt coating is applied to the plates before field erection, identify each plate’s nominal metal thickness by painting the data on the inside surface of the plates after coating. Other methods of plate identification may be used if approved.

707.08 Polymer-Coated Steel Pipe. Provide pipe, special sections (such as elbows and branch connections) and coupling bands conforming to AASHTO M 245, Grade 250/250 and AASHTO M 246, Grade 250/250, for the dimensions, classification type, and class, if applicable, specified.

707.09 Corrugated Metal Units. Conform to AASHTO M 36 for steel corrugated units. Conform to AASHTO M 196 for aluminum corrugated units. See the plans for the diameter, shape, specific pipe classification and, if applicable, class. For coatings, conform to the following:

(a) Bituminous-coated corrugated units	AASHTO M 190, Type A
(b) Polymer-precoated corrugated units	AASHTO M 245, Grade 250/250

707.10 Metallic-Coated Slotted Drain Pipe. Provide pipe conforming to AASHTO M 36 and either AASHTO M 218, AASHTO M 274, or AASHTO M 289 for the dimensions, thicknesses, classification type, class, if applicable, and coating type specified.

Fabricate the pipe with either angle slots or grate slots and as shown in the plans.

Provide grate assemblies for the grate slot drain conforming to ASTM A1011, SS Grade 36. Galvanize slot angles and grate slot assemblies according to AASHTO M 111.

707.11 Metallic-Coated Spiral Rib Pipe. Provide pipe, special sections (such as elbows and branch connections), and coupling bands conforming to AASHTO M 36, Type IR and Type IIR, AASHTO M 218, AASHTO M 274, or AASHTO M 289 for the dimensions, thicknesses, and coating type specified.

707.12 Aluminum-Alloy Spiral Rib Pipe. Provide pipe, special sections (such as elbows and branch connections) and coupling bands conforming to AASHTO M 196, Type IR and Type IIR for the dimensions and thicknesses specified.

707.13 Concrete-Lined Corrugated Steel Pipe. Provide pipe, special sections (such as elbows and branch connections), and coupling bands conforming to Subsection 707.02 for the dimensions and thicknesses specified. Fully line the pipe and special sections with concrete according to ASTM A849, Class C.

707.14 Invert-Paved Corrugated Steel Pipe. Provide pipe, special sections (such as elbows and branch connections), and coupling bands conforming to Subsection 707.02 for the dimensions and thicknesses specified. Pave the invert of the pipe and special sections with concrete or asphalt material according to ASTM A849, Class A or Class C.

707.15 Cast Iron Soil Pipe and Fittings. Conform to ASTM A74, Class SV for the designated sizes.

707.16 Seamless Copper Water Tube and Fittings. Conform to ASTM B88, Type L for the designated sizes.

707.17 Gaskets for Metal Pipe.

(a) O-ring gaskets for flexible metal pipe. Conform to ASTM C1619, Class C.

(b) Continuous flat gaskets for flexible metal pipe with flat bands or bands with projections.

(1) Conform to ASTM D1056.

(2) Gasket thickness	½ in greater than the nominal depth of pipe corrugations

(c) Continuous flat gaskets for flexible metal pipe with corrugated bands.

(1) Conform to ASTM D1056.

(2) Gasket thickness ⅜ in

707.18 Gaskets for Ductile Iron Pipe. Conform to ASTM A746.

Section 708. — PLASTIC PIPE

708.01 Smooth Wall Polyethylene Pipe.

(a) General use. Provide perforated and nonperforated 12- to 42-inch diameter pipe conforming to ASTM F714 and minimum cell Class PE335434C according to ASTM D3350.

(b) Water systems (4 inches and over). Provide pipe conforming to the requirements of ANSI/AWWA C906. Fabricate from high-density polyethylene PE3408 conforming to a minimum cell Class 345464 C, D or E according to ASTM D3350.

708.02 Corrugated Polyethylene Pipe.

(a) General use. Provide perforated and nonperforated 12- to 48-inch diameter pipe conforming to AASHTO M 294.

(b) Culvert and storm drains. Provide Type S pipe conforming to AASHTO M 294.

708.03 Profile Wall (Ribbed) Polyethylene Pipe. Provide perforated and nonperforated 18- to 48-inch diameter pipe conforming to ASTM F894 and minimum cell Class 334433C or 335434C according to ASTM D3350.

708.04 Corrugated Polyethylene Drainage Tubing. Provide perforated and nonperforated 3- to 10-inch diameter tubing conforming to AASHTO M 252.

708.05 Corrugated Polypropylene Pipe.

(a) Culvert and storm drains. Provide 12- to 48-inch diameter pipe conforming to AASHTO M 330, Type S or Type D.

(b) Sanitary sewers. Provide pipe conforming to ASTM F2764/F2764M.

708.06 Smooth Wall Polyvinyl Chloride Pipe.

(a) General use. Provide perforated and nonperforated 4- to 15-inch diameter pipe conforming to AASHTO M 278 and minimum cell Class 12454 or Class 12364 according to ASTM D1784.

(b) Sanitary sewers. Conform to ASTM D3034.

(c) Water systems.

(1) PVC pipe (4 inches and over). Provide pipe and fittings conforming to the requirements of ANSI/AWWA C900 or ANSI/AWWA C905 and listed by UL. Provide joints conforming to the requirements of ASTM D3139 and using a restrained rubber gasket conforming to ASTM F477.

(2) PVC pipe (under 4 inches). Provide pipe and fittings conforming to ASTM D2241. Select PVC 1120, PVC 1220, or PVC 2120 with a minimum wall thickness equal or greater than a standard dimension ratio (SDR) of 21. Provide pipes bearing the National Sanitation Foundation Seal for use to transport potable water. Provide joints conforming to the requirements of ASTM

D3139 using a restrained rubber gasket conforming to ASTM F477. Provide solvent cement for pipe and fittings conforming to ASTM D2564.

(d) Horizontal drains. Provide Schedule 80 pipe and couplers conforming to ASTM D1785. Select PVC 1120, PVC 1220, PVC 2112, PVC 2116, or PVC 2120. Provide Schedule 80, solvent weld fittings conforming to ASTM D2467.

(e) Lined drain holes in rock. Provide Schedule 80 pipe and couplers conforming to ASTM D1785. Provide Schedule 80 solvent weld fittings conforming to ASTM D2467.

Provide slotted pipe with three rows of 0.01-inch slots on 120-degree centers cut around the circumference and at least 0.75 square inch of slot opening per linear foot.

708.07 Profile Wall (Ribbed) Polyvinyl Chloride Pipe. Provide perforated and nonperforated 4- to 48-inch diameter pipe conforming to AASHTO M 304 and minimum cell Class 12454C or Class 12364C according to ASTM D1784. For sanitary sewer applications, conform to ASTM F794 or ASTM F949.

708.08 Acrylonitrile-Butadiene-Styrene (ABS) Pipe. Conform to ASTM D2680.

708.09 Gaskets for Plastic Pipe.

(a) Elastomeric seals. Conform to ASTM F477.

(b) Thermoplastic elastomeric seals. Conform to ASTM F913.

Section 709. — REINFORCING STEEL AND WIRE ROPE

709.01 Reinforcing Steel.

(a) Reinforcing bars. Provide deformed, Grade 60 bars conforming to AASHTO M 31 or AASHTO M 322.

(b) Epoxy-coated reinforcing bars. Provide bars conforming to Subsection 709.01(a). For epoxy-coated prefabricated reinforcing bars, conform to ASTM A934. For epoxy-coated reinforcing bars, conform to ASTM A775.

Inspect the reinforcing bars after the near-white blast cleaning. Reject bars with steel slivers or scabs.

Provide epoxy-coated reinforcing steel coated at a CRSI-certified epoxy coating plant.

(c) Corrosion-resistant steel reinforcing bars. Fabricate from one of the following:

(1) Stainless steel reinforcing bars, AASHTO M 334, UNS Designations: S24000, S30400, S31603, S31653, S31803, or S32304.

(2) Low-carbon, chromium steel reinforcing bars, AASHTO M 334, Type 1035 CS.

(d) Tie bars. Provide deformed, Grade 60 bars conforming to AASHTO M 31.

(e) Hook bolts. Provide plain, Grade 60 bars conforming to AASHTO M 31 with M14 rolled threads or M16 cut threads. Provide a threaded sleeve nut that can sustain a minimum axial load of 15,000 pounds.

(f) Dowel bars. Conform to AASHTO M 254, Type A or Type B. Use plain round bars, without burring or other deformation restricting free movement in the concrete. Paint one-half of the length of each dowel bar with one coat of tar paint. When the paint dries and immediately before placing the dowels, lubricate the painted end to prevent concrete from bonding to the painted end.

For expansion joints, provide a dowel cap that snugly covers 2±¼ inches of the dowel, has a closed end, and has a stop to hold the closed end 1 inch from the end of the dowel bar.

Lubricants for Type B dowels may be medium setting emulsified asphalt or flaked graphite. Lubricants are not required for Type A coated dowel bars.

Provide dowel assemblies that hold dowel bars within ¼-inch tolerance vertically and horizontally during concrete placement and allow unrestricted movement of the pavement slab.

Provide wire conforming to AASHTO M 336 for dowel assemblies. Coat dowel assemblies with the same material as the dowel bar. Recoat or repair damaged coatings equivalent to the manufacturer’s original coating.

(g) Deformed steel wire. Conform to AASHTO M 336.

(h) Steel welded wire reinforcement, plain, for concrete. Conform to AASHTO M 336.

(i) Cold-drawn steel wire. Conform to AASHTO M 336.

(j) Welded deformed steel wire reinforcement. Conform to AASHTO M 336.

(k) Fabricated deformed steel bar or rod mats. Conform to AASHTO M 54.

(l) Low alloy steel deformed bars. Conform to ASTM A706.

709.02 Prestressing Steel. Conform to the following:

(a) Low-relaxation, uncoated seven-wire steel strand, AASHTO M 203, Grade 270;

(b) High-strength steel bars, AASHTO M 275, Type II; or

(c) Stress-relieved steel wire, AASHTO M 204, Type BA or Type WA.

709.03 Wire Rope. Provide IWRC or equivalent, EIP stranded steel 6 x 19 or 7 x 19 wire ropes conforming to ASTM A1023.

Section 710. — FENCING AND MESH FABRICS

710.01 Barbed Wire. Provide galvanized wire or aluminum coated wire conforming to AASHTO M 280.

710.02 Smooth Wire. Provide smooth wire conforming to ASTM A854.

710.03 Woven Wire. Provide galvanized fabric or aluminum coated fabric conforming to AASHTO M 279.

710.04 Chain Link Fence. Provide fabric, posts, rails, ties, bands, bars, rods and other fittings, and hardware conforming to AASHTO M 181.

Provide 0.177-inch coiled spring steel tension wire conforming to ASTM A641 hard temper with a Class 3 galvanized coating. Use the same coating on the tension wire as used on the rest of the chain link fence.

710.05 Fence Posts and Bollards.

(a) Wood. Conform to AASHTO M 168.

Peel bark, except for red cedar posts and bracing, which do not require peeling. Trim knots flush with the surface and season the wood.

For dimension lumber for fences, bollards, or gate posts, use timber that is sound, straight, and reasonably without knots, splits, and shakes. Provide S4S finish.

(b) Steel. Conform to AASHTO M 281, except that chain link fence conforms to AASHTO M 181.

710.06 Split Rail. Conform to ASTM F537.

710.07 Fence Gates. For frame gates using chain link fabric, conform to AASHTO M 181. Use the same chain link fabric in the gate as in the fence.

710.08 Temporary Plastic Fence. Provide plastic noncorrosive fence fabricated from polyethylene and UV stabilized for outdoor weathering. Conform to the following:

(a) Height	48 in minimum
(b) Mesh openings	3.15 to 3.35 in
(c) Color	International orange
(d) Mass	0.16 lb/ft minimum

710.09 Draped Rockfall Protection Fabric.

(a) Double-twist wire mesh. Provide 8x10 double-twist, hexagonal wire mesh conforming to ASTM A975, Style 1.

(b) High tensile strength steel wire mesh. Provide a homogenous high tensile strength steel wire mesh consisting of one wire type with a minimum tensile strength exceeding 250,000 pounds per square inch with a zinc and aluminum galvanizing applied at a minimum weight of 0.025 ounces per square feet. Provide a mesh with a minimum tensile strength of 10.0 kips per foot.

(c) Wire mesh fastener. Provide wire mesh fasteners specified by the wire mesh manufacturer.

(d) Cable net with wire mesh backing.

(1) Cable net panels. Provide net panels that are constructed from either a 1x3 high tensile steel wire spiral rope or a 7x19 galvanized aircraft cable (GAC), EIP steel with a minimum nominal diameter of $^{5}/_{16}$ inch and breaking strength of at least 9800 pounds. Use net panels with a grid size opening no larger than 12 inches by 12 inches or with a diamond in-circle diameter less than 10 inches. For the net panels made with GAC wire rope, provide wire rope conforming to Federal Specification RR-W-410 and ASTM A1023.

(2) Wire mesh backing. Provide one of the following mesh fabrics for use as the wire mesh backing attached to the cable net wire panels:

(a) 8x10 double-twist, hexagonal wire mesh conforming to ASTM A975, Style 1;

(b) Galvanized wire mesh consisting of No. 9 gauge (0.148-inch diameter) commercial quality steel wire, 3½ inches by 5½ inches diamond mesh chain link conforming to AASHTO M 181. Galvanize the wire according to ASTM A392, Class 1. Galvanize wire before weaving. Provide a wire mesh fabric with knuckled selvages; or

(c) Homogenous high tensile strength steel wire mesh consisting of one type of wire. Provide a mesh with wires with a minimum diameter of 0.079 inch, minimum tensile strength of 250,000 pounds per square inch, and a zinc and aluminum coating applied at a minimum weight of 0.40 ounce per square feet. Provide a mesh with a longitudinal minimum tensile strength of 3.6 kips per foot, and a mesh diamond in-circle diameter no larger than 4 inches.

(e) Lacing and seaming wire rope. Conform to Subsection 709.03.

710.10 Midslope Rockfall Attenuator Materials.

(a) Fence post columns. Provide columns fabricated from wide flange structural members conforming to ASTM A992 or AASHTO M 270, Grade 50 or 50S and galvanized following fabrication according to AASHTO M 111 or ASTM A123. Provide bars or plates welded to steel posts conforming to ASTM A572 Grade 50 or AASHTO M 270, Grade 50 and galvanized after fabrication according to AASHTO M 111 or ASTM A123.

(b) Attenuator net panels. Conform to Subsection 710.09(d)(1).

(c) Steel post foundation. Provide #3 diameter and #4 deformed, Grade 60 bars conforming to AASHTO M 31 or AASHTO M 322 as reinforcing steel bars for the concrete foundations.

(d) Wire mesh backing. Provide one of the following mesh fabrics for use as the wire mesh attached to the attenuator net panels:

(1) Double-twist wire mesh. Provide 8x10 double-twist, hexagonal wire mesh conforming to ASTM A975, Style 1; or

(2) High tensile strength steel wire mesh. Provide a homogenous high tensile strength steel wire mesh consisting of one type of wire. Provide a mesh with wires with a minimum diameter of 0.079 inch, minimum tensile strength of 250,000 pounds per square inch, and a zinc and aluminum coating applied at a minimum weight of 0.40 ounce per square feet. Provide a mesh with a longitudinal minimum tensile strength of 3.6 kips per foot, and a mesh diamond in-circle diameter no larger than 4 inches.

(e) Wire mesh fastener. Conform to Subsection 710.09(c).

(f) Lacing and seaming wire rope. Conform to Subsection 709.03.

Section 711. — CONCRETE CURING MATERIAL AND ADDITIVES

711.01 Curing Material. Conform to the following:

(a) Burlap cloth	AASHTO M 182
(b) Sheet material	ASTM C171
(c) Liquid membrane forming compounds	ASTM C309, Type I-D or Type 2

711.02 Air-Entraining Admixtures. Conform to AASHTO M 154.

711.03 Chemical Admixtures. Provide water-reducing, retarding, set-accelerating, and hydration stabilizing admixtures, or combinations thereof, conforming to AASHTO M 194. For hydration stabilizing admixtures, conform to AASHTO M 194, Type B or Type D.

711.04 Latex Emulsion. Provide a homogeneous, nontoxic, film forming polymeric emulsion in water with stabilizers added at the point of manufacture. Conform to the following:

(a) Color	White
(b) Styrene butadiene polymer type stabilizer	68±4 percent styrene 32±4 percent butadiene
(c) Chlorides	0 percent
(d) Polymer particle size	1500 to 2500 Angstroms average
(e) Latex	nonionic surfactant
(f) Solids	46.5 to 49.0 percent
(g) Mass	8.40 to 8.55 lb/gal @ 77 °F
(h) pH	9.0 to 13.0
(i) Shelf life	2 years minimum
(j) Portland cement composition	Polydimethylsiloxene

711.05 Concrete Coloring Agents. Conform to ASTM C979. Use only coloring agents composed of synthetic or natural inorganic iron oxides.

711.06 Reinforcing Fibers.

(a) Fibers for shotcrete. Use deformed steel or fibrillated polyolefin fibers conforming to ASTM A820 or ASTM D7508.

(b) Fibers for concrete. Use fully oriented, collated, fibrillated, white, ¾-inch long fibers of 100 percent virgin polyolefin conforming to ASTM D7508. Dose at 1.5 to 3 pounds per cubic yard of concrete.

(c) Fibers for UHPC.

(1) Closure pour. Use deformed steel fibers conforming to ASTM A820, minimum tensile strength 290,000 pounds per square inch conforming to ASTM A370.

(2) UHPC overlay. Conform to ASTM A820, Type I cold drawn wire.

Section 712. — JOINT MATERIAL

712.01 Sealants, Fillers, and Seals. Conform to the following:

(a) Joint sealants and crack fillers.

(1) Joint and crack sealant, hot-applied, for concrete and asphalt concrete pavements	ASTM D6690, Type II or Type III
(2) Crack filler, hot-applied, for concrete and asphalt concrete pavements	ASTM D5078

(3) Proprietary asphalt-rubber products, provide the following:

(a) Source and grade of asphalt binder;

(b) Total quantity of granulated rubber and mass as a percent of asphalt-rubber mixture;

(c) Granulated rubber types and quantity of each type (if blend);

(1) Mass as a percent of combined rubber; and

(2) Gradation of granulated rubber.

(d) Type of asphalt modifier, if any;

(e) Quantity of asphalt modifier and mass as a percent of asphalt binder;

(f) Other additives;

(g) Heating and application temperatures; and

(h) Manufacturer's recommended application procedures.

(4) Elastomeric joint sealant	ASTM C920, Type M, Grade P, Class 25, use T_1 or T_2
(5) Flexible cellular joint filler	ASTM D1056, Type 2, Class B or Class C, Grades 3, 4, or 5

(b) Preformed expansion joint fillers. Provide in a single piece for the depth and width required for the joint.

(1) Preformed expansion joint filler for concrete (bituminous type)	AASHTO M 33
(2) Preformed sponge rubber expansion joint filler for concrete paving and structural construction	AASHTO M 153, Type I

(3) Preformed cork expansion joint filler for concrete paving and structural construction	AASHTO M 153
(4) Performed expansion joint filler for concrete paving and structural construction (non-extruding and resilient bituminous types)	AASHTO M 213

(c) Preformed polychloroprene elastomeric joint seal for concrete pavements. Conform to ASTM D2628. Use a lubricant conforming to ASTM D2835, which was manufactured within 9 months of use.

(d) Cold-applied, single component, chemically curing silicone joint sealant for concrete pavement (non-sag). Conform to ASTM D5893, Type NS.

(e) Cold-applied, single component, chemically curing silicone joint sealant for concrete pavement (self-leveling). Conform to ASTM D5893, Type SL.

(f) Backer rod. Conform to ASTM D5249, Type 1. Use a compatible sealant as recommended by the rod manufacturer. For size of backer rod, conform to Table 712-2.

Table 712-2
Backer Rod Sizes

Joint Width After Preparation, inch	Rod Diameter, inch
5/16	3/8
3/8	1/2
1/2	5/8
5/8	3/4
3/4	1
1	1 1/4
1 1/4	1 1/2
1 1/2	2

(g) Preformed polychloroprene elastomeric joint seal for bridges. Conform to AASHTO M 297. Use an adhesive lubricant conforming to ASTM D4070.

(h) Pre-compressed foam-supported silicone joint seal.

(i) Provide a joint system comprised of the following:

(1) Cellular polyurethane foam impregnated with hydrophobic 100 percent acrylic, water-based emulsion, factory coated with highway-grade, fuel resistant silicone conforming to Table 712-3.

(2) Field-applied epoxy adhesive primer conforming to Table 712-4.

(3) Field-injected silicone sealant bands conforming to Table 712-5.

Table 712-3
Impregnated Foam Requirements

Property	Test Method	Minimum Requirement
Base material	–	Cellular, high density, polyurethane foam
Tensile strength	ASTM D3574	18 psi
UV and moisture resistance	ASTM G155	No changes - 2000 hours, Pass
Density	ASTM D545	4 lb./cu. ft.
Elongation	ASTM D3574	125%
Temperature service range	ASTM C711	-40 to 185 °F

Table 712-4
Epoxy Adhesive Requirements

Property	Test Method	Minimum Requirement
Tensile strength	ASTM D638	3500 psi
Shear strength	ASTM D732	3000 psi
Bond strength	ASTM D882	2500 psi
Compressive strength	ASTM D695	8000 psi

Table 712-5
Silicone Sealant Bands Requirements

Property	Test Method	Requirement
Color	Visual	Black
Movement capability	ASTM C719	±50%
Elongation	ASTM D412	> 600%
Tensile strength	ASTM D412	≥ 100 psi

(j) Asphaltic plug joints. Conform to ASTM D6297 except for Table 1 recommended application heating range.

Section 713. — ROADSIDE IMPROVEMENT MATERIAL

713.01 Topsoil.

(a) Provided topsoil. Provide fertile, friable, free draining, sandy loam soil that is free of subsoil, refuse, stumps, roots, brush, weeds, rocks larger than 1 inch, or other substances detrimental to the development of plant growth. Conform to the following:

(1) Texture

(a) Organic matter, AASHTO T 267 — 3.0 to 10.0 percent

(b) Sand, AASHTO T 88 — 20 to 70 percent

(c) Silt, AASHTO T 88 — 10 to 60 percent

(d) Clay, AASHTO T 88 — 5 to 30 percent

(2) pH, AASHTO T 289 — 6.0 to 8.0

(b) Conserved topsoil. Conform to Subsection 204.02(c).

713.02 Agricultural Limestone. Provide calcic or dolomitic ground limestone conforming to the standards of the Association of Official Analytical Collaboration (AOAC) International, applicable Federal and state rules and regulations, and the following:

(a) Purity (calcium and magnesium) carbonates — 75 percent minimum

(b) Gradation — Table 713-1

Table 713-1
Agricultural Limestone Gradation

Sieve Size	Minimum Percent by Mass Passing Designated Sieve (AASHTO T 27)
No. 10	90
No. 40	50

Granulated slag or other approved natural sources of lime may be used provided the application rate is adjusted to equal the total neutralizing power of the specified ground limestone.

713.03 Fertilizer. Provide standard commercial grade dry formulated fertilizer conforming to the standards of the AOAC International, applicable Federal and state rules and regulations, and required minimum percentages of available nutrients.

Provide the fertilizer in new, clean, sealed, and properly labeled containers with name, mass, and guaranteed analysis of contents clearly marked.

Liquid fertilizer containing the minimum percentage of available nutrients may be used.

713.04 Seed. Conform to the Federal Seed Act, the Federal Plant Protection Act, and applicable state and local seed and noxious weed laws. Do not use wet, moldy, contaminated, or damaged seed. Provide each seed type in separate sealed containers. Clearly label each container with the following:

(a) Name and type of seed;

(b) Lot number;

(c) Net mass;

(d) Percent of purity, germination, and hard seed;

(e) Percent of maximum weed seed content;

(f) Seed origin;

(g) Noxious weeds present;

(h) Other crop seed;

(i) Inert matter;

(j) Name and address of seed distributor; and

(k) Mixture percent of each component.

Inoculate legume seed with approved cultures according to the manufacturer's recommendations.

713.05 Mulch.

(a) Straw. Provide certified weed free straw from oats, wheat, rye, rice, or other grain crops that is not discolored, brittle, rotten, or moldy. Provide straw in an air-dry condition suitable for placing with mulch blower equipment.

(b) Wood fiber. Provide processed wood fiber from wood chips conforming to the following:

(1) Colored with a green dye non-injurious to plant growth;

(2) Readily dispersible in water;

(3) Nontoxic to seed or other plant material;

(4) Free of growth or germination inhibiting substances;

(5) Free of weed seed;

(6) Air dried to a moisture content of 12±3 percent;

(7) Packaged in new containers labeled with the manufacturer's name; and

(8) Packaged in a condition appropriate for mixing in a homogeneous slurry suitable for application with power spray equipment.

(c) Grass straw cellulose fiber. Provide processed grass straw fiber conforming to the following:

(1) Colored with a green dye non-injurious to plant growth;

(2) Readily dispersible in water;

(3) Nontoxic to seed or other plant material;

(4) Free of growth or germination inhibiting substances;

(5) Free of weed seed;

(6) Air dried to a moisture content of 10±0.2 percent;

(7) Air dried to a uniform mass of ±5 percent;

(8) Packaged in new containers labeled with the manufacturer's name and air-dry mass; and

(9) Packaged in a condition appropriate for mixing in a homogeneous slurry suitable for application with power spray equipment.

(d) Peat moss. Provide a granulated sphagnum peat moss conforming to the following:

(1) Sticks, stones, and mineral matter	0 percent
(2) Partially decomposed stems and leaves of sphagnum	75 percent minimum
(3) Color	Brown
(4) Textured from porous fibrous to spongy fibrous	
(5) pH	3.5 to 7.5
(6) Air-dried	

(e) Mature compost. Provide partially decomposed organic material, (such as leaves, grass, shrubs, and yard trimmings) cured for 4 to 8 weeks. Maturity is indicated by temperature stability and soil like odor. Provide friable, dark brown, weed-free, and pathogen-free mature compost conforming to the following:

(1) Carbon/nitrogen ratio	25/1 to 35/1
(2) Carbon/phosphorus ratio	120/1 to 240/1
(3) pH	6.0 to 7.8
(4) Water content	40 percent maximum
(5) Particle size	

(a) Seeding and sodding	½ inch maximum
(b) Erosion control	1 inch maximum
(6) Organic material	50 percent minimum
(7) Synthetic, plastic, metal, or glass material	2 percent maximum

(f) Straw for hydroseeding. Provide clean agricultural straw milled to 1 inch or less in length. Dry the fibers to 10 percent moisture for compaction. Bale in heat-sealed plastic bags.

(g) Bonded fiber matrix hydromulch. Provide a mixture of fibers and bonding agent which, when hydraulically applied and dried, produce a matrix conforming to the following:

(1) Does not dissolve or disperse when wetted;

(2) Holds at least 10 ounces of water per ounce of dry matrix;

(3) Has no germination or growth inhibiting factors;

(4) Forms no water insensitive crust;

(5) Contains material that is 100 percent biodegradable; and

(6) Is colored with a green dye non-injurious to plant growth.

(h) Recycled pulp fiber. Provide cellulose fiber mulch products manufactured from natural material diverted from the waste-stream of manufacturing processes or produced from recycled material. These include newsprint, chipboard, corrugated cardboard, wood chips, and similar material. Process the material to eliminate substances that inhibit seed germination and plant growth. Add a colored dye that is non-injurious to plant growth and fades rapidly with exposure to light. Provide fiber that readily blends with water, grass seed, fertilizer, and other additives to form a slurry suitable for application with power spray equipment. Provide a homogeneous mixture conforming to the following:

(1) Synthetic, plastic, metal, or glass material	0 percent
(2) Weed seed	0 percent
(3) Moisture content	15 percent maximum
(4) Ash content	7 percent maximum
(5) Organic matter	90 percent minimum
(6) Boron	250 ppm maximum
(7) Water-holding capacity	800 to 1200 percent by mass
(8) pH	4.0 to 8.5

(i) Wood chips. Provide wood chips from local sources including clearing. Maximum size of chips is 4 by 2 by ½ inches.

713.06 Plant Material. Unless otherwise specified, conform to the *American Standard for Nursery Stock*.

(a) Quality of plant material. Provide plants that are excellent representatives of their normal species or varieties. Provide nursery grown stock that has been transplanted or root-trimmed two or more times according to the kind and size of plant. Provide plants with a normally developed branch system. Do not provide plants with disfiguring knots, sun-scald, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other disfigurements.

Provide trees with reasonably straight stems and well branched and symmetrical branches according to their natural habits of growth.

(b) Plant names. For scientific and common plant names, conform to the United States Department of Agriculture (USDA) PLANTS Database. Clearly tag and identify plants by name and size.

(c) Grading standards. Conform to the latest edition of the *American Standard for Nursery Stock ANSI Z60.1*.

(d) Nursery inspection and plant quarantine. Provide plants that are without plant diseases and insect pests.

Comply with nursery inspection and plant quarantine rules and regulations of the states of origin and destination including Federal rules and regulations governing interstate movement of nursery stock. Provide a valid copy of the certificate of inspection with each package, box, bale, or carload shipped or otherwise delivered.

(e) Balled and burlapped plants. Provide plants from the original and undisturbed soil in which the plants were grown. Dig balled and burlapped plants to retain as many fibrous roots as possible. Wrap, transport, and handle the plants so the soil ball and small fibrous roots remain intact.

713.07 Cellular Confinement Systems. Provide a flexible honeycomb three-dimensional structure fabricated from light stabilized polyethylene plastic. Conform to the following:

(a) Functional longevity	120 months minimum
(b) Cell area	31.0 to 46.5 in^2
(c) Sheet thickness, ASTM D751	48.8 to 49.6 mils
(d) Density, ASTM D792	0.549 to 0.555 oz/in^3
(e) Carbon black content, ASTM D1603	1.5 to 2.5 percent
(f) Environmental stress-cracking, ASTM D1693	2000 hours minimum

(g) Conform to Table 713-2 for the depth specified.

Table 713-2
Cellular Confinement Systems

Property	Requirements				
Nominal cell depth, inch	2	3	4	6	8
Cell joint Strength, pound	110 minimum	160 minimum	225 minimum	315 minimum	450 minimum

713.08 Miscellaneous Planting Material.

(a) Stakes for bracing and anchoring. Conform to the *American Softwood Lumber Standard (Voluntary Product Standard PS 20)*. Fabricate stakes for bracing and anchoring trees from rough cypress, cedar, locust, or other approved wood essentially without knots, rot, crossgrain, or other defects that would impair the strength of the stake. Provide stakes with a minimum 2- by 2-inch square cross-section and adequate length.

Provide anchor stakes of the same size and quality as bracing stakes. Provide deadman anchors with the diameter and length specified.

(b) Hose. Provide 1-inch diameter hose (rubber and fabric) to be used with wire for bracing and anchoring trees.

(c) Wire. Provide 0.15-inch diameter soft annealed galvanized steel wire for bracing and anchoring trees.

(d) Wrapping material. Provide 4-inch-wide rolls of waterproof paper (triple lamination 30-30-30) or 6-inch-wide rolls of burlap for wrapping trees.

(e) Twine. Provide two-ply twine for trees 3 inches and less in diameter and three-ply twine for trees over 3 inches in diameter for tying wrapping material to the trees.

(f) Antidesiccant. If approved, provide a commercially available antidesiccant emulsion to provide a film over plant surfaces that is permeable enough to allow transpiration.

(g) Tree wound dressing. Provide a commercially available product with asphalt base and fungicide. Provide material that is antiseptic, waterproof, adhesive, and elastic. Do not use material that is harmful to living tree tissue (such as kerosene, coal tar, or creosote).

713.09 Sod. Provide living vigorous sod of the type of grass and thickness specified. Provide sod with a dense root system that is free of noxious weeds and grasses. Before taking up the sod, cut the top growth to less than 3-inch height.

713.10 Pegs for Sod. Provide square or round pegs of sound wood conforming to the following:

(a) Length	8 inches minimum
(b) Approximate cross-sectional area	1 square inch

713.11 Tackifiers. Provide a commercially available product containing no solvents or other diluting agents toxic to plant life that is without growth or germination inhibiting factors, nonflammable, nontoxic to aquatic organisms, and functional for at least 180 days.

(a) General purpose tackifier. Provide one of the following:

(1) Plant based tackifier. Provide a natural high molecular weight polysaccharide, a high viscosity hydrocolloid that is miscible in water, and labeled as one of the following:

(a) Guar gum. A product derived from the ground endosperm of the guar plant, Cyamopsis tetragonolobus, treated with dispersing agents for easy mixing and dilutable at the rate of 1 to 5 pounds per 100 gallons of water.

(b) Psyllium. A product manufactured from the finely ground mucilloid coating of Plantago ovata or Plantago ispaghula seeds; able to dry and form a firm, but rewettable membrane.

(c) Starch. A product manufactured from a nonionic, water-soluble, granular material derived from corn, potato, or other plant-based source.

(2) Polymeric emulsion blend tackifier. Provide a prepackaged liquid or dry powder, anionic formulation with a residual monomer content no more than 0.05 percent by mass and labeled with one of the following as the primary active ingredient:

(a) Acrylic copolymers and polymers;

(b) Polymers of methacrylates and acrylates;

(c) Copolymers of sodium acrylates and acrylamides;

(d) Polyacrylamide and copolymer of acrylamide; or

(e) Hydrocolloid polymers.

(b) Polymer stabilized fiber matrix tackifier. Provide the following:

(1) A liquid formulation with polyacrylamide as the primary active ingredient with the following requirements:

(a) Linear, anionic copolymer of acrylamide and sodium acrylate; and

(b) Anionic with a residual monomer content that is no more than 0.05 percent by mass.

(2) Formulated and labeled as one of the following:

(a) Water-in-oil emulsion. A product containing at least 2.6 pounds per gallon pure polyacrylamide that is at least 30 percent active; or

(b) Liquid dispersed polyacrylamide. A product containing at least 4.4 pounds per gallon pure polyacrylamide that is at least 35 percent active.

713.12 Fiber Rolls.

(a) Excelsior fiber rolls. Provide fiber rolls of curled excelsior fiber rolled into a cylindrical shape and encased in a tubular netting.

(b) Straw fiber rolls. Provide straw fiber rolls that are manufactured from certified weed free straw and wrapped in a tubular netting.

(c) Coir fiber rolls. Provide coir fiber rolls that are 100 percent coconut fiber rolled into a cylindrical shape and encased in a tubular netting.

(d) Compost fiber rolls. Provide tubular netting filled with mature compost conforming to Subsection 713.05(e).

(e) Tubular netting for fiber rolls. Provide biodegradable tubular netting with openings no larger than ⅜ inch. Provide tubular netting diameter according to the plans. Do not use monofilament netting or similar material.

713.13 Gravel Bags. Provide woven fabric bags with a minimum water flow rating of 145 gallons per minute per foot as tested by ASTM D4491. Fill the bags with clean coarse aggregate.

713.14 Sandbags. Use clean, silt free material for sand filler. Conform to the following:

(a) Bag material	canvas, geotextile, or burlap
(b) Volume per bag	⅓ ft^3 minimum

713.15 Temporary Culvert Pipe. Provide temporary culvert pipe fabricated from corrugated metal, plastic, or concrete. Provide temporary culvert pipe placed beneath the traveled way conforming to HS-20 (M-18) loading rating in AASHTO, *LRFD Bridge Design Specifications*.

713.16 Silt Fence.

(a) Geotextile. Conform to Table 7 of AASHTO M 288.

(b) Posts. Conform to the following:

(1) Wood posts. Conform to the following:

(a) 1½ inches by 1½ inches by 4 feet minimum dimensions;

(b) Untreated fir, redwood, cedar, or pine, cut from sound timber with no loose or unsound knots; and

(c) Pointed on end driven in ground.

(2) Steel posts. Conform to the following:

(a) 48 inches minimum length;

(b) Cross-section shape that can resist failure from lateral loads (T-shaped, U-shaped, or L-shaped); and

(c) 0.75 pound per foot minimum mass.

(c) Silt fence reinforcement. Provide a wire mesh consisting of 14-gauge steel with mesh spacing of 6 by 6 inches or prefabricated polymeric mesh of equivalent strength.

713.17 Rolled Erosion Control Products. Provide RECP conforming to Table 713-3 and the following:

(a) Type 1.A, ultra-short-term netting or open weave textiles. Provide a photodegradable synthetic mesh or woven biodegradable natural fiber netting.

(b) Type 1.B, ultra-short-term net-less rolled erosion control blankets. Provide natural or polymer fibers mechanically interlocked or chemically adhered together.

(c) Type 1.C, ultra-short-term single-net erosion control blankets. Provide a processed degradable natural or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting

(d) Type 1.D, ultra-short-term double-net erosion control blankets. Provide a processed degradable natural or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.

(e) Type 2.A, short-term netting or open weave textiles. Provide a photodegradable synthetic mesh or woven biodegradable natural fiber netting.

(f) Type 2.B, short-term net-less rolled erosion control blankets. Provide a natural or polymer fibers mechanically interlocked or chemically adhered together.

(g) Type 2.C, short-term single-net erosion control blankets. Provide processed degradable natural or polymer fibers mechanically bound together by a single degradable synthetic or natural fiber netting.

(h) Type 2.D, short-term double-net erosion control blankets. Provide processed degradable natural or polymer fibers mechanically bound between two degradable, synthetic or natural fiber nettings.

(i) Type 3.A, extended-term open weave textiles. Provide an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.

(j) Type 3.B, extended-term erosion control blankets. Provide an erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix.

(k) Type 4.A, long-term open weave textiles. Provide an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.

(l) Type 4.B, long-term erosion control blankets. Provide an erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix.

Do not use monofilament netting or similar material.

Table 713-3
Rolled Erosion Control Product Type

Property	Test Method	1.A[1]	1.B	1.C	1.D	2.A[1]	2.B	2.C	2.D	3.A	3.B	4.A	4.B
Typical functional longevity, months[2]	N/A	3	3	3	3	12	12	12	12	24	24	36	36
Maximum "C" factor[3]	ASTM D6459[6]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.05	0.05	0.05	0.05
Maximum gradient slope[4]	N/A	1V:5H	1V:3H	1V:3H	1V:2H	1V:5H	1V:3H	1V:3H	1V:2H	1V:2H	1V:1.5H	1V:1H	1V:1H
Minimum shear stress, lb/ft^2 [5]	ASTM D6460[6]	1.00	1.00	1.50	1.75	1.00	1.00	1.50	1.75	2.00	2.00	2.25	2.25
Minimum MD material tensile strength, lb/ft	ASTM D6818	125	125	60	75	125	125	60	75	100	100	100	100
Minimum TD material tensile strength, lb/ft	ASTM D6818	10	10	20	40	10	10	20	40	40	40	40	40
Material thickness, inch	ASTM D6525	>0.03	>0.30	>0.25 to <0.50	>0.25 to <0.50	>0.03	>0.30	>0.25 to <0.50	>0.25 to <0.50	>0.20 to <0.40	>0.25 to <0.50	>0.20 to <0.40	>0.20 to <0.50
Ground coverage	ASTM D6567	>3%	>50% to <90%	>50% to <90%	>50% to <90%	>3%	>50% to <90%	>50% to <90%	>50% to <90%	>40%	>50% to <95%	>50%	>50% to <95%
Material mass, oz/yd^2	ASTM D6475	>0.2	>10.0	>8.0	>8.0	>0.2	>10.0	>8.0	>8.0	>11.0	>8.0	>20.0	>8.0

(1) Obtain the C Factor and permissible shear stress for Types 1.A. and 2.A. mulch control nettings with netting used in conjunction with pre-applied mulch material.
(2) Functional longevities are for guidance only. Actual functional longevities may vary based on site and climatic conditions.
(3) Maximum C Factor from standardized large-scale rainfall performance testing, ASTM D6459, or approved equivalent.
(4) Maximum recommended gradient for the product for rainfall and slope application.
(5) Minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (greater than 0.5 in soil loss) during a 30-minute flow event in large-scale performance testing, ASTM D6460, or approved equivalent.
(6) Or other approved large-scale test methods.

713.18 Turf Reinforcement Mats. Provide turf reinforcement mat composed of UV-stabilized non-degradable synthetic fibers, filament, nets, wire mesh, or other elements processed into a permanent, three-dimensional matrix conforming to Table 713-4.

Table 713-4
Turf Reinforcement Mats

Property[1]	**Test Method**	**Rolled Erosion Control Product Type**					
		5.A	**5.B**	**5.C**	**5.D**	**5.E**[2]	**5.F**[2]
Maximum gradient	N/A	1V:1H	1V:1H	1V:0.5H	1V:0.5H	1V:0.5H	1V:0.5H
Performance test unvegetated shear stress, lb/ft^2 [4,5,6]	ASTM D6460	>2.0	>2.0	>2.0	>2.0	>2.0	>2.0
Performance test vegetated shear stress, lb/ft^2 [4,5,7]	ASTM D6460	>6.0	>8.0	>10.0	>12.0	>12.0	>14.0
Seedling emergence[4]	ASTM D7322	>250%	>250%	>250%	>250%	>250%	>250%
Minimum MD material tensile Strength, lb/ft [3,4,8]	ASTM D6818	150	175	200	325	1500	3000
Minimum TD material tensile Strength, lb/ft [3,4,8]	ASTM D6818	150	175	200	225	1500	3000
Material mass, oz/yd^2 [4]	ASTM D6566	>8.0	>8.0	>8.0	>8.0	>8.0	>8.0
Minimum material thickness, inch[4]	ASTM D6525	0.25	0.25	0.25	0.25	0.25	0.25
UV stability[4]	ASTM D4355	>80% @500 hours	≥ 80% @500 hours	≥ 80% @1000 hours	≥ 80% @1000 hours	≥ 90% @1000 hours	≥ 80% @3000 hours

(1) For turf reinforcement mats containing degradable components, obtain property values on the nondegradable portion of the matting alone.
(2) For material Types 5.E and 5.F, property values tested according to ASTM D6818 and D6525 are reported as minimum average roll values (MARVs). MARVs are calculated as the typical minus two standard deviations. Statistically, it yields a 97.7 percent degree of confidence that any samples taken from QA testing will exceed the value reported.
(3) Minimum average roll values: MD = machine direction only, TD = transverse direction.
(4) Typical values are calculated as the average value. Statistically, it yields a 50 percent degree of confidence that any samples taken from QA testing will exceed the value reported.
(5) Acceptable large-scale testing protocol may include ASTM D6460, or other approved independent testing. Large scale performance testing typically involves limited soil types and vegetative stands; therefore, it is recommended that an appropriate factor of safety be used in design and product selection.
(6) Required minimum stress turf reinforcement mat (unvegetated) can sustain without physical damage or excess erosion (greater than 0.5-inch soil loss) during ~~a~~ successive 30-minute flow event in large-scale.
(7) Required minimum shear stress turf reinforcement mat (fully vegetated) can sustain without physical damage or excess erosion (greater than 0.5-inch soil loss) during successive 30-minute flow event in large-scale testing.
(8) Or other approved large-scale test methods.

713.19 Sediment Filter Bags. Provide rot and mildew resistant bags composed of a non-woven geotextile fabric conforming to Table 713-5 and the following:

(a) Minimum size 150 ft^2

(b) Sewn-in sleeve to fit minimum 4-inch pump discharge hose.

Secure discharge hose with a hose clamp.

Table 713-5
Sediment Filter Bag Geotextile Requirements

Property	Test Method ASTM	Units	Specifications
Mass	D3776	oz/yd^2	8.0
Minimum grab tensile strength	D4632	lb	205
Minimum tensile elongation at break	D4632	%	50
Static California Bearing Ratio puncture	D6241	lb	500 to 700
Minimum trapezoid tear strength	D4533	lb	80
Minimum ultraviolet resistance	D4355	%	70
Minimum permittivity	D4491	sec^{-1}	1.4
Water flow rate	D4491	$gal/min/ft^2$	95
Apparent opening size	D4751	US Sieve	80 to 100

713.20 Prefabricated Filter Insert. Provide a commercially available prefabricated filter insert that provides a highflow bypass and meets the size and dimension of the catch basin or drop inlet. Follow the manufacturer's recommendations.

713.21 Floating Turbidity Curtains. Provide turbidity curtains that meet the intended application for the site conditions (flow, depth, width, wind, and wave activity). Provide turbidity curtains made of tightly woven nylon, plastic, or other nondeteriorating material conforming to Table 713-6 and the following:

(a) Fabric overlap, if more than one width of fabric is required;

(b) Supporting flotation buoyancy;

(c) Ballast chain (galvanized); and

(d) Dual galvanized wire rope load lines with a vinyl coating.

Table 713-6
Floating Turbidity Curtain Material Requirements

Property	Test Method ASTM	Units	Specifications
Minimum grab tensile strength: machine direction	D4632	lb	370
Minimum grab tensile strength: cross machine direction	D4632	lb	250
Trapezoid tear strength: machine direction	D4533	lb	100
Trapezoid tear strength: cross-machine direction	D4533	lb	60
California Bearing Ratio puncture strength	D6241	lb	500
Apparent opening size	D4751	US standard sieve	70
4% permittivity	D4491	s^{-1}	0.28

713.22 Plastic Lining. Provide a film or fabric that is serviceable for the duration of the installation.

Section 714. — GEOSYNTHETIC MATERIAL

714.01 Geotextile. Provide geotextile conforming to the following physical properties based on intended use of the geotextile:

(a) Separation geotextile. Conform to AASHTO M 288 Table 1, Class 1 and Table 3. Separation geotextiles can be in either the <50 percent elongation category (woven) or the ≥50 percent elongation (non-woven) category.

(b) Stabilization geotextile. Conform to AASHTO M 288 Table 1, Class 1, <50 percent elongation (woven) only, and AASHTO M 288 Table 5.

(c) Geotextile filter. Conform to AASHTO M 288 Table 1, Class 1 and Table 6 for riprap, special rock embankment, rock buttress, and other high survivability applications.

Conform to AASHTO M 288 Table 1, Class 2 and Table 2 for underdrains and other subsurface drainage applications.

Geotextile filter can be in either the <50 percent elongation category (woven) or the ≥50 percent elongation (non-woven) category.

(d) Paving geotextile. Provide geotextile conforming to AASHTO M 288, Table 8.

Do not use woven slit film geotextile.

714.02 Geocomposite Drain. Provide a prefabricated geocomposite drain composed of a drainage core and a nonwoven geotextile that allows in-flow from both sides. Geocomposites that only allow in-flow from one side may only be used directly against a concrete surface. Provide geotextile conforming to AASHTO M 288 and drainage core manufactured from long chain synthetic polymers composed of at least 95 percent by mass of polypropylene, polyester, polyamide, PVC, polyolefin, or polystyrene. Build the core up in thickness by columns, cones, nubs, cusps, meshes, stiff filaments, or other configurations. Fabricate the core in sheets, panels, or rolls of adequate strength to resist installation stresses and long-term loading conditions. Firmly attach the encapsulating geotextile to the core at the manufacturing plant, so that folding, wrinkling, or other movement cannot occur during handling or after placement. Use a nonwater-soluble adhesive, heat sealing, or other methods recommended by the geotextile manufacturer. Do not use adhesive on areas of the geotextile where flow is intended to occur.

If heat sealing is used, do not weaken the geotextile below the required strength values. Extend the geotextile beyond the core length on all sides sufficiently to encapsulate the core and collector pipe.

Conform to Table 714-1.

Table 714-1
Geocomposite Drain Requirements

Property	Test Method	Units	Specifications[5]		
			Sheet Drain	Strip Drain	
			Type 1	Type 1	Type 2
Transmissivity (flow rate)[1]	ASTM D4716	Gal/min/ft	5.0	15.0	20.0
Compressive strength at yield	ASTM D1621	psi	100	50	50
Applied normal compressive stress	ASTM D4716[4]	psi	14.5	1.45	1.45
Hydraulic gradient	ASTM D4716[2],[3],[4]	dimensionless	1.0	0.1	0.1
Fungi resistance	ASTM G21	–	No visible growth		

(1) If core construction separates the flow channel into two or more discrete sections, only the flow rate on one in-flow face is considered in determining the core's acceptability.
(2) 14-inch-long specimen.
(3) 100-hour seating period.
(4) Rubber membrane between platens and geocomposite.
(5) The property values in this Table are specified as minimum average roll value (MARV) in the weakest principal direction as described in ASTM D4759, except for fungi resistance.

714.03 Stabilization Geogrid. Provide biaxial geogrid conforming to AASHTO M 288, Table 12, Class 4C.

714.04 Reinforcement Geotextile and Geogrid. Provide reinforcement geotextile and geogrid conforming to AASHTO M 288 Tables 9 and 10, and Table 714-2.

The minimum allowable long-term strength (T_{al}) for each layer of reinforcement geotextile or geogrid is based on:

$$T_{al} = \frac{T_{ult}}{RF}$$

where:

T_{ult} = Ultimate tensile strength of the reinforcement geotextile or geogrid

RF = Reduction Factors = $RF_{ID} \times RF_{CR} \times RF_{D}$.

Provide manufacturer test data for RF_{ID}, RF_{CR}, and RF_{D} values by evaluation of independent test results by Highway Innovative Technology Evaluation Center (HITEC), AASHTO Product Evaluation & Audit Solutions, Innovations, Developments, Enhancement and Advancements (IDEA), or an equivalent third-party report.

Table 714-2
Reinforcement Geotextile and Geogrid Strength Requirements

Property	Test Method ASTM	Units	Minimum Specifications(1),(2)					
			Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Allowable long-term strength (T_{al})	D4595 or D6637(3),(4)	lb/ft	1000	1500	2000	2500	3000	4000

(1) For reinforcement geotextile, also meet the Class 1 strength requirements in AASHTO M 288 Table 1 and the ultraviolet stability requirements of AASHTO M 288 Table 10.
(2) The specified strength is in the principal direction of reinforcement, perpendicular to the wall or slope face and based on MARV.
(3) ASTM D4595 is for reinforcement geotextile and ASTM D6637 is for geogrid.
(4) See the nominal long-term strength (T_{al}) formula above.

714.05 Geomembrane. Provide geomembrane that consists of textured (roughened) surface polyvinyl chloride, HDPE, or linear low density polyethylene with a thickness of 28.5 to 31.5 mils. Glue or weld seams of the geomembrane to prevent leakage.

Conform to Table 714-3.

Table 714-3
Geomembrane Requirements

Geomembrane Type	Test Method
Polyvinyl chloride (PVC)	ASTM D7176(1)
HDPE	GRI Test Method GM13(2)
Linear low density polyethylene (LLDPE)	GRI Test Method GM17(2)

(1) The minimum average asperity height is 10 mils. Ensure 8 of 10 readings are greater than or equal to 7 mils and the lowest individual reading is greater than or equal to 5 mils.
(2) Geosynthetic Research Institute.

714.06 Geosynthetic Reinforced Soil Reinforcement Geosynthetic. Provide reinforcement geotextile or geogrid conforming to AASHTO M 288, Tables 9 and 10, and Table 714-4.

Table 714-4
GRS Reinforcement Geotextile and Geogrid Strength Requirements

Property	Test Method ASTM	Units	Minimum Specifications(1)
Ultimate tensile strength(2) (T_{ult})	D4595	lb/ft	4800
Tensile strength at 2% strain ($T_{2\%}$)	D4595	lb/ft	1320

(1) The specified strength is in the principal direction of reinforcement perpendicular to the wall or slope face.
(2) Based on MARV.

Section 715. — PILING

715.01 Untreated Timber Piles. Conform to AASHTO M 168. Fabricate the piles from the following species (or group):

(a) Douglas fir;

(b) Larch;

(c) Red pine;

(d) Red oak; or

(e) Southern pine.

715.02 Treated Timber Piles. Conform to AASHTO M 133 and AASHTO M 168. Use Douglas-fir or southern pine.

Use the pressure method procedure prescribed in AWPA. Apply the treatment to the piles after millwork is completed.

Imprint legible symbols or legend on the end of piles identifying the name of the treating company and type and year of treatment according to AWPA Standards M1, *Standard for the Purchase of Treated Wood Products* and M6, *Brands Used on Preservative Treated Materials*.

715.03 Steel Pipes. Provide steel pipe piles conforming to one of the following:

(a) API 5L X52 PSL2; or

(b) ASTM A709, Grade 50, meeting non-fracture critical tension component impact test requirements. Use Zone 2 if no temperature zone is shown in the plans.

Provide closure plates for closed end piles conforming to ASTM A572, ASTM A588, or ASTM A690, Grade 50.

715.04 Steel H-Piles. Fabricate the H-piles from structural steel conforming to ASTM A709, Grade 50.

Provide base metal, coil or plate, used for fabrication of steel H-piling meeting ASTM A709 non-fracture critical tension component impact test requirements. Use Zone 2 if no temperature zone is shown in the plans.

715.05 Sheet Piles. Conform to AASHTO M 202.

715.06 Pile Shoes. For timber and steel piles, provide prefabricated cast steel shoes or driving points conforming to ASTM A27, Grade 65-35 or ASTM A148, Grade 90-60.

715.07 Splices. Manufacture splices from structural steel conforming to ASTM A709, Grade 50 for H or pipe piles.

715.08 Helical Piles. Provide cold-formed welded and seamless carbon steel round or square central shaft helical piles conforming to ASTM A500. Provide high strength low alloy structural steel helix plates conforming ASTM A572. Use hot-dip galvanized coating conforming to AASHTO M 111 with a minimum thickness of 3.9 mils. Provide bolts and assemblies conforming to ASTM F3125 and galvanized according to AASHTO M 232.

Section 716. — MATERIAL FOR TIMBER STRUCTURES

716.01 Untreated Structural Timber and Lumber. Conform to AASHTO M 168. Provide an inspection certification from an agency accredited by the American Lumber Standards Committee for the species and grade. Mark pieces with the inspection service, grade designation, species, and inspector identity.

Season and dry structural timber and lumber before fabrication. Do not use material that is twisted, curved, or otherwise distorted.

Do not use boxed-heart pieces of Douglas fir or redwood in outside stringers, floor beams, caps, posts, sills, or rail posts.

716.02 Treated Structural Timber and Lumber. Provide wood according to Subsection 716.01, treated according to AASHTO M 133 and AWPA Standards U1 and T1.

Provide treated timber members with a quality mark approved by the American Lumber Standards Committee or equivalent for individual pieces or sealed pallets assuring that treatment conforms to the appropriate AWPA standards.

For hand-contact surfaces such as handrails, use timber treated with waterborne copper-based solutions or suspensions containing copper that do not contain arsenic or chromium compounds.

716.03 Structural Glued Laminated Timber. Conform to ANSI A190.1, Product Standard for Structural Glued Laminated Timber and ANSI 117, Standard Specifications for Structural Glued Laminated Timber of Softwood Species.

Provide members with industrial appearance grade for wet use conditions. Use only single-piece or multiple-piece laminations with bonded edge joints.

Provide straight or slightly cambered members which are to be loaded perpendicular to the wide face of the laminates that are stamped *top* on the top at both ends of the beam.

716.04 Wood-Plastic Composite. Provide composite timber decking that can support commercial use with the stringer spacing as shown in the plans. Provide boards with a flat, non-grooved texture at the bottom face. Conform to ASTM D7568 and the following:

(a) Ultimate bending strength, ASTM D198	2500 psi minimum
(b) Ultimate modulus of rupture, ASTM D7031	2500 psi minimum
(c) Ultimate modulus of elasticity, ASTM D7031	200,000 psi minimum
(d) Fungus resistance, ASTM D1413	No decay

716.05 Hardware. Provide bolts, drift pins, and dowels conforming to ASTM A307. Provide nuts conforming to ASTM A563.

Provide gray iron castings according to Subsection 717.04(c), and malleable iron castings according to Subsection 717.04(d).

Provide nails and spikes conforming to ASTM F1667.

Galvanize iron and steel hardware according to ASTM A153.

Section 717. — STRUCTURAL METAL

717.01 Structural Steel.

(a) Structural carbon steel. Conform to the following:

(1) Primary bridge members	AASHTO M 270, Grade 36T or 50ST
(2) Fracture critical bridge members	AASHTO M 270, Grade 36F or 50SF
(3) Hollow structural sections	ASTM A500, Grade B or C, ASTM A618, ASTM A847, or ASTM A1085
(4) Other shapes, plates, and bars	AASHTO M 270, Grade 36 or 50S

(b) High-strength low-alloy structural steel. Conform to the following:

(1) Primary bridge members and welded members	AASHTO M 270, Grade 50T or 50WT
(2) Fracture critical bridge members and fracture critical welded members	AASHTO M 270, Grade 50F or 50WF
(3) Other shapes, plates, and bars	AASHTO M 270, Grade 50 or 50W

(c) HPS. Conform to the following:

(1) Primary bridge members	AASHTO M 270, Grade HPS 50WT, HPS 70WT, or HPS 100WT
(2) Fracture critical bridge members	AASHTO M 270, Grade HPS 50WF, HPS 70WF, or HPS 100WF
(3) Other shapes, plates, and bars	AASHTO M 270, Grade HPS 50W, HPS 70W, or HPS 100W

(d) Bolts and nuts. Conform to ASTM F1554, Grade 36 or 55, or ASTM A307 as shown in the plans. Provide nuts conforming to ASTM A563 for appropriate grade and size of anchor bolt. Lubricate galvanized nuts with a lubricant containing a visible dye.

(e) High-strength bolts, nuts, and washers. Provide bolts conforming to ASTM F3125 or ASTM F3148 as specified. If not provided as an assembly (ASTM F3125 Grades F1852 and F2280, or ASTM F3148), provide nuts conforming to ASTM A563, Grade DH or DH3, with the S1 *Supplementary Lubricant Requirement*, and provide washers conforming to ASTM F436. Use Type 3 bolts, nuts, and washers to connect uncoated weathering steel components. Use Type 1 or 3 in other scenarios.

Provide fastener assembly coatings conforming to ASTM F3125 Annex A1 or ASTM F3148 Table 1. If hot-dip or mechanically galvanized coatings are used, use a lubricated nut dyed blue.

Provide fastener assemblies (bolt, nut, and washers) that have been rotation-capacity tested by the manufacturer and fastener components that have been assigned a rotation-capacity lot number.

(f) Rockfall protection hardware. Provide wire rope clips that meet Federal Specification FF-C-450G, wire rope thimbles that meet Federal Specification FF-T-276C, and shackles and swivels that meet Federal Specification RR-C-271D. Provide wire rope clips, thimbles, shackles, and swivels sized for wire rope diameters of 1 inch, ¾ inch, $^{9}/_{16}$ inch, ½ inch, $^{5}/_{16}$ inch, and ¼ inch. Galvanize all other hardware according to AASHTO M 232 or ASTM A153.

(g) Rockfall protection nuts and washers. Provide nuts conforming to ASTM A563 or ASTM A536 that can develop 100 percent of the minimum ultimate tensile strength (MUTS) of the bar. Provide anchor nuts that meet the specified strength requirement while allowing a maximum 5-degree misalignment between the nut and the bearing plate. Provide hardened washers conforming to ASTM F436, ASTM A536, or ASTM A47, and plate washers conforming to ASTM A572, Grade 50. Galvanize nuts and washers after fabrication according to AASHTO M 232, ASTM A153, or ASTM F2329.

(h) Anchor plates. Provide anchor plates conforming to ASTM A572 Grade 50, hot-dipped galvanized according to AASHTO M 232, and with the following characteristics:

(1) Steel plate thickness of at least ¼ inch.

(2) Bent edges to provide load-bearing points extending through the mesh.

717.02 Steel Forgings. Conform to AASHTO M 102, Classes C, D, F, and G.

717.03 Pins and Rollers. Provide pins and rollers more than 9 inches in diameter from annealed carbon steel forgings conforming to AASHTO M 102, Class C.

Provide pins and rollers no more than 9 inches diameter from either annealed carbon steel forgings conforming to AASHTO M 102, Class C or cold finished carbon steel shafting conforming to AASHTO M 169, Grade 1016 to Grade 1030 inclusive, with a minimum Rockwell Scale B hardness of 85. The hardness requirement may be waived if the steel develops a tensile strength of 70,000 pounds per square inch and a yield point of 36,000 pounds per square inch.

For pin threads, conform to ANSI B1.1, Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms), Class 2A. Thread pin ends with a diameter of at least 1⅜ inches with 6 threads to the inch.

717.04 Castings.

(a) Steel castings. Conform to AASHTO M 103, Grade 70-36.

(b) Chromium alloy steel castings. Conform to AASHTO M 163, Grade CA15.

(c) Gray iron castings. Conform to AASHTO M 105, Class 30B or 35B.

(d) Malleable iron castings. Conform to ASTM A47, Grade 32510.

717.05 Welded Stud Shear Connectors. Conform to AASHTO M 169 and AASHTO, *LRFD Bridge Construction Specifications,* Article 11.3.3, Welded Stud Shear Connectors.

717.06 Steel Pipe. Provide galvanized steel pipe conforming to ASTM A53, Type F, standard weight class, and plain ends for the designation specified.

717.07 Galvanized Coatings. Galvanize steel according to AASHTO M 111.

717.08 Steel Grid Floors. Conform to AASHTO M 270, Grade 36. Galvanize according to AASHTO M 111 unless coating is specified.

717.09 Bearings.

(a) Elastomeric bearings, plain or laminated. Conform to AASHTO M 251.

(b) High load rotational spherical bearings. Conform to ASTM D5977.

(c) Polytetrafluoroethylene surfaces for bearings. Conform to the following:

(1) PTFE resin. Provide virgin PTFE resin material conforming to ASTM D4894 or ASTM D4895.

(2) Filler material. Provide milled glass fibers, carbon, or other approved inert material.

(3) Adhesive material. Provide epoxy resin adhesive conforming to AASHTO M 235.

(4) Unfilled PTFE sheet. Provide unfilled PTFE sheet made from PTFE resin. Conform to Table 717-1.

(5) Filled PTFE sheet. Provide filled PTFE sheet made from PTFE resin uniformly blended with filler material. Do not exceed 15 percent filler content using fiberglass or 25 percent filler content using carbon fibers. For filled PTFE sheets containing glass fibers or carbon, conform to Table 717-1.

(6) Fabric containing PTFE fibers. Provide fabric made from oriented multifilament PTFE fluorocarbon and other fibers or from a mixture of PTFE fibers made from twisted, slit PTFE tape and other fibers according to the manufacturer's recommendations. Conform to Table 717-1.

Table 717-1
Polytetrafluoroethylene Sheeting

Property	ASTM Method	Sheet Unfilled	Sheet with 15 percent Glass Fibers	Sheet with 25 percent Carbon Fibers	Woven Fabric
Tensile strength, minimum	D638 or D2256	2800 psi	2000 psi	1300 psi	24,000 psi
Elongation, minimum	D638 or D2256	200%	150%	75%	35%
Specific gravity, minimum	D792	2.16±0.03	2.20±0.03	2.10±0.03	–
Melting point	D4591	623±2 ºF	621±18 ºF	621±18 ºF	–

(7) Interlocked bronze and filled PTFE components. Provide a phosphor bronze plate conforming to ASTM B100 with a 0.010 inch thick, porous bronze surface layer conforming to ASTM B103 into which is impregnated a lead-PTFE compound. Overlay the surface with compounded PTFE at least 0.001 inch thick.

(8) Lubricants. Use lubricants consisting of a combination of solids that do not react chemically or electrolytically with the PTFE and its mating surface and remain stable in the environmental conditions expected at the bridge site.

(9) Surface treatment. For epoxy bonding, factory treat one side of the PTFE sheet with a sodium naphthalene or sodium ammonia process.

(10) Stainless steel mating surface. Conform to ASTM A264, Type 304 and the following:

(a) Thickness	0.0598 inch minimum, if maximum dimension is 12 inches or less 0.0897 inch minimum, if maximum dimension exceeds 12 inches
(b) Surface finish	8 μin root mean square maximum

Polish or roll stainless steel mating surfaces as necessary to a finish at least 20 micro-inches.

717.10 Aluminum Alloy for Bridge Rail. For extruded bars, rods, shapes, and tubes, conform to ASTM B221, alloy 6061-T6. For rolled or extruded structural shapes, conform to ASTM B308, alloy 6061-T6.

717.11 Aluminum Bolt Heads and Nuts. Conform to American standard heavy hexagon ANSI B18.2. For threads, conform to American standard coarse series, Class 2 fit, ANSI specification B1.1, Unified Inch Screw Threads (UN, UNR, and UNJ Thread Forms).

717.12 Aluminum Welding Wire. Conform to Table 717-2.

Table 717-2
Aluminum Welding Wire

Alloy Series	Specification	Wire
3xxx and 6xxx	AWS A5.10	ER 4043
3xxx, 5xxx, and 6xxx		ER 5356
5xxx and 6xxx		ER 5556 or ER 5183

Section 718. — TRAFFIC SIGNING AND MARKING MATERIAL

718.01 Retroreflective Sheeting. Conform to ASTM D4956, including supplementary requirements. Clean and degrease the face of the metal panels using methods recommended by the manufacturer before applying retroreflective sheeting. Wipe plastic panels clean with a slightly dampened cloth before applying retroreflective sheeting. Provide retroreflective sheeting conforming to Table 718-1.

Table 718-1
Retroreflective Sheeting Types

Application	Description	Sheeting Types
Permanent	Roadside signs	Type III, IV, VIII, IX, or XI prismatic retroreflective sheeting. Use fluorescent yellow-green sheeting for signs associated with school buses, schools, and related supplementary plaques.
Permanent	Multilane or overhead guide signs	Type III or Type IV prismatic retroreflective sheeting for the background and Type IX or Type XI retroreflective sheeting for the legend.
Permanent	Parking lot and non-roadway signs	Types I and Type II retroreflective sheeting may be used.
Temporary	Signs	Type III, IV, VIII, IX, or XI prismatic retroreflective sheeting. Use fluorescent sheeting for orange signs. For roll-up signs, use fluorescent Type VI retroreflective sheeting.
Temporary	Barricades	Type III, IV, IX, or XI retroreflective sheeting.
Temporary	Cones and tubular markers	Type III or Type VI retroreflective sheeting.
Temporary	Drums	Type III or Type VI retroreflective sheeting.
Temporary	Flagger paddles	Type III, IV, VIII, IX, or XI retroreflective sheeting.
Temporary	Vertical panels	Type III, IV, VIII, IX, or XI retroreflective sheeting.

718.02 Legends and Borders. Form letters, numerals, and other units to provide a continuous stroke width with smooth edges. Make the surface flat and free of warp, blisters, wrinkles, burrs, and splinters. Do not fabricate letters, numerals, arrows, symbols, or borders using a red screen ink process.

Conform to one of the following techniques:

(a) Type L-1 (screen process). Apply letters, numerals, arrows, symbols, borders, and other features on the sign background by direct or reverse screen process. Apply messages and borders of a color darker than the sign background by the direct process. Apply messages and borders of a color lighter than the sign background by the reverse screen process.

Apply screen inks for use on the various types of retroreflective sheeting. Apply ink that has the same durability and color as specified for that type of retroreflective sheeting. Apply black screen ink until opaque on retroreflective sheeting.

Provide a uniform color and tone, with sharply defined edges of legends and borders. Do not allow running, streaking, or sagging.

Air dry or bake the signs after screening to provide a smooth hard finish.

(b) Type L-2 (transparent films). Apply letters, numerals, arrows, symbols, borders, and other features on the sign background with colored transparent films. Select durable, electronically cuttable films coated with a transparent pressure-sensitive adhesive protected by a removable liner. Use transparent films recommended by the manufacturer within the color requirements specified for the retroreflective sheeting.

(c) Type L-3 (direct applied characters). Cut letters, numerals, arrows, symbols, borders, and other features from black opaque or retroreflective sheeting of the color specified. Apply characters to the sign background. Use the same sheeting manufacturer for both the sign legend, border, and background.

Use colors specified in the plans or the MUTCD, *Standard Highway Signs, Including Pavement Markings and Standard Alphabets* and material conforming to Subsection 718.01.

718.03 Panels. Package sign panels in protective material and transport in a vertical position. Provide sign panels that show the manufacturer's name and date of manufacture on the back. Conform to the following:

(a) Plywood. Provide exterior Grade B-B high-density overlay plywood or better conforming to NIST Voluntary Product Standard PS 1, *Structural Plywood*. Use ½-inch thick plywood for sign panels with a facial area 24 by 24 inches or less and the horizontal dimension no greater than the vertical dimension. Use ¾-inch thick plywood for larger panels.

(b) Steel. Provide continuous coated (galvanized) 0.08-inch sheet steel blanks conforming to ASTM A653 and zinc coating designation G90.

Provide panels with a substantially plane surface. Do not use twisted or buckled panels.

(c) Aluminum. Provide panels conforming to ASTM B209, alloy 6061-T6 or 5052-H38.

Fabricate temporary panels and permanent panels smaller or equal to 30 by 30 inches from 0.080-inch-thick aluminum sheets. Fabricate larger permanent panels from 0.125-inch-thick aluminum sheets.

Provide blanks without laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. Use blanks with uniform thickness and that are commercially flat.

Join extruded aluminum panel sections with panel nuts, bolts, and washers to achieve the desired sign size. Use 6- and 12-inch plate heights to achieve the sign panel vertical dimensions in increments of 6 inches. Do not include more than one 6-inch plate per sign.

(d) Plastic.

(1) Non-reinforced plastic. Provide polycarbonate material that is ultraviolet stabilized for outdoor weathering and will accept adhesives, coatings, and retroreflective sheeting material.

Fabricate panels smaller or equal to 24 by 24 inches from 0.08-inch-thick plastic blanks. Fabricate larger panels from 0.125-inch-thick plastic blanks.

Provide panels that are flat and free of buckles, warps, and other defects. Do not allow a gap between adjacent panels greater than ⅝ inch where multiple panels adjoin. Attach reinforcement stiffeners on the back of panels larger than 24 by 24 inches rigidity and mounting on supports.

(2) Reinforced plastic (fiberglass). Provide panels made from fiberglass reinforced thermoset polyester acrylic modified laminate sheets. Provide sign panels ultraviolet stabilized for outdoor weathering ability that will accept adhesives, coatings, and retroreflective sheeting material.

Provide sign panels free of visible cracks, pinholes, foreign inclusions, or surface wrinkles that would affect implied performance, alter the specific dimensions of the panel, or otherwise affect the sign panels serviceability.

Fabricate fiberglass reinforced panels conforming to the following mechanical and physical properties:

(a) Average tensile strength, ASTM D638	10,000 psi minimum
(b) Average tensile modulus, ASTM D638	1,200,000 psi minimum
(c) Average flexural strength, ASTM D790	20,000 psi minimum
(d) Average flexural modulus, ASTM D790	1,200,000 psi minimum
(e) Average compression strength, ASTM D695	32,000 psi minimum
(f) Average compression modulus, ASTM D695	1,400,000 psi minimum
(g) Punch shear, ASTM D732	13,000 psi minimum
(h) Thickness	0.13±0.004 in
(i) Size, dimension less than 12 ft, ASTM D3841	±0.12 in
(j) Squareness per 12 ft of length, ASTM D3841	±0.12 in
(k) Surfaces, top and bottom	Smooth
(l) Color, visually uniform gray, Munsell color system	N7.5 to N8.5
(m) Coefficient of linear thermal expansion, ASTM D696	0.000004 in/in/°F maximum
(n) Flame resistance (extent of burning), ASTM D635	1 in maximum
(o) Weather resistance, ASTM D3841	Grade 1 or 2

(e) Extruded aluminum. Provide panels conforming to ASTM B221, aluminum alloy 6063T6. Conform to Subsection 718.03(c) for panel thickness and fabrication. The maximum allowable deviation from flat on the face is 0.05 inch per foot.

718.04 Sign Posts. Provide sign posts that are straight, smooth, and without defects affecting strength, durability, or appearance. Conform to the following:

(a) Wood. Provide posts conforming to AASHTO M 168. Treat the posts according to Category 4A of the AWPA Standard U1-UC4A, *Ground Contact, General Use* for waterborne preservative treatments ammoniacal copper arsenate (ACA), ammoniacal copper zinc arsenate (ACZA), or chromated copper arsenate (CCA).

(b) Galvanized metal. Conform to the following:

(1) U-channel steel. Provide flanged, channel, galvanized steel posts conforming to ASTM A499, Grade 60 and the following:

(a) Punching. Starting 1 inch from the top and extending the full length of the post, drill or punch ⅜-inch holes on 1-inch centers along the centerline of the bottom of the U. Remove burrs and sharp edges.

(b) Galvanizing after punching	AASHTO M 111

(2) Square tubular steel. Provide square tubular galvanized steel posts conforming to ASTM A1011, Grade 55 and the following:

(a) Punching. Starting 1 inch from the top and extending the full length of the post, drill or punch $^{7}/_{16}$-inch holes on 1-inch centers along the centerline of all four sides, in true alignment and opposite each other directly and diagonally. Remove burrs and sharp edges.

(b) Galvanizing after punching	ASTM A123 or ASTM B695

(c) Aluminum. Provide standard shapes and thicknesses conforming to ASTM B221, alloy 6061-T6, 6351-T5, 6063-T6, or 6005-T5.

(d) Corrosion resistant (weathering) steel. Provide posts conforming to ASTM A588 or ASTM A242. Zinc-coat the embedded portion of the corrosion resistant steel post according to ASTM A123.

718.05 Delineator and Object Marker Posts. Conform to the following:

(a) Wood. Provide 4- by 4-inch wood posts conforming to Subsection 718.04(a).

(b) Steel. Provide flanged U-channel steel posts weighing at least 2 pounds per foot and conforming to ASTM A36. Galvanize according to AASHTO M 111.

(c) Aluminum. Provide standard shaped ⅛-inch thick aluminum posts conforming to ASTM B221, alloy 6063-T6.

(d) Plastic. Provide flexible delineator posts made with high-impact resistant polymer material.

718.06 Hardware. Provide galvanized steel or aluminum alloy lag screws, washers, clip angles, wood screws, shear plates, U-bolts, clamps, bolts, nuts, and other fasteners.

For high-strength steel bolts, nuts, and washers, conform to Subsection 717.01(e). Galvanize steel hardware according to AASHTO M 232.

For aluminum alloy bolts, nuts, and washers, conform to Subsections 717.10 and 717.11 as applicable.

For neoprene or nylon washers, provide ⅛-inch thick by 1-inch minimum outside diameter with maximum allowable applied torque of 480 inch-pounds.

718.07 Delineator and Object Marker Retroreflectors. Provide retroreflectors that are ready for mounting.

(a) Acrylic plastic lens. Provide an acrylic plastic lens with a minimum dimension of 3 inches with prismatic optical elements and a smooth, clear, transparent face. Fabricate the back from similar material and fuse it to the lens around the entire perimeter to form a homogenous unit. Seal the units against the intrusion of foreign material. Conform to Table 718-2 regardless of the orientation angle.

Table 718-2
Minimum Coefficient of (Retroreflective) Luminous Intensity (R_I)(1)

Candelas per Foot-candle				
Observation Angle	**Entrance Angle**	**White(2)**	**Yellow**	**Red**
0.1°	0°	115	70	30
0.1°	20°	45	25	12

(1) See ASTM E808.

(2) Crystal, clear, or colorless are acceptable color designations.

Mount the retroreflector unit in a housing fabricated from 0.063-inch ASTM B209, aluminum alloy 3003-H-14 or similar, or from 0.064-inch cold rolled and hot-dip galvanized steel. Provide antitheft attachment hardware.

(b) Retroreflective sheeting. Provide a prismatic retroreflective sheeting with a minimum dimension of 3 inches and with a Class 1 or Class 2 adhesive backing conforming to Subsection 718.01. Attach the sheeting to an aluminum or plastic support panel (target plate) of the size and dimension specified.

718.08 Solventborne Pavement Markings. Provide VOC-compliant solventborne paint with a VOC of 1.25 pounds per gallon or less. Provide yellow pigment without lead, chrome, or other heavy metals as defined by the EPA.

718.09 Waterborne Pavement Markings. Provide an acrylic water-based, ready-mixed paint conforming to AASHTO M 348.

(a) Composition. Provide a paint composed of resin solids of 100 percent acrylic polymer with the exact formulation determined by the manufacturer. Conform to the following:

(1) Pigment, ASTM D3723	45 to 55 percent by mass
(2) Lead, chromium, cadmium, or cobalt, ASTM D3335 and ASTM D3718	0 percent by mass
(3) VOC, EPA Method 24	20.0 oz/gal maximum

(4) Density of paint, ASTM D1475	12.0 lb/gal minimum
(b) Viscosity. ASTM D562	80-95 Krebs units
(c) Drying time.	
(1) Dry to no pickup, ASTM D711	10 minutes maximum
(2) Drying to no track, ASTM D713	90 seconds maximum
(d) Flexibility. ASTM D522, using the ¼-in cylindrical mandrel	No cracking or flaking
(e) Contrast ratio. ASTM D2805, contrast ratio at 319 square feet per gallon spreading rate	0.96 minimum
(f) Color.	
(1) White, ASTM D1729	Match FHWA standard highway white
(2) Yellow, ASTM D1729	Match FHWA standard highway yellow
(g) Daylight reflectance (without glass bead).	
(1) White, ASTM D6628	84 percent relative to magnesium oxide standard
(2) Yellow, ASTM D6628	55 percent relative to magnesium oxide standard
(h) Bleeding ratio. ASTM D868. Determine reflectance according to ASTM E1347 immediately after drying. Divide the average of three reflectance readings of the paint over the bleeding surface by the average of three readings over the non-bleeding surface to determine the bleeding ratio.	0.96 minimum
(i) Freeze-thaw stability. ASTM D2243	Initial viscosity ±5 Krebs units maximum

718.10 High-Build Waterborne Pavement Markings. Conform to Subsection 718.09, except conform to Section 634 for film thickness.

718.11 Epoxy Pavement Markings. Provide a 2-component, 100 percent solids type system for hot-spray application conforming to the following:

(a) Pigments. Component A. Percent by mass.

(1) White.

(a) Titanium dioxide (TiO_2), ASTM D476, Type IV	18 percent minimum
(b) Epoxy resin, ASTM D1652	75 to 82 percent

(2) Yellow.	
(a) Chrome yellow ($PbCrO_4$), ASTM D126	23 percent minimum
(b) Epoxy resin, ASTM D1652	70 to 77 percent
(3) Non-lead yellow.	
(a) Titanium dioxide (TiO_2), ASTM D476, Type II and Type III	14 percent minimum
(b) Organic yellow	7 to 8 percent
(c) Epoxy resin, ASTM D1652	75 to 79 percent
(b) Epoxy content. Component A. Mass per epoxy equivalent, ASTM D1652	Manufacturer's target value ±50
(c) Amine value. Component B, ASTM D2074	Manufacturer's target value ±50
(d) Toxicity. Toxic or injurious fumes at application temperature	None
(e) Color. 15-mil film thickness specimen (cured).	
(1) White, ASTM D1729	Match FHWA standard highway white
(2) Yellow, ASTM D1729	Match FHWA standard highway yellow
(f) Directional reflectance. (Without glass beads)	
(1) White, ASTM E1347	84 percent relative to magnesium oxide standard
(2) Yellow, ASTM E1347	55 percent relative to magnesium oxide standard
(g) Drying time. 15-mil film thickness with glass beads (cured).	
(1) Laboratory at 72 °F, ASTM D711	30 minutes maximum to no-pick-up condition
(2) Field at 77 °F, viewed from 50 ft, ASTM D713	10 minutes maximum to no-tracking condition
(h) Abrasion resistance. Wear index with a CS-17 wheel under a 35.3 oz load for 1000 cycles, ASTM D4060	82 maximum
(i) Hardness. Type D hardness with 72-hour cure at 72 °F, ASTM D2240	75 to 100

718.12 Thermoplastic Pavement Markings. Conform to AASHTO M 249.

718.13 Preformed Pavement Marking Tape. Conform to the following:

(a) ASTM D4505, Reflectivity Level I;

(b) Class 1, 2, or 3; and

(c) Skid Resistance Level A or B.

718.14 Glass Beads. Conform to AASHTO M 247. Treat glass beads with an adherence coating according to the manufacturer's recommendations.

718.15 Pavement Markers. Provide markers of uniform composition, without surface irregularities, cracks, checks, chipping, peeling, spalling, crazing, and other physical damage interfering with appearance, application, or durability. Provide precast markers in the form of a single-based spheroidal segment ending in a rounded or squared shoulder.

(a) Non-plowable. Conform to ASTM D4280.

(b) Plowable. Conform to ASTM D4383.

(c) Non-reflective. Provide ceramic, plastic, or thermoplastic markers that are $4 \pm 1/8$ inches in diameter at the base, $11/16 \pm 1/16$ inch in height, and where the base of the marker does not deviate from a flat plane by more than $1/16$ inch.

718.16 Temporary Pavement Markings.

(a) Preformed retroreflective tape. Provide 4-inch-wide tape conforming to ASTM D4592, Type I (removable).

(b) Pavement markers. Provide temporary pavement markers conforming to ASTM D4280 or flexible pavement markers no more than 2 inches high, with retroreflective tape on both faces of the vertical section, that can retroreflect light from opposite directions, and has an adhesive on the base.

(c) Traffic markings. Conform to Subsection 718.08 or 718.09 as applicable.

718.17 Epoxy Resin Adhesives. Provide epoxy resin adhesives conforming to AASHTO M 237 for bonding traffic markers to rigid and asphalt concrete pavements.

718.18 Methyl Methacrylate Pavement Markings. Conform to the following:

(a) Adhesion to pavement. ASTM D4541	150 psi
(b) Hardness. Type D hardness with 24-hour cure at 72 °F, ASTM D2240	50 minimum
(c) No track time. ASTM D711	30 minutes maximum
(d) Skid resistance. ASTM E303	45 British Pendulum Number minimum

(e) Color.

(1) White, ASTM D1729	Match FHWA standard highway white
(2) Yellow, ASTM D1729	Match FHWA standard highway yellow

Section 719. — COATING MATERIAL

719.01 General. Provide a contrasting color for each coat of the coating system. Provide color chips from the coating supplier.

(a) Packaging. Provide coatings in strong, substantial containers, plainly marked with the following:

(1) Trade name or trademark;

(2) Coating type, color, formulation, lot number, and date of manufacture;

(3) Net mass;

(4) Volume including the percent of solids and the percent of VOC;

(5) Storage requirements and shelf life;

(6) Mixing instructions and equipment cleanup instructions; and

(7) Name and address of the manufacturer.

(b) VOC content. Conform to the following VOC limits for both shop- and field-applied coatings:

(1) Clear (unpigmented) coatings	3.7 lb/gal maximum
(2) Other coatings	2.9 lb/gal maximum

(c) Lead content. Provide coatings with zero lead content.

(d) Other properties. Provide coatings that:

(1) Do not show excessive settling in a freshly opened full container;

(2) Easily redisperse with a paddle to a smooth, homogeneous state free of curdling, livering, caking, color separation, lumps, and skins;

(3) Do not skin within 48 hours in a three-quarter filled, closed container;

(4) Brush on easily;

(5) Possess good leveling properties;

(6) Show no running or sagging tendencies when applied to vertical surfaces;

(7) Dry to a smooth uniform finish, without roughness, grit, unevenness, and other surface imperfections;

(8) Show no streaking or separation when flowed on clean glass; and

(9) Show no thickening, curdling, gelling, or hard caking after 6 months of storage in a full, sealed container stored at a temperature of 70 ºF.

719.02 Coating for Iron and Steel Structures. Provide a coating system conforming to AASHTO R 31, and that appears in one of the following:

(a) AASHTO Product Evaluation & Audit Solutions; or

(b) North East Protective Coating Committee.

719.03 Coating for Aluminum Structures. Provide a coating system conforming to American Architectural Manufacturers Association 2605 specifications.

719.04 Coating for Other Structural Material. Provide coatings on the Master Painters Institute (MPI) approved products lists as shown in Table 719-1.

Table 719-1
Coating for Other Structural Material

Substrate	Coating		
	Primer	Intermediate	Finish
Lumber & Timber	MPI #5	MPI #5 or #6	MPI #10
Masonry Block	MPI #4	MPI #10 or #11	MPI #10 or #11
Concrete	MPI #108 or #177	–	–
Other Metals	MPI #107 or #134	MPI #5 or #6	MPI #5 or #6

719.05 Penetrating Stain for Concrete. Provide coatings on MPI Approved Products List #58.

Section 720. — STRUCTURAL WALL AND STABILIZED EMBANKMENT MATERIAL

720.01 Mechanically-Stabilized Earth Wall Material.

(a) Segmental retaining wall units. Conform to ASTM C1372 and the following:

(1) Net area compressive strength, ASTM C140	4000 psi minimum
(2) Freeze-thaw durability, ASTM C1262	1 percent maximum weight loss after 100 cycles for five of five specimens tested in saline solution or 1.5 percent maximum weight loss after 150 cycles for four of 5 specimens tested in water
(3) Absorption, ASTM C140	5 percent maximum
(4) Height, nominal	8 in
(5) Connection and alignment devices or mechanisms	Manufacturer's recommendations

(b) Wire facing and backing mat. Fabricate from welded wire fabric conforming to AASHTO M 336. Galvanize according to AASHTO M 111, Coating Grade 85.

(c) Clevis connector. Fabricate from welded wire conforming to AASHTO M 336. Galvanize according to AASHTO M 111, Coating Grade 85.

(d) Connector bars. Fabricate from cold-drawn steel wire conforming to AASHTO M 336. Galvanize according to AASHTO M 111, Coating Grade 85.

(e) Fasteners. Provide ½-inch diameter, heavy hexhead bolts, nuts, and washers conforming to ASTM F3125, A563, and F436. Galvanize according to AASHTO M 232.

(f) Hardware cloth. Fabricate with maximum ¼-inch square mesh openings from woven or welded galvanized steel wire fabric conforming to ASTM A740.

(g) Reinforcing mesh. Fabricate from welded wire conforming to AASHTO M 336. Galvanize according to AASHTO M 111, Coating Grade 85.

(h) Reinforcing strips. Fabricate from high-strength, low-alloy structural steel conforming to ASTM A572, Grade 65, Type 3. Galvanize according to AASHTO M 111, Coating Grade 85.

(i) Tie strip. Fabricate from hot-rolled steel conforming to ASTM A1011, Grade 50. Galvanize according to AASHTO M 111, Coating Grade 85.

720.02 Gabion and Revet Mattress Material. Fabricate gabion baskets and revet mattresses from either welded wire mesh or twisted wire mesh. Conform to the following:

(a) Welded wire mesh	ASTM A974
(b) Twisted wire mesh	ASTM A975

Section 721. — ELECTRICAL AND ILLUMINATION MATERIAL

721.01 Electrical Material.

(a) Conduit. Conform to the following:

(1) Nonmetallic conduit, duct, couplers, connectors, and fittings. For above ground and underground use without concrete encasement, provide rigid PVC, heavy wall conduit conforming to UL 651, *Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings*. Conform to ASTM D2564 for solvent cement to join conduit.

(2) Metallic conduit, duct, couplers, connectors, fittings, and nipples. Provide rigid galvanized steel conduit conforming to UL 6, *Electrical Rigid Metal Conduit - Steel*. Provide rigid, full-mass sherardized or galvanized threaded fittings.

(3) Coated Metallic conduit, duct, couplers, connectors, fittings, and nipples. Provide rigid galvanized steel conduit conforming to UL 6, *Electrical Rigid Metal Conduit - Steel*. Uniformly coat the conduit on the outside with an asphalt mastic conforming to AASHTO M 243 or a 20-mil PVC coating. Provide rigid, full-mass sherardized or galvanized threaded fittings.

(4) Flexible metallic conduit. Provide a watertight metallic conduit conforming to UL 360, *Liquid-tight Flexible Metal Conduit*. Provide insulated throat, grounding, malleable iron watertight fittings.

(5) Flexible nonmetallic conduit. Provide a watertight nonmetallic conduit conforming to UL 1660, *Liquid-tight Flexible Nonmetallic Conduit*. Provide insulated throat, grounding, malleable iron watertight fittings.

(6) Conduit bodies, boxes, and fittings. Provide watertight, galvanized steel conforming to UL 514B, *Conduit, Tubing, and Cable Fittings*.

(b) Pull boxes, frames, and covers. Fabricate boxes formed in concrete with cast iron or welded sheet steel having a minimum thickness of 0.188 inch. Galvanize, inside and out, according to AASHTO M 232.

(c) Wire and cable.

(1) Lighting. Provide either ozone resistant cross-linked polyethylene (XLP) or PVC insulated cable, with or without a nylon jacket conforming to the following:

(a) Polyethylene. Insulated Cable Engineers Association (ICEA) S-95-658/NEMA WC70, Non-Shielded Power Cables Rated 2000 V or Less, ICEA S-96-659/NEMA WC71, Non-Shielded Power Cables Rated 2001-5000 V, ICEA S-93-639/NEMA WC74, Shielded Power Cable 5,000-46,000 V; or

(b) PVC. UL 83, Thermoplastic-Insulated Wires and Cables.

(2) Electrical. Provide soft drawn or annealed copper conductors conforming to ASTM B3 and stranding conforming to ASTM B8.

Provide stranded wire for #10 AWG and larger. Provide #6 AWG minimum solid copper ground wires.

Provide type thermoplastic high-heat resistant, nylon-coated wire (THHN) or thermoplastic heat and water-resistant nylon-coated (THWN) #14 AWG, stranded, single-conductor loop wire according to the IMSA Specification 51-7.

Provide type THHN or THWN, stranded, single-conductor lead-in cable according to IMSA Specification 50-2.

Follow the manufacturer's recommendations in the selection of the wire insulation cable color inside the cabinet.

(d) Circuit breakers and panels. Conform to UL 489, *Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures* and UL 67, *Panelboards*. Provide molded case thermal magnetic trip type breakers. Provide panel enclosures conforming to NEMA 250, *Enclosures for Electrical Equipment (1,000 V Maximum)*, Type 3R and lockable with padlocks.

(e) Safety disconnect switches. Provide heavy-duty safety disconnect switches conforming to NEMA 250, *Enclosures for Electrical Equipment (1,000 V Maximum)*, Type 3R and UL 98 *Enclosed and Dead-Front Switches*.

(f) Grounding and bonding equipment. Provide ⅝-inch diameter, 8-foot long, copper-clad steel ground rods, ground clamps, grounding and bonding bushings, and lock nuts conforming to UL 467, *Grounding and Bonding Equipment*.

(g) Contactors and control transformers. Provide a magnetic 60-ampere, two-pole contactor with a 120-volt coil, equipped with control switches for automatic actuation conforming to UL 508, *Industrial Control Equipment*. Provide cadmium-sulfide type photocell controls for 120 or 240-volt operation as applicable rated at 1000 watts resistive load or 1800 volt-amperes inductive load; adaptable for pole-top mounting in a plug-in, locking-type receptacle conforming to UL 773, *Plug-In Locking Type Photocontrols for Use with Area Lighting;* and with a built-in surge protective device for protection from induced high-voltage and follow-through currents.

Provide single-phase, 240/480-volt primary, 120/240-volt secondary, dry type, 60 hertz, 1 KVA transformers for indoor or outdoor use, conforming to UL 506, *Specialty Transformers*.

(h) Secondary lightning arrester. Provide a secondary lightning arrester rated for a maximum operating voltage of 650 volts RMS with a bracket for mounting on the control cabinet backboard.

(i) Service poles. Provide treated southern yellow pine, treated Douglas fir, butt-treated western red cedar, or butt-treated northern white cedar service poles that are at least 30 feet long. Treat the poles according to Subsection 716.02.

(j) Meter cabinet. Conform to local power company requirements.

(k) Control enclosure. Provide a watertight outdoor cabinet conforming to NEMA 250, *Enclosures for Electrical Equipment (1,000 V Maximum)*, Type 3R, fabricated from 0.125-inch-thick ASTM B209 aluminum alloy 5052-H-32, with continuous welded seams, rounded corners, hinge with stainless steel pin, stainless steel external hardware, and backboard for mounting apparatus.

Provide loop surge protection devices conforming to Table 721-1 at the terminal block on all lead-ins.

Table 721-1
Surge Protection Device Minimum Requirements

Property	Rating
Operating voltage	75 voltage direct current (VDC)
Clamping voltage	130 VDC
Peak surge current	250 Ampere
Technology	Silicon breakover device
Operating temperature	-40 °F to 185 °F
Weight	3 oz
Dimensions	1.2 in cube

Provide a surge protection power strip, 120-volt with RJ-11 or RJ-45 surge protection. Connect incoming phone line and modem phone line to power bar RJ-11 or RJ-45 ports.

Provide a tube axial compact type, 120-volt, corrosion resistant cabinet fan with a minimum 100 cubic foot per minute capacity, minimum 100,000 hour design life, maximum 40 decibel operating noise, and a five-year duty cycle. Fuse the fan at 125 percent of the motor's ampere capacity. Ensure the fan's magnetic field does not affect the performance of the surrounding traffic counting equipment.

Provide an inline type, single pole, 120-volt, 10-ampere cabinet fan thermostat that is adjustable in 10-degree increments from 70 °F to 200 °F, and with a turn-on setting that is adjustable from 90 °F to 120 °F.

(l) Splices and crimps. Use UL listed splices and crimp type connectors and terminals. Use waterproof connections in damp or wet locations.

721.02 Lighting Material. Conform to the following:

(a) Poles. Provide 11 gauge round steel conforming to ASTM A595 or aluminum shafts conforming to ASTM B429, alloy 6063-T6, tapered uniformly at 0.14 inch per foot. Provide hand holes with no rough edges and a reinforcing frame and cover designed to maintain the required pole strength. Weld a 2⅜- to 3.0-inch outside diameter vertical tenon, fabricated from the same material as the pole, and welded at the top and on the same axis as the pole.

Provide pole sections in minimum 15-foot lengths. Provide pole sections less than 70 feet in height in two sections or less, between 70 and 100 feet in three sections or less, and over 100 feet in four sections or less.

Provide poles that can sustain the following loadings:

(1) A horizontal load of 500 pounds applied 18 inches from the shaft top, in any direction, without failure of any component part, and a maximum allowable vertical deflection of 7.5 percent of the shaft length.

(2) A horizontal load of 50 pounds applied at the luminaire attachment point and normal to the pole bracket member plane, with a vertical load of 30 pounds on the luminaire supporting arm, and a maximum allowable horizontal deflection of 10 percent of the luminaire supporting arm's horizontal length.

(3) A vertical load of 100 pounds applied at the luminaire attachment point, and a maximum allowable vertical deflection of 5.5 percent of the pole arm's horizontal length.

(4) A vertical load of 250 pounds applied at the luminaire attachment point, and no collapse or rupture of any portion of the structure.

(5) The pole arm and luminaire mass with a maximum allowable deflection from vertical at the top of the pole of 1 percent of the total shaft length.

Prime the poles inside and out according to the fabricator's recommendation. Use epoxy modified enamel for the finish coat.

(b) Pole arms.

(1) Material. Provide steel or aluminum. Use the same material as the pole.

(2) Type. Provide bracket type, truss or single member arms. Provide single member arms with a minimum diameter of 2 inches and the same taper as the pole.

(3) Connection. Provide a weather resistant connection to the pole and a smooth raceway for wiring. Provide fittings for connection to the pole.

(c) Anchor bases. Provide a one-piece base dimensioned for adequate pole mounting and structural support with holes for anchor bolts and tapped holes for anchor bolt covers. Fabricate anchor bases from material similar to the pole material and conform to the following:

(1) Steel casings	AASHTO M 103, Grade 65-35
(2) Steel plate	ASTM A36
(3) Aluminum castings	ASTM B26

(d) Bolts, nuts, and washers.

(1) Steel anchor bolts. Conform to ASTM F1554, Grade 55 or Grade 105.

(2) Hex head bolts. Conform to the following:

(a) 120 ksi yield anchor bolts	ASTM F3125
(b) 105 ksi yield anchor bolts	ASTM A354, Grade BC

(3) Nuts. Conform to ASTM A563. Provide nuts appropriate for the strength of the anchor bolt.

(4) Washers. Provide flat, circular washers conforming to ASTM F436.

Galvanize the top 12 inches of anchor bolts and associated hardware according to AASHTO M 232.

(e) Anchor bolt covers. Provide a bolt cover for each anchor bolt and ¼-inch stainless steel, phillips-head or hex-head screws to attach the cover to the base or pole.

(f) Luminaires. Provide luminaires that operate on a 240-volt series circuit. Provide the following types of luminaires:

(1) Conventional highway luminaires. Provide material for a complete installation including:

(a) Aluminum housings with refractor holder and slipfitter;

(b) Thermal shock-resistant glass prismatic refractors with gaskets and clips;

(c) Aluminum detachable reflectors with ethylene propylene terpolymer gaskets; and

(d) Internal regulator or auto regulator type ballast, with a power factor greater than 90 percent that will start lamps at a minimum ambient temperature of -20 °F or equivalent Light-Emitting Diode (LED).

Comply with ANSI specifications.

(2) Sign lighting luminaires. Provide material for a complete installation including:

(a) Die-cast aluminum housings with mounting bracket and door assembly;

(b) Thermal, shock-resistant, borosilicate glass refractors with gaskets;

(c) Aluminum reflectors; and

(d) 120/240-volt, 60 hertz constant-wattage ballasts with a power factor greater than 90 percent that will start lamps at a minimum ambient temperature of -20 °F or equivalent LED.

Section 722. — ANCHOR MATERIAL

722.01 Anchorage Devices. Galvanize anchorage device components according to AASHTO M 232.

722.02 Anchor Tendons. Provide material conforming to the following:

(a) Prestressing steel. Conform to one of the following:

(1) Wire, uncoated stress-relieved for prestressed concrete	ASTM A421
(2) Steel strand, uncoated seven-wire stress-relieved for prestressed concrete	AASHTO M 203
(3) Steel strand, uncoated, seven-wire, compacted, stress-relieved for prestressed concrete	ASTM A779
(4) Uncoated high-strength steel bar for prestressed concrete	AASHTO M 275

(b) Couplers. Provide couplers that can develop 95 percent of the minimum specified ultimate tensile strength of the tendon.

(c) Sheathing. Conform to one of the following:

(1) Free-stressing length.

(a) Polyethylene plastic tubing. Conform to ASTM D1248, Types II, III, or IV with a minimum wall thickness of 60 mils.

(b) Hot-melt extruded polypropylene tubing. Conform to ASTM D4101, cell classification PP 210 B5554211 with a minimum wall thickness of 60 mils.

(c) Hot-melt extruded polyethylene tubing. Conform to ASTM D3350 and ASTM D1248 Type III high-density with a minimum wall thickness of 60 mils.

(d) Steel tubing. Conform to ASTM A500 with a minimum wall thickness of 0.20 inch.

(e) Steel pipe. Conform to ASTM A53, Schedule 40 minimum.

(f) Plastic pipe. Conform to ASTM D1785, Schedule 40 minimum.

(2) Bonded length.

(a) High-density corrugated polyethylene tubing. Conform to AASHTO M 252 with a minimum wall thickness of 30 mils.

(b) Corrugated, polyvinyl chloride tubes. Conform to ASTM D1784, Class 13464-B.

(c) Fusion-bonded epoxy. Conform to ASTM A775 with a minimum film thickness of 15 mils.

(d) Corrosion inhibiting compounds. Use grease conforming to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

(e) Centralizers and spacers. Fabricate centralizers and spacers from material, except wood, that are not deleterious to the prestressing steel.

(f) Anchorages. Provide material conforming to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

For strand tendons, provide anchorages that allow lift-off testing without the jack engaging the strand.

Provide steel plates conforming to ASTM A36 or ASTM A588 for bearing plates. Provide grout tube holes in the bearing plates.

722.03 Rock Bolts and Rock Dowels.

(a) Bars. Provide continuously threaded steel reinforcement bars that conform to ASTM A615 Grade 75 deformed bars. The bending requirements of ASTM A615 do not apply.

Provide rock dowels with a minimum No. 7 bar size.

For rock bolts, Grade 150 threaded steel reinforcement bars meeting the requirements of ASTM A722 Type II, or AASHTO M 275 Type II that can be post-tensioned to the design loads, performance test loads, and proof loads specified are also allowed.

(b) Hardware. Provide the following:

(1) Bearing plates. Provide bearing plates that conform to PTI, *Recommendations for Prestressed Rock and Soil Anchors* for the respective application.

(2) Nuts and couplers. Provide nuts and couplers that exceed 100 percent of the MUTS of the bar. Provide nuts and couplers meeting ASTM A563, AASHTO M 169 or ASTM A108, ASTM A536, or ASTM A29.

(3) Washers. Provide washers conforming to ASTM F436. Provide spherical and beveled washers conforming to ASTM A536 and ASTM A47.

(4) Centralizers. Fabricate centralizers from materials that are not deleterious to steel bars. Do not use wood.

(c) Corrosion protection. Provide anchor bars and hardware with hot-dip galvanizing for corrosion protection as applicable. Use hot-dip galvanizing conforming to AASHTO M 232, ASTM A153, or ASTM F2329 with a minimum thickness of 3.4 mils. Provide corrosion protection for steel anchor bars and hardware, from delivery of materials through complete installation, repairing damaged galvanizing according to Section 563.

(d) Rock bolt bond breakers. Provide a grease that conforms to PTI, *Recommendations for Prestressed Rock and Soil Anchors*.

Provide sleeved bond breakers for rock bolts fabricated from plastic tube or pipe having the following properties:

(1) Resistant to chemical attack from aggressive environment, grout, or corrosion inhibiting compound;

(2) Resistant to aging by ultra-violet light;

(3) Non-detrimental to rock bolts;

(4) Resistant to damage caused by abrasion, impact, crushing, and bending during handling and installation;

(5) Enables rock bolts to elongate during testing; and

(6) Resistant to distortion caused by heat generated by the curing of the grout.

Table 722-1
Wall Thickness Requirements for Sleeved Bond Breakers

Type	Nominal, inch	Minimum, inch
HDPE and Polypropylene	0.060	0.050
PVC	0.040	0.035

722.04 Soil Nails.

(a) Tendon. Provide deformed bars conforming to one of the following:

(1) Deformed bars, Grade 60 or Grade 75 ASTM A615

(2) Deformed bars ASTM A722

Provide new, straight, continuous, undamaged bars. Provide, bare, epoxy-coated, or encapsulated bars.

(b) Coupler. Provide couplers that can develop the full, ultimate tensile strength of the tendon as certified by the manufacturer.

(c) Fusion bonded epoxy coating. Apply epoxy coating conforming to ASTM A775, except for the bend test requirements. Electrostatically apply the coating to a minimum thickness of 12 mils. The coating at the wall anchorage end of epoxy-coated bars may be omitted over the length provided for threading the nut against the bearing plate.

(d) Encapsulation. Provide corrugated polyethylene pipe conforming to AASHTO M 252 or corrugated polyvinyl chloride pipe conforming to ASTM D1784, Class 13464.

722.05 Anchor Nails. Provide 1¼-inch diameter, high strength steel, hollow-core, self-drilling, anchor nails with corrosion protection that conforming to ASTM A615 and come supplied with a 3-inch diameter sacrificial bit. Provide nails with corrosion protection conforming to ASTM A153 for hot-dip galvanizing. Provide nails that are groutable and can be post tensioned to a design load of at least 10,000 pounds and an ultimate strength of at least 55,000 pounds.

722.06 Micropile Materials.

(a) Tendon. Provide deformed bars conforming to one of the following:

(1) Deformed bars, Grade 60 and Grade 80	AASHTO M 31
(2) Deformed bars	AASHTO M 275

Provide new, straight, continuous, and undamaged bars.

(b) Coupler. Provide couplers that can develop the full, ultimate tensile strength of the tendon as certified by the manufacturer.

(c) Fusion bonded epoxy coating. Apply epoxy coating conforming to ASTM A775, except for the bend test requirements. Electrostatically apply the coating to a minimum thickness of 12 mils. Do not epoxy coat bearing plates and nuts encased in the concrete footing unless footing reinforcement is epoxy coated.

(d) Encapsulation. Provide corrugated polyethylene pipe conforming to AASHTO M 252 or corrugated polyvinyl chloride pipe conforming to ASTM D1784, Class 13464.

(e) Sheathing. Provide watertight smooth polyvinyl chloride sheathing conforming to ASTM D1784, Class 13464-B.

722.07 Rockfall Protection Anchor Materials.

(a) Hollow-core self-drilling anchors. Provide 1.25-inch hollow-core, threaded, deformed steel bar, self-drilling anchors conforming to ASTM A513 and A519. Include a sacrificial drill bit at least 3-inch diameter.

(b) Wire rope anchors. Provide ASTM A1023 galvanized, stranded carbon steel wire ropes. Provide double-legged wire rope anchors in the sizes and with minimum breaking strengths to provide the working loads specified. Provide 6x19 classification IWRC made from EIP steel with a factory-installed swage-eye terminal on the distal end of the wire rope, possessing ferrules, thimbles, or wire clips as required by the manufacturer.

(c) Threaded bar ground anchors. Provide 1-inch diameter deformed continuously threaded bars. Provide a minimum Grade 60 steel deformed continuously threaded bars and couplers conforming to ASTM A615 and ASTM A775 or AASHTO M 111.

Section 723. — DAMPPROOFING AND WATERPROOFING MATERIAL

723.01 Dampproofing Material.

(a) Primer. Conform to ASTM D41.

(b) Asphalt. Conform to ASTM D449.

723.02 Waterproofing Material.

(a) Primer. If preformed membrane sheets are used, provide primers of a type recommended by the manufacturer.

If elastomeric spray-applied membranes are used, provide primers conforming to the manufacturer's recommendations. Provide a primer with an adhesion to concrete that is at least 150 pounds per square inch when tested according to ASTM D7234.

(b) Preformed membrane sheet. Provide either a rubberized asphalt type or a modified bitumen type. A rubberized asphalt type consists of a rubberized asphalt sheet reinforced with a polyethylene film or mesh. A modified bitumen sheet type consists of a polymer-modified bitumen sheet reinforced with a stitch-bonded polyester fabric or fiberglass mesh.

For surfaces other than bridge decks, conform to Table 723-1. For bridge deck surfaces, conform to ASTM D6153, Type III, and Table 723-2.

Table 723-1
Preformed Membrane Sheet for Surfaces Other Than Bridge Decks

Property	Test	Value	
		Rubberized Asphalt Type	Modified Bitumen Type
Tensile strength, minimum	ASTM D882	20 lb/in	20 lb/in
Elongation at break, minimum	ASTM D882	150% at 73.4 °F	25%
Water vapor transmission, maximum	ASTM E96	0.1 perms	0.1 perms
Pliability	ASTM D146[(1)]	No cracks	No cracks
Thickness, minimum	–	60 mils	60 mils
Softening point, minimum	ASTM D36	165 °F	210 °F

(1) Base ASTM D146 on a 180-degree bend over a 4.0-inch mandrel at 10 °F.

Table 723-2
Preformed Membrane Sheet for Bridge Decks

Property	Test	Value	
		Rubberized Asphalt Type	Modified Bitumen Type
Tensile strength, minimum	ASTM D882	1500 lb/in	1500 lb/in
Elongation at break, minimum	ASTM D882	300%	300%
Water vapor transmission (permeance), water method, maximum	ASTM E96	0.1 perms	0.1 perms
Puncture resistance, minimum	ASTM E154	200 lb	200 lb
Pliability	ASTM D146(1)	No cracks	No cracks
Thickness	–	65 - 120 mils	65 - 120 mils
Softening point, minimum	ASTM D36	200 °F	210 °F

(1) Base ASTM D146 on a 180-degree bend over a 4.0-inch mandrel at 10 °F.

(c) Mastic. Provide mastic consisting of a rubberized asphalt cold-applied sealing compound for use with preformed rubberized sheets. Provide mastic consisting of a blend of bituminous and synthetic resins for use with modified bitumen sheet.

(d) Elastomeric spray-applied membrane. Provide cold spray-applied, elastomeric membrane conforming to Table 723-3.

Table 723-3
Elastomeric Spray-Applied Membrane Performance Requirements

Property	Test	Value
Solids content	–	100%
Gel time, maximum	–	10 sec
Tack-free time, maximum	–	30 sec
Shore D hardness, minimum	ASTM D2240	40
Adhesion to concrete, minimum	ASTM D7234	150 psi
Tensile strength, minimum	ASTM D638	2000 psi
Tear strength (Die C), minimum	ASTM D624	300 lb/in
Elongation, minimum	ASTM D638	250%
Crack bridging (80 mils, ⅛ in opening @ -15 °F)	ASTM C1305	Pass @ 40 cycles

(e) Elastomeric membrane topcoat. Provide membrane topcoat conforming to Table 723-4.

Table 723-4
Elastomeric Membrane Topcoat Performance Requirements

Property	Test	Value
Solids content	–	100%
Gel time, minimum	–	30 sec
Tack-free time, minimum	–	2 min
Open to traffic	–	1 hr
Shore D hardness, minimum	ASTM D2240	40
Tensile strength, minimum	ASTM D638	2000 psi
Tear strength (Die C), minimum	ASTM D624	300 lb/in
Elongation, minimum	ASTM D638	250%
Crack bridging (80 mils, ⅛ in opening @ -15 °F)	ASTM C1305	Pass @ 40 cycles

(f) Broadcast topcoat aggregate. Provide washed, clean, durable, angular aggregate with a Mohs hardness of at least 6. Provide aggregate conforming to Table 723-5.

Table 723-5
Broadcast Topcoat Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
No. 8	100
No. 20	10
No. 30	5
No. 100	1

Section 724. — GUARDRAIL

724.01 Rail Elements.

(a) Metal beam rail. Provide metal beam rail conforming to Task Force 13 (TF13), *Guide to Standardized Roadside Hardware*.

(1) Galvanized steel. Provide W-beam or thrie-beam rail fabricated from corrugated sheet steel conforming to AASHTO M 180 for the designated shape, type, class, and mass of coating specified.

(2) Painted steel. Provide W-beam or thrie-beam rail conforming to AASHTO M 180 for the designated shape, class, type, and mass of coating specified.

(3) Corrosion resistant (weathering) steel. Provide W-beam or thrie-beam rail conforming to AASHTO M 180, Type IV, Class B.

(b) Box beam rail. Provide steel box beam rail conforming to TF13, *Guide to Standardized Roadside Hardware*.

(c) Steel-backed timber rail and rub rail. Provide timber conforming to AASHTO M 168. Fabricate the timber rail and rub rail from dry, seasoned, and dressed rough sawn southern pine or other species having a stress grade of at least 1500 pounds per square inch. Do not use refractory species (such as larch or Rocky Mountain Douglas fir). Provide treated timber conforming to AASHTO M 133.

Provide steel backing elements according to ASTM A242.

(d) Steel-backed log rail. Provide No. 1 Grade western hemlock, western red cedar, or pine logs that are seasoned, straight, and sound. Do not use logs that taper more than 2 inches between the butt and tip ends of adjacent logs. Remove bark and at least 80 percent of the inner bark. Do not use logs with peeler or incision marks on surfaces that will be visible. Do not use logs with knot clusters. Logs may contain sound, tight, well-spaced knots. Do not use logs with season checks, singular or any two opposite each other, that exceed the thickness of the member. Provide treated timber conforming to AASHTO M 133.

Provide steel backing elements according to ASTM A242.

724.02 Guardrail Posts. Provide guardrail posts conforming to TF13, *Guide to Standardized Roadside Hardware*.

(a) Wood. Provide posts that do not have a through check, shake, or end slit in the same plane as, or a plane parallel to the bolt hole and extending from the top of the post to within 3 inches or the bolt hole. Provide according to AASHTO M 168 and treat according to AASHTO M 133.

For steel-backed timber guardrail systems, provide posts conforming to Subsection 724.01(c).

For steel-backed log rail systems, provide posts conforming to Subsection 724.01(d).

(b) Steel. Provide posts of the appropriate size shape according to ASTM A6. Zinc-coat the embedded portion of corrosion resistant (weathering) steel posts according to ASTM A123.

724.03 Guardrail Blockouts. Provide guardrail blockouts conforming to TF13, *Guide to Standardized Roadside Hardware*.

(a) Wood. Treat according to AASHTO M 133.

(b) Steel. Provide steel conforming to Subsection 724.02(b).

(c) Plastic or composite. Provide blockouts that are crashworthy. Provide a new homogeneous blockout with uniform texture that does not crack, chip, flake, peel, or splinter after fabrication.

724.04 Guardrail Hardware. Provide hardware conforming to TF13, *Guide to Standardized Roadside Hardware*. For angles, channels, wide flanges, and plates not contained in TF13, conform to ASTM A36 for non-weathering steel and ASTM A242 for corrosion resistant (weathering) steel. For structural tubing for short steel posts, conform to ASTM A500 or ASTM A513, Grade 1008.

Galvanize soil plates and structural tubing according to AASHTO M 111. Do not punch, drill, cut, or weld the metal after galvanizing.

Provide a flexible hinged guardrail delineator that allows the reflector to fold down and spring back to an upright position after impact. Provide retroreflective sheeting conforming to ASTM D4956, including supplementary requirements. Use Type IV or XI reflective sheeting permanently adhered to 0.090-inch minimum thick body. Manufacture reflector tabs from 0.15-inch aluminum or plastic. Use an adhesive that resists peeling with a force of 5 pounds per inch of width. Use mildew resistant adhesive that has no staining effect on retroreflective sheeting.

Provide nuts, bolts, and cables conforming to the following:

(a) Galvanized nuts and bolts. Provide nuts conforming to ASTM A563, Grade A. Provide bolts conforming to ASTM A307, Grade A.

(b) Corrosion resistant (weathering) nuts and bolts. Provide nuts conforming to ASTM A563, Grade C3. Provide bolts conforming to ASTM A449, Type 3.

(c) Cable. Provide cable conforming to AASHTO M 30, Type II, Class A.

Section 725. — MISCELLANEOUS MATERIAL

725.01 Water. Conform to the following:

(a) Water for cementitious materials. Provide water for mixing or curing cement, concrete, mortar, or grout that conforms to AASHTO M 157. Potable water of known quality may be used without testing according to ASTM C1602. Potable water is safe for human consumption as defined by the public health authority having jurisdiction.

(b) Water for vegetation. Provide water for the planting or care of vegetation that is free of substances injurious to plant life (such as oils, acids, alkalies, or salts).

(c) Water for construction. Provide water for earthwork, pavement courses, dust control, and incidental construction that is free of substances detrimental to the work.

725.02 Calcium Chloride, Magnesium Chloride, and Lignosulfonate.

(a) Calcium chloride liquid. Provide a water solution conforming to the following:

(1) Calcium chloride liquid	ASTM D98, Type L
(2) Calcium chloride by mass	35 percent minimum

(b) Calcium chloride flake. Conform to ASTM D98, Type S, Grades N1, N2, N3, or N4, Class A.

(c) Magnesium chloride liquid. Provide a water solution conforming to the following:

(1) Magnesium chloride by mass	28 percent minimum
(2) Specific gravity, ASTM D1298	1.29 to 1.33

(d) Lignosulfonate liquid. Provide a water solution with a base cation of ammonia, calcium, or sodium. Conform to the following:

(1) Dry solids	50 percent

Use Pulp and Paper Technical Association of Canada standard test Method H.1, *Determination of Solids Content of Pulp and Paper Mill Effluents*.

(2) Specific gravity, ASTM D1475	1.20 minimum
(3) pH, ASTM E70	3.0 to 8.0

725.03 Lime.

(a) Lime for masonry. Conform to ASTM C207, Type NA.

(b) Lime for soil stabilization. Conform to AASHTO M 216.

(c) Lime for asphalt mixtures. Conform to AASHTO M 303.

725.04 Reserved.

725.05 Mineral Filler. Conform to AASHTO M 17.

725.06 Concrete Building Brick. Conform to ASTM C55, normal weight.

725.07 Concrete Masonry Units. Conform to one of the following:

(a) Loadbearing concrete masonry units	ASTM C90, normal weight
(b) Concrete masonry units for constructing catch basins and manholes	ASTM C139
(c) Nonloadbearing concrete masonry units	ASTM C129, normal weight

725.08 Paving Brick. Conform to one of the following:

(a) Pedestrian and light traffic paving brick	ASTM C902, Class SX, Type I
(b) Heavy vehicular paving brick	ASTM C1272, Type F, Application PS

725.09 Precast Concrete Units and Accessories. Conform to the following:

(a) Precast reinforced concrete manhole sections	AASHTO M 199
(b) Precast concrete barrier	ASTM C825
(c) Concrete grid paving units	ASTM C1319
(d) Underground precast concrete utility structures	ASTM C858
(e) Precast concrete water and wastewater structures	ASTM C913
(f) Solid concrete interlocking paving units	ASTM C936

725.10 Frames, Grates, Covers, and Ladder Rungs. Fabricate metal grates and covers to evenly bear on the frames. Correct bearing inaccuracies by machining. Assemble units before shipment. Mark pieces to facilitate reassembly at the installation site. Uniformly coat castings with a commercial preservative according to the manufacturer’s standard practice. Conform to the following:

(a) Gray iron castings	AASHTO M 105
(b) Carbon steel castings	AASHTO M 103
(c) Structural steel	ASTM A36
(d) Galvanizing	AASHTO M 111
(e) Malleable iron castings	ASTM A47

(f) Aluminum alloy ladder rung material — ASTM B221, alloy 6061-T6

(g) Aluminum castings — ASTM B26, alloy 356.0-T6

725.11 Detectable Warning Tape. Provide tape conforming to ASTM D2103.

725.12 Epoxy Resin Adhesives. Provide epoxy resin adhesives conforming to AASHTO M 235.

725.13 Slurry (Drilling Fluids).

(a) Mineral slurry. Provide sodium bentonite or attapulgite in potable water. Use a mineral grain size that remains in suspension with sufficient viscosity and gel characteristics to transport drilled material out of the hole.

(b) Polymer slurry. Provide a slurry compatible with soil type and water chemistry.

725.14 Polymer Concrete and Mortar. Provide a mixture of monomers or resin binders that polymerize without the use of portland cement aggregates in the proportions recommended by the polymer manufacturer with a minimum compressive strength of 3500 pounds per square inch in 4 hours. Conform to the following:

(a) Epoxy mortar. Conform to ACI 503.4, *Standard Specification for Repairing Concrete with Epoxy Mortars*.

(b) Polyester resin grout. Provide polyester resin grout with a minimum ultimate compressive strength of 14,000 pounds per square inch, a minimum ultimate tensile strength of 2500 pounds per square inch, and a minimum ultimate shear strength of 4500 pounds per square inch when fully cured. Conform to ASTM F432, except where noted.

Provide polyester resin grout consisting of an unsaturated polyester resin, evenly filled with nonreactive, inorganic aggregate of suitable size, and a separated catalyst filled with nonreactive inorganic filler. Provide resin in cartridge form. Provide cartridge lengths and diameters according to the manufacturer recommendations for the specified drill hole and reinforcing bar size. Provide resin cartridges readily and individually identified as to their respective gel times.

(c) Polyurethane grout. Conform to Table 725-1.

Table 725-1
Polyurethane Grout Properties

Property	Test Method	Requirement
Grout density	ASTM D1622	3 lb/ft^3 minimum
Compressive strength	ASTM D1621	30 psi minimum
Compressive modulus	ASTM D1621	1700 psi minimum
Dimensional stability - 40 °F 200 °F	ASTM D2126	 2% maximum 15% maximum
Tensile strength	ASTM D1623	60 psi minimum
Tensile modulus	ASTM D1623	1700 psi minimum
Shear strength	ASTM C273	35 psi minimum
Shear modulus	ASTM C273	500 psi minimum
Flexural strength	ASTM D790	50 psi minimum
Flexural modulus	ASTM D790	950 psi minimum
Water absorption	ASTM D2842	2% maximum
Elongation	ASTM D1623	1% maximum
Closed cell content	ASTM D6226	90% minimum

725.15 Color Coating. Provide a semi-opaque colored toner containing methyl methacrylate-ethyl acrylate copolymer resins or equivalent resins, solvents, and color-toning pigments suspended in solution by a chemical suspension agent. Provide color-toning pigments consisting of laminar silicates, titanium dioxide, and inorganic oxides. Conform to the following:

(a) Mass per gallon, ASTM D1475	8.3 lb minimum
(b) Solids by mass, ASTM D2369	30 percent minimum
(c) Solids by volume	21 percent minimum
(d) Drying time, ASTM D1640	30 minutes at 70 °F and 50 percent maximum humidity
(e) Color change, ASTM D822, 1000 hours	No appreciable change
(f) Resistance to acids, alkalies, gasoline, and mineral spirits, ASTM D543	Excellent
(g) Water vapor transmission from interior concrete, ASTM D1653	Transmittable
(h) Oxidation over time	None

725.16 Galvanic Anodes. Provide galvanic anodes that have at least 100 grams of zinc conforming to ASTM B418 Type II.

725.17 Polyester Resin Binder. Provide polyester resin binder meeting the following requirements:

(a) Be an unsaturated isophthalic polyester-styrene co-polymer;

(b) Contain at least 1 percent by weight gamma-methacryloxypropyltrimethoxysilane, an organosilane ester silane coupler;

(c) Used with a promoter that is compatible with suitable methyl ethyl ketone peroxide and cumene hydroperoxide initiators;

(d) Conform to Table 725-2.

Table 725-2
Polyester Binder Resin Properties

Quality Characteristic	Test Method	Requirement
Viscosity, cP, RV, No. 1 spindle, 20 RPM, at 77 °F(1)	ASTM D2196	75 to 200
Specific gravity at 77 °F(1)	ASTM D1475	1.05 to 1.10
Elongation, % Type I specimen, 0.25±0.03-inch-thick, rate = 0.45 in/min Sample conditioning: 18/25/50+5/70	 ASTM D638 ASTM D618	35 minimum
Tensile strength, psi Type I specimen, 0.25±0.03-inch-thick, rate = 0.45 in/min Sample conditioning: 18/25/50+5/70	 ASTM D638 ASTM D618	2500 minimum
Styrene content, % by weight(1)	ASTM D2369	40 to 50
PCC saturated surface-dry bond strength, psi, at 24 hours and 70±2 °F	California Test 551	500 minimum

(1) Perform test before adding initiator.

725.18 High Molecular Weight Methacrylate. Provide a wax-free, low odor, high molecular weight methacrylate primer consisting of a resin, initiator, and promoter. Use a promoter recommended by the system provider. Use an initiator consisting of a metal drier and peroxide. When supplied separately from the resin, do not mix the metal drier directly with the peroxide.

Conform to Table 725-3.

Table 725-3
High Molecular Weight Methacrylate Resin Properties

Property	Test Method	Requirement
Viscosity, cP, Brookfield RV with UL adaptor, 50 RPM, at 77 °F(1)	ASTM D2196	25 maximum
Volatile content, %(1)	ASTM D2369	30 maximum
Specific Gravity, at 77 °F(1)	ASTM D1475	0.90 minimum
Flash Point, °F(1)	ASTM D3278	180 minimum
Vapor Pressure, inches Hg, at 77 °F(1)	ASTM D323	0.04 maximum
Tack-free time, minutes, at 77 °F	Prepare specimens under California Test 551	400 maximum
PCC Saturated Surface-Dry Bond Strength, Adhesive, psi, at 24 hours and 70±1 °F(2)	California Test 551, Part 5	700 minimum

(1) Perform test before adding initiator.
(2) PPC at 12 percent resin content by weight of the dry aggregate.

725.19 Fiber-Reinforced Polymer. Fabricate polymer structures from high-strength E-glass and isophthalic polyester resin unless otherwise specified. Apply weathering and ultraviolet light protection by addition of a 10-mil polyester veil to the laminate construction.

Conform to Table 725-4.

Table 725-4
FRP Performance Requirements

Property	Test Method	Requirement, psi
Tensile strength	ASTM D638	30,000 minimum
Compressive strength	ASTM D6641	30,000 minimum
Shear strength	ASTM D2344	4500 minimum
Flexural strength	ASTM D790	30,000 minimum
Young's modulus	ASTM D638	2,500,000 minimum

725.20 Penetrating Sealant. Provide a silane penetrating sealant, with 40 percent solids and active materials dispersed in water, conforming to Table 725-5.

Table 725-5
Penetrating Sealant Requirements

Property	Test Method	Requirement
VOC content	EPA Method 24	675 lb/yd^3 maximum
Water absorption	NCHRP Report 244 Series II	85% reduction minimum
Chloride absorption	NCHRP Report 244 Series II	85% reduction minimum
Chloride absorption	NCHRP Report 244 Series IV Weathering Test	95% reduction minimum
Resistance to chloride ion penetration	AASHTO T 259 & T 260	0.55 lb/yd^3 at 0.5 inch depth maximum

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