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

FP-03

U.S. Customary Units

U.S. Department
of Transportation

**Federal Highway
Administration**

**Federal
Lands Highway**

Publication No. FHWA-FLH-03-002

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

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U.S. 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-03 U.S. Customary Units" indicating “Federal Project” Standard Specifications issued in 2003 and converted to United States customary measure units. U.S customary units were previously referred to as English units and are the units of measurement customarily used in the U.S. today.

When designated in a contract, the FP-03 becomes part of the contract and binding upon all parties to the contract. All 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-03. A complete copy of the FAR is available from the Superintendent of Documents, Congressional Sales Office, U.S. Government Printing Office, Washington, DC 20402.

U.S. customary measure units are used in the FP-03 U.S. Customary Units as authorized by the Waiver Request of DOT Metric Policy approved on May 5, 1999.

SI[1] (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	2.202	pounds	lb
Mg	Megagrams	1.1023	short tons	T
(or "t")	(or "metric ton")		(2000 lb)	
		TEMPERATURE (exact)		
ºC	Celsius	1.8C +32	Fahrenheit	ºF
	Temperature		temperature	
		ILLUMINATION		
lx	Lux	0.0929	foot-candles	fc
cd/m^2	caldela/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	lbf/in^2
			per square inch	

(1) SI is the symbol for the International System of Units.
Appropriate rounding should be made to comply with Section 4 of ASTM E 380.

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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,"* or other similar words are used, the *"direction," "requirement,"* or *"order"* of 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 are applicable to all contracts.

Division 150 consists of project contract requirements that are applicable to all contracts. Work under Division 150 is paid for directly or indirectly according to Subsection 109.05 and the Section ordering the work. When 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 and the Section ordering the work. When 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. Whenever these abbreviations are used in the specifications, they represent the following:

(a) Acronyms.

AA — Aluminum Association

AAN — American Association of Nurserymen

AAR — Association of American Railroads

AASHTO — American Association of State Highway and Transportation Officials

ACI — American Concrete Institute

ACPA — American Concrete Pavement Association

ADA — Americans with Disabilities Act

AGC — Associated General Contractors of America

AI — Asphalt Institute

AIA — American Institute of Architects

AISC — American Institute of Steel Construction

AISI — American Iron and Steel Institute

AITC — American Institute of Timber Construction

ANSI — American National Standards Institute

APWA — American Public Works Association

ARA — American Railway Association

AREA — American Railway Engineering Association

ARTBA — American Road and Transportation Builders Association

ASCE — American Society of Civil Engineers

ASCII — American Standard Code for Information Interchange

ASLA — American Society of Landscape Architects

ASTM — American Society for Testing and Materials

ATSSA — American Traffic Safety Services Association

AWPA — American Wood Preservers Association

AWS — American Welding Society

AWWA — American Water Works Association

CFR — Code of Federal Regulations

CO — Contracting Officer and all representatives

CRSI — Concrete Reinforcing Steel Institute

FAR — Federal Acquisition Regulations (48 CFR Chapter 1)

FHWA — Federal Highway Administration

FICA — Federal Insurance Contributions Act

FLH — Federal Lands Highways

FSS — Federal Specifications and Standards

FTMS — Federal Test Method Standard

FUTA — Federal Unemployment Tax Act

GSA — General Services Administration

IEEE — Institute of Electrical and Electronic Engineers

ISO — International Organization for Standardization

ISSA — International Slurry Surfacing Association

ITE — Institute of Transportation Engineers

MIL — Military Specifications

MPI — Master Painters Institute

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

NCHRP — National Cooperative Highway Research Program

NEMA — National Electrical Manufacturer's Association

NFPA — National Forest Products Association

NIST — National Institute of Standards and Technology

OSHA — Occupational Safety and Health Administration

PCA — Portland Cement Association

PCI — Prestressed Concrete Institute

PVC — Polyvinyl Chloride

PTI — Post-Tensioning Institute

SAE — Society of Automotive Engineers

SF — Standard Form

SI — International System of Units

SSPC — Steel Structures Painting Council

TAR — Transportation Acquisition Regulations (48 CFR Chapter 12)

UL — Underwriter's Laboratory

U.S. — United States of America

USC — United States Code

USGS — United States Geological Survey

USPS — United States Postal Service

(b) SI symbols.

A	—	ampere	electric current
cd	—	candela	luminous intensity
°C	—	degree Celsius	temperature
d	—	day	time
g	—	gram	mass
h	—	hour	time
H	—	Henry	inductance
ha	—	hectare	area
Hz	—	hertz (s^{-1})	frequency
J	—	joule (N•m)	energy
K	—	kelvin	temperature
L	—	liter	volume
lx	—	lux	illuminance
m	—	meter	length
m^2	—	square meter	area
m^3	—	cubic meter	volume
min	—	minute	time
N	—	newton (kg•m/s^2)	force
Pa	—	pascal (N/m^2)	pressure
s	—	second	time
t	—	metric ton	mass
V	—	volt (W/A)	electric potential
W	—	watt (J/s)	power
S	—	ohm V/A	electric resistance
°	—	degree	plane angle
'	—	minute	plane angle
"	—	second	plane angle

(c) SI prefix symbols.

E	—	exa	10^{18}
P	—	peta	10^{15}
T	—	tera	10^{12}
G	—	giga	10^{9}
M	—	mega	10^{6}
k	—	kilo	10^{3}
c	—	centi	10^{-2}
m	—	milli	10^{-3}
µ	—	micro	10^{-6}
n	—	nano	10^{-9}
p	—	pico	10^{-12}
f	—	femto	10^{-15}
a	—	atto	10^{-18}

(d) Slope notation (vertical : horizontal). For slopes flatter than 1V:1H, express the slope as the ratio of one unit vertical to a number of units horizontal. For slopes steeper than 1V:1H, express the slope as the ratio of a number of units vertical to one unit horizontal.

101.04 Definitions. The following definitions apply to this contract:

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 layer or layers 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 — Any 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 furnish 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 more than 20 feet long, including supports, spanning and providing passage over a depression, waterway, railroad, highway, or other obstruction.

Clear Zone — The portion of the roadside, including the shoulder, available for the safe use by an errant vehicle in which the driver may regain control of the vehicle. Recommended distances for the clear zone are in the AASHTO Roadside Design Guide.

Commercial Certification — See Subsection 106.03.

Construction Limits — The limits on each side of the project that establish the area disturbed by construction operations and beyond which no disturbance is permitted. Typically the construction limits are the same as the clearing limits, except when additional clearing is required.

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

Contract Modification — Any 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 (e.g., 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 mutual action of the parties.

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

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

Crashworthy — A highway feature is crashworthy if it was successfully crash tested under the NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features* or earlier comparable criteria or if it was accepted through analysis by FHWA, based on similarity to other crashworthy features. A list of crashworthy highway features is available on the FHWA Safety website.

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

Day — Each and every day shown on the calendar, beginning and ending at midnight.

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

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

Diversion — A temporary rerouting of public traffic onto a temporary alignment within the project limits in order to bypass the work or a portion of the work.

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

Government — The Government of the United States of America.

Highway, Street, or Road — A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Layer — See "lift."

Lift — Defined as follows:

> **(a)** When placing and compacting soils and aggregates, a lift is any single, continuous layer of material that receives the same compactive effort throughout during a single work operation.
>
> **(b)** When installing culvert pipe less than or equal to 48 inches in diameter, the backfill material 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 in a continuous operation.

Material — Any substances specified or necessary to satisfactorily complete the contract work.

Maximum Particle Size — The smallest sieve opening through which all particles in the material will pass.

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

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

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 for which a unit and price is provided in the contract.

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

Performance Bond — The security executed by the Contractor and surety or sureties furnished to the Government 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 who hold valid State licenses permitting them to offer engineering services directly to the public, who are experienced in the work for which they are responsible, who take legal responsibility for their engineering designs, and who 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 as shown on 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 — All area within the right-of-way excluding the traveled way and shoulders.

Roadway — In general, the portion of a highway, including shoulders, 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 volume defined by the area between the original terrain cross-section and the final design cross-section multiplied by the horizontal distance along the centerline of the roadway.

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

Shoulder — The portion of the roadway contiguous to the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of the pavement structure.

Sieve — See AASHTO M 92.

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

Special Contract Requirements — Additions and revisions to the standard specifications applicable to an individual project.

Specifications — The written requirements for performing work.

Standard Forms — Numbered forms issued by the General Services Administration for use as contract documents.

Standard Plans — Detailed plans approved for repetitive use and included as part of the plans.

Standard Specifications — The Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects approved for general application and repetitive use.

Station — (1) A measure of distance used for highways and railroads. A station is equal to 100 feet. (2) 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 layer or layers of material placed on a subgrade to support a base.

Subcontract — The written agreement between the Contractor and an individual or legal entity prescribing the performance of a specific portion of the work.

Subcontractor — An individual or legal entity with which the Contractor sublets part of the work. This includes all subcontractors in any tier.

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 such that it 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 all bridge deck, parapet, pavement structure, shoulder, drainage, sidewalk, permanent signing and markings, traffic barrier, safety appurtenance, utility, and lighting work is complete.

Substructure — All of the 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 reasonably free of organic matter, roots, muck, sod, or other detrimental material. Suitable material may require drying or adding water, root picking, and other methods of manipulation before use. Suitable material includes the classifications of materials for which the project was designed.

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

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 layer or layers of a pavement structure designed to accommodate the traffic load and resist skidding, traffic abrasion, and weathering.

Target Value (TV) — 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.

Traveled Way — The portion of the roadway designated for the movement of vehicles, including curve widening, exclusive of shoulders.

Unsuitable Material — Material not capable of creating stable foundations, embankments, or roadbeds. Unsuitable material includes muck, sod, or soils with high organic contents.

Work — The furnishing of all labor, material, equipment, and other incidentals necessary to successfully 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 are governed by the FAR and TAR.

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

Execute and submit all required standard forms, bid schedules, and solicitation provisions contained in the solicitation as part of the bid.

Complete SF 1442, *Solicitation, Offer, and Award*, and sign as follows:

(a) Individuals. Sign your individual signature. For individuals doing business as a firm, follow the individual signature with the individual's typed, stamped, or printed name and the words, *"an individual doing business as ______(name of firm)______."*

(b) Partnerships. Submit a list of all partners having authority to bind the partnership. One of the listed partners must sign on behalf of the partnership.

(c) Corporations. Sign in the corporate name, followed by the word *"by"* and the signature and title of the person authorized to sign. Submit evidence from the corporation that the person signing has authority to bind the corporation.

(d) Joint ventures. Submit a copy of the Joint Venture agreement. Sign the SF 1442 according to the Joint Venture agreement.

(e) Limited liability company. Sign in the company name, followed by the word "by" and the signature of the person authorized to sign. Submit evidence that the individual executing the document has authority to bind the company.

(f) Agents. When an agent signs, other than as stated in (a) through (e) above, furnish satisfactory evidence that the agent has authority to bind the bidder.

Insert a unit bid price, in figures, 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. Should any mathematical check made by the Government show a mistake in the amount bid, the corrected unit price extension shall govern.

When the words *"lump sum"* appear as a unit bid price, insert an amount bid for each lump sum pay item.

When the words *"contingent sum"* or a fixed rate appears as a unit bid price, include the Government inserted amount bid for the item in the total bid amount.

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

The quantities shown 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 furnished 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.

(a) General. Submit a bid guarantee of 20 percent of the amount of the bid or $3 million, whichever is less. Submit the bid guarantee on SF 24, *Bid Bond*. If the bid guarantee is other than a corporate or individual surety, sign the SF 24 as the principal and make a statement on the form pledging the security. Make checks or money orders payable to the agency issuing the solicitation.

(b) Power of attorney. A corporate surety shall submit a current power of attorney for the signing agent or attorney-in-fact with each SF 24.

(c) Evidence of guarantee assistance. A surety that has a guarantee of assistance from the Small Business Administration shall submit a copy of its *"Surety Bond Guarantee Agreement"* with each SF 24. In addition, submit a power of attorney for the surety representative identified in the agreement.

102.04 Individual Surety. Follow the requirements of FAR Clause 52.228-11 Pledges 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. Execution by power of attorney is not acceptable. Bidders cannot serve as their own surety. Assets named shall be committed to the project with a bank designated to serve as trustee.

After reviewing the SF 28, the surety may be requested to provide further documentation with respect to any of its assets, debts, or encumbrances. The information may be required to be furnished 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 permitted.

102.05 Public Opening of Bids. Bids will be publicly opened at the time specified in the SF 1442. Their contents will be made public information. The Government reserves the right to reject bids as set forth in the FAR, Part 14.

102.06 Performance and Payment Bonds. Follow the requirements of FAR Clause 52.228-15 Performance and Payment Bonds – Construction. Furnish a performance bond and a payment bond each in the penal amount of 100 percent of the original contract price.

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

The requirements contained in Subsections 102.03 and 102.04 relating to power of attorney, evidence of guarantee assistance, and individual sureties also apply to performance and payment bonds.

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. The precise details of performing the work are not stipulated except as considered essential for the successful completion of the work. Furnish all 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.

When requesting a CO's decision on an interpretation of contract terms for the recovery of increased costs, quantify the amount and, if required by FAR Clause 52.233-1, certify the amount. Include an explanation of the interpretation of contract terms, the contract clause under which the claim is made, all supporting documentation, and adequate cost data to support the amount claimed.

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

Before undertaking significant expenditures, provide the CO with 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, prepare and submit the formal VECP proposal.

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

Include a provision in all 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 this contract, the Government offers to participate in a formal 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, mutually agree with the Government 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 and Government representatives to attend a partnership development and team-building workshop usually between the time of award and the notice to proceed. 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. Provide invoices to the Government. 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. The time allowed for completion of the project is not affected by partnering.

Section 104. — CONTROL OF WORK

104.01 Authority of the Contracting Officer (CO). The CO may delegate authority to representatives to decide on acceptability of work, progress of work, suspension of work, interpretation of the contract, and acceptable fulfillment of the contract. The term *"CO"* includes all authorized representatives of the CO, including inspectors, acting within the limits of their authority as delegated by the CO.

104.02 Authority of Inspectors. Inspectors are authorized to inspect all work including the preparation, fabrication, or manufacture of material for the project. The inspector is not authorized to alter or waive contract requirements, issue instruction contrary to the contract, act as foreman for the Contractor, or direct the Contractor's operations. The inspector has authority to identify non-conforming work until the issue can be referred to and decided by the CO. The inspector may take necessary action to prevent imminent and substantial risk of death or injury including stopping work.

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

(a) General. Prepare drawings as necessary to construct the work. Drawings include, but are not limited to, layouts that show the relative position (vertical and horizontal as appropriate) of work to be performed, fabrication details for manufactured items and assemblies, installation and erection procedures, details of post-tensioning and other systems, detailed trench and excavation procedures that conform to OSHA requirements, traffic control implementation drawings, and methods for performing work near existing structures or other areas to be protected. Show all the drawing dimensions in United States customary units.

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

Furnish 5 sets of drawings and supporting calculations for acceptance before performing work covered by the drawings. If drawings are returned for revision, correct and resubmit for acceptance. Allow 40 days per submission for railroad structures and 30 days per submission for all other structures. The review time as specified is applied separately to each drawing submitted. The CO may request additional specific drawings for unique situations in order to clarify layout, construction details, or methodology. If drawings must be resubmitted, the time for acceptance starts over. Obtain written approval before changing or deviating from the accepted drawings.

(b) Specific requirements for concrete and miscellaneous structures.

(1) Furnish drawings for the following:

(a) Site-specific layouts for all wall types and gabion installations;

(b) Gabion and revet mattress details and installation procedures;

(c) Forms and falsework for reinforced concrete box culverts less than or equal to 6 feet in height;

(d) Fabrication drawings for bridge railings and parapets;

(e) Fabrication drawings for prestressed members;

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

(g) Fabrication drawings for bearing assemblies;

(h) Construction joint location and concrete deck placement sequences not shown on the plans;

(i) Erection diagrams for Soil-Corrugated Metal Structure interaction systems (multi-plate structures);

(j) Structural steel fabrication drawings;

(k) Utility hangar details; and

(l) Fabrication and installation drawings for precast items.

(2) Furnish drawings that bear the seal and signature of a professional engineer proficient in the pertinent design field for the following:

(a) Erection plans;

(b) Reinforced soil slopes details;

(c) MSE wall and crib wall details;

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

(e) Temporary bridge structures for public use;

(f) All bridge forms except for railings, parapets, and components less than 6 feet in height;

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

(h) All shoring systems that support traffic loadings;

(i) Forms and falsework for all structures greater than 6 feet in height;

(j) Post-tensioning systems;

(k) Ground anchors, soil nail, and rock bolt assembly details, layout, and installation and testing procedures;

(l) Tie back wall details; and

(m) Alternate retaining wall details.

(3) Furnish drawings that bear the seal and signature of a professional engineer who is proficient in forms and falsework design and licensed in the state where the project will be constructed for the following:

(a) Falsework for any structure with a span exceeding 16 feet;

(b) Falsework for any structure with a height exceeding 14 feet; and

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

104.04 Coordination of Contract Documents. The FAR, TAR, special contract requirements, 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) Federal Acquisition Regulations;

(b) Transportation Acquisition Regulations;

(c) Special contract requirements;

(d) Plans; and

(e) Standard specifications.

104.05 Load Restrictions. Follow the requirements of FAR Clause 52.236-10 Operations and Storage Areas, paragraph (c).

Comply with all legal load restrictions when hauling material and equipment on public roads to and from the project. A special permit does not relieve the Contractor of liability for damage resulting from the moving of material or equipment.

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 except those pavements intended to be removed.

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 provide acceptable material. Notify the CO of all 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. Approval does not constitute acceptance. If an approved source does not continue to supply acceptable material during the life of the project, further use of that source may be denied.

105.02 Material Sources.

(a) Government-provided sources. The Government will acquire the permits and rights to remove material from provided sources identified in the contract and to use such property for a plant site and stockpiles. Test reports and available historical performance data verifying the presence of acceptable material are available upon request.

Do not perform work within a Government-provided source until a plan of operation for the development of the source is accepted. Perform all work necessary to produce acceptable material including site development, preparation, erosion control, and restoration.

The quality of material in provided sources is acceptable in general, but may contain layers or pockets of unacceptable material. It is not feasible to ascertain from samples the quality of material for an entire deposit, and variations may be expected. Determine the quantity and type of equipment and work necessary to select and produce acceptable material.

Strip and stockpile the overburden. After operations are complete, move all waste back into the source. Neatly trim and flatten the side slopes to the extent practicable. Spread the stockpiled overburden uniformly over the sides and bottom of the mined area. Shape the mined area to blend into the surrounding natural terrain.

(b) Contractor-located sources. The Contractor is responsible for located sources, including established commercial sources. Use sources that fulfill the contract quantity and quality requirements. Determine the quantity and types of equipment and work necessary to select and produce acceptable material. Secure all permits and clearances for use of the source and provide copies of the documents.

Provide laboratory test reports and available historical performance data indicating that acceptable material is available from the source. Do not use material from a source that is unacceptable to the Government. Dispose of unacceptable material and locate another source at no cost to the Government.

105.03 Material Source Management. Notify the CO 14 days before starting pit operations. Develop and operate within a material source according to the accepted plan of operation or written agreement for developing the source.

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. Control all erosion so the sediment levels in the bodies of water within the drainage area of the work area do not increase. Control erosion so that sediment does not leave the work area.

105.04 Storing and Handling Material. Store and handle 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 and placing plants and equipment. Provide all additional space needed. Do not use private property for storage without written permission of the owner or lessee. Furnish copies of all agreements. Restore all Government-provided storage sites to their original condition.

The Contractor is responsible for the security of all stored material.

105.05 Use of Material Found in the Work. Material, such as stone, gravel, or sand, found in the excavation may be used for another pay item when acceptable. When there is an applicable excavation item in the bid schedule, such material will be paid both as excavation and as the other pay item for which it is used. Replace material so used and needed for embankment or backfill with acceptable material at no 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 does not include the use and processing of material for nongovernment contract work except for the disposal of waste material. If the Contractor produces or processes material from Government lands in excess of 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 cost to the Government.

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 test methods of AASHTO, ASTM, GSA, and other recognized standard authorities refer to the methods in effect on the date of solicitation for bids.

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

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

Plan dimensions and contract specification values are the values to be strived for and complied with as the design values from which any 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.

The Government may inspect, sample, or test all work at any time before final acceptance of the project. When the Government tests work, copies of test reports are furnished to the Contractor upon request. Government tests may or may not be performed at the work site. If Contractor testing and inspection is verified by the Government, the Contractor's results may be used by the Government to evaluate work for acceptance. Do not rely on the availability of Government test results for process control.

Acceptable work conforming to the contract will be paid for at the contract unit bid price. Four methods of determining conformity and accepting work are described in Subsections 106.02 to 106.05 inclusive. The primary method of acceptance is specified in each Section of work. However, work may be rejected at any time it is found by any of the methods not to comply with the contract.

Remove and replace work that does not conform to the contract, or to prevailing industry standards where no specific contract requirements are noted, at no cost to the Government.

As an alternative to removal and replacement, the Contractor may submit a written request to:

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

(b) Be given permission to perform corrective measures to bring the work into conformity.

The request must contain 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.

When standard manufactured items are specified (such as fence, wire, plates, rolled shapes, pipe conduits, etc., that are identified by gauge, unit mass, section dimensions, etc.), the identification will be considered to be nominal masses or dimensions. Unless specific contract tolerances are noted, established manufacturing tolerances will be accepted.

106.02 Visual Inspection. Acceptance is based on visual inspection of the work for compliance with the contract and prevailing industry standards.

106.03 Certification. For material manufactured off-site, use a manufacturer with an ISO 9000 certification or an effective 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 these Standard Specifications reference certifications; certificates; or certified documents, equipment, or individuals, these references are not certifications under Section 4301 of Public Law 104-106, National Defense Authorization Act for Fiscal Year 1996. These 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.

Material accepted by certification may be sampled and tested at any time. If found not in conformance with the contract, the material will be rejected whether in place or not.

One of the following certifications may be required:

(a) Production certification. Material requiring a production certification is identified in the Acceptance Subsection of each Section. Require the manufacturer to furnish a production certification for each shipment of material. Include the following with each production certification:

(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 quality requirements as required by FAR 46.105(a)(4), including all of 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 all contract requirements; and

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

(b) Commercial certification. When a certification is required, but not a production certification, furnish one commercial certification for all similar material from the same manufacturer.

A commercial certification is a manufacturer's or Contractor's representation that the material complies with all contract requirements. 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.

106.04 Measured or Tested Conformance. Provide all necessary production and processing of the work and control performance of the work so that all of the work complies with the contract requirements.

Results from inspection or testing shall have values within the specified tolerances or specification limits. When no tolerance values are identified in the contract, the work will be accepted based on customary manufacturing and construction tolerances.

106.05 Statistical Evaluation of Work and Determination of Pay Factor (Value of Work). Statistical evaluation of work is a method of analyzing inspection or test results to determine conformity with the contract requirements. 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 price (α_{100}).

Acceptable quality level is the lowest percentage of work within the specification limits that is considered acceptable for payment at contract price. There are 2 categories. Category I is based on an AQL of 95 percent. Category II is based on an AQL of 90 percent. In both cases, the Contractor's risk (α_{100}) is 5 percent and the risk of rejection (α) 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 price may be obtained under certain conditions.

The quality characteristics to be evaluated, lot size, sampling frequency, sampling location, test methods, specification limits, and category are as follows:

(1) Quality characteristics. The quality characteristics to be evaluated are listed in the Acceptance Subsection of each Section.

(2) 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 job-mix formula are requested in writing and approved.

(3) Sampling frequency. The frequency of sampling is listed in the Acceptance Subsection of each Section. The frequency rate shown normally results in a minimum of 5 samples. The minimum number required to perform a statistical evaluation is 3. The maximum obtainable pay factor with 3, 4, or 5 samples is 1.01. A minimum of 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, a written request is required to increase the sampling frequency to provide for a minimum of 8 samples. Provide the request to increase the sampling frequency at least 48 hours before beginning production. An increase in the sampling frequency may result in a reduced pay factor.

(4) Sampling location. The point of sampling is listed in the Acceptance Subsection of each Section. The exact location of sampling will be specified by the CO based on random numbers.

(5) Test methods. The test methods used to test the sample are listed in the Acceptance Subsection of each Section.

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

(7) Category. The category for the quality characteristics to be analyzed is listed in the acceptance subsection of each Section.

(b) Acceptance. The work in the lot will be paid for at a final pay factor when all inspections or test results are completed and evaluated.

Before determining the final pay factor, the work may be incorporated into 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, terminate production. Production may resume after the Contractor takes effective and acceptable actions to improve the quality of the production.

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

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

When approved, it is permissible to voluntarily remove nonspecification material and replace it with new material to avoid or minimize a pay factor of less than 1.00. New material will be sampled, tested, and 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 Variability-Unknown/Standard Deviation Method will be used to determine the estimated percentage of the lot that is within specification limits.

The number of significant figures used in the calculations will be according to AASHTO R 11, absolute method.

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 deviation (s):

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

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): $Q_U = \dfrac{USL - \overline{X}}{s}$

where: USL = upper specification limit

Note: 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): $Q_L = \dfrac{\overline{X} - LSL}{s}$

where: LSL = lower specification limit

Note: 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.

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

(1) From Table 106-2, determine the pay factor for each quality characteristic using the total number of test values and the total estimated percentage within the specification limits from step (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 (with a minimum of 8 test values).

(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 payment is based on the lowest single pay factor for all category I characteristics. The maximum obtainable pay factor is 1.05 (with a minimum of 8 test values).

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.

(continued)

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	84	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.

(continued)

Table 106-2 Pay Factors (continued)

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	35	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.

(b) When any Category II quality characteristic is less than 1.00, the lot payment 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 bid price by the lot pay factor as determined above, or as described in the Payment Subsection of the Section ordering the work.

106.06 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 full entry at all times to the parts of the plant producing the work.

106.07 Partial and Final Acceptance. Maintain the work during construction and until the project is accepted. Damage caused by the Contractor prior to final acceptance of the entire project will be repaired at the Contractor's expense. See FAR Clause 52.236-11 Use and Possession Prior to Completion.

(a) Partial acceptance. When a separate portion of the project is completed, a final inspection of that portion may be requested. If the portion is complete and in compliance with the contract, it may be accepted. If accepted, the CO will relieve the Contractor of further responsibility for maintenance of the completed portion. Partial acceptance does not void or alter any of the terms of the contract.

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

(b) Final acceptance. When notified that the entire project is complete, an inspection will be scheduled. If all work is determined to be complete, the inspection will constitute the final inspection and 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 any 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. Furnish notification when the work has been completed as provided above.

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

Comply with all permits and agreements obtained by the Government for performing the work that is included in the contract. Obtain all additional permits or agreements and modifications to Government-obtained permits or agreements that are required by the Contractor's methods of operation. Furnish copies of all permits and agreements.

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.

Preserve public and private property, and protect monuments established for the purpose of perpetuating horizontal, vertical, cadastral, or boundary control. When 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.

Do not disturb the area beyond the construction limits. Replace trees, shrubs, or vegetated areas damaged by construction operations as directed and at no cost to the Government. Remove any damaged limbs of existing trees by an approved arborist.

Do not excavate, remove, damage, alter, or deface any 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 any of these items be encountered, suspend operations at the discovery site, notify the CO, and continue operations in other areas. The CO will inform the Contractor when operations may resume at the discovery site.

When utilities are to be relocated or adjusted, the Government will notify all utility owners affected by the relocations or adjustments. The relocations or adjustments will be performed by others or will be included in the contract work.

Before beginning work in an area, the Contractor shall have all utility owners locate their 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 as a result 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.

If utility adjustment work, not included in the contract, 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 cost to the Government.

Repair of damage to underground utilities that were not shown on 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. Furnish 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 each of the following documents on the bulletin board:

(a) "Equal Opportunity" poster, according to FAR Clause 52.222-26 Equal Opportunity;

(b) "Notice" that the project is subject to Title 18, U.S. Criminal Code, Section 1020, FHWA Form 1022;

(c) "Notice to Employees" poster, WH-1321, regarding proper pay;

(d) "Right to Safe and Healthful Workplace" poster, according to Title 29, Code of Federal Regulations, Part 1903;

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

(f) Company equal employment opportunity policy.

107.04 Railroad Protection. The Government will obtain the necessary permits and agreements from the railroad for specified contract work for relocating railroads or for work at railroad crossings. Make arrangements for all other work that, due to the method of operation, may also impact the railroad. Furnish copies of all permits and agreements.

Conduct the work covered by the railroad permit or agreement in a manner satisfactory to the railroad. Do not interfere with railroad operations. If the construction damages railroad property, reimburse the railroad for all damages, or at the railroad's option, repair the damage at no 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 all temporary grade crossing work or, at the railroad's option, perform the work.

The requirements of the railroad are as follows:

(a) Indemnify and hold harmless the railroad according to Subsection 107.05. Carry insurance meeting the following minimums:

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

(2) Bodily injury liability insurance. $2,000,000 each occurrence.

(3) Property damage liability insurance. $2,000,000 aggregate coverage.

(4) Railroad protective public liability and property damage liability insurance. $2,000,000 each occurrence. $6,000,000 aggregate coverage.

(b) Notify the railroad in writing not less than 1 week before beginning construction within the railroad right-of-way. Secure permission from the railroad before performing work within the railroad right-of-way. Confer with the railroad concerning clearance requirements, operations, and safety regulations.

(c) Reimburse the railroad for all flaggers and watchers provided by the railroad because of the work. The railroad generally requires 2 watchers or flaggers during construction operations that interfere with the railroad's tracks or traffic, that violate the railroad's operating clearances, or that involve a reasonable probability of accidental hazard to railroad traffic.

Flaggers are also furnished whenever, in the railroad's opinion, such protection is needed. Notify the railroad 36 hours in advance of required protective services.

(d) Railroad employees are paid the prevailing railroad hourly rate for regularly assigned 8-hour days for the work classification and overtime according to labor agreements and schedules in effect when the work is performed.

(e) Wage rates are subject to change by law or agreement between the railroad and employees and may be retroactive. If the wage rates change, reimburse the railroad based on the new rates.

(f) Reimburse the railroad monthly for the cost of all services performed by the railroad. Furnish satisfactory evidence that the railroad has received full reimbursement before final acceptance.

(g) Do not store any material, supplies, or equipment closer than 15 feet from the centerline of any railroad track.

(h) Upon completion of the work, remove all equipment and surplus material, and leave the railroad right-of-way in a neat condition satisfactory to the railroad.

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 any 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. The insurance shall cover all operations under the contract whether performed by the Contractor or by subcontractors.

Before work begins, furnish *"certificates of insurance"* certifying that the policies will not be changed or canceled until 30 days written notice has been given to the Government. Insurance coverage in the minimum amounts set forth below shall not relieve the Contractor of liability in excess of the coverage.

Carry insurance meeting 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 106.07. This includes periods of suspended work. Protect the work against injury, loss, or damage from all causes whether arising from the execution or nonexecution of the work.

Maintain public traffic according to Section 156. Rebuild, repair, restore, and make good all 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 losses, injuries, and damages to work put in place that was caused by declared enemies and terrorists of the Government and cataclysmic natural phenomenon such as tornadoes, earthquakes, major floods, and other officially declared natural disasters. The Government will only be responsible for costs attributable to repairing or replacing damaged work. 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 all 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 permit any worker to work in surroundings or under conditions that are unsanitary, hazardous, or dangerous.

Admit any OSHA inspector or other legally responsible official 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 a *"Log of Work Related Injuries and Illnesses,"* OSHA Form 300, and make it available for inspection.

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

107.09 Legal Relationship of the Parties. In the performance of the contract, the Contractor is an independent contractor and neither the Contractor nor anyone used or employed by the Contractor shall be an agent, employee, servant, or representative of the Government. The Contractor's independent contractor status does not limit the Government's general rights under the contract.

107.10 Environmental Protection. Do not operate mechanized equipment or discharge or otherwise place any material within the wetted perimeter of any waters of the U.S. within the scope of the Clean Water Act (33 USC § 1251 et seq.). This includes wetlands unless authorized by a permit issued by the U.S. Army Corps of Engineers according to 33 USC § 1344, and, if required, by any State agency having jurisdiction over the discharge of material into the waters of the U.S. In the event of an unauthorized discharge:

(a) Immediately prevent further contamination;

(b) Immediately notify appropriate authorities; and

(c) Mitigate damages as required.

Comply with the terms and conditions of any permits that are issued for the performance of work within the wetted perimeter of the waters of the U.S.

Separate work areas, including material sources, by the use of a dike or other suitable barrier that prevents sediment, petroleum products, chemicals, or other liquid or solid material from entering the waters of the U.S. Use care in constructing and removing the barriers to avoid any discharge of material into, or the siltation of, the water. Remove and properly dispose of the sediment or other material collected by the barrier.

Repair leaks on equipment immediately. Do not use equipment that is leaking. Keep a supply of acceptable absorbent materials at the job site in the event of spills. Acceptable absorbent materials are those that are manufactured specifically for the containment and clean up of hazardous materials.

107.11 Protection of Forests, Parks, and Public Lands. Comply with all regulations of the State fire marshal, conservation commission, Forest Service, National Park Service, Bureau of Land Management, Fish & Wildlife Service, Bureau of Indian Affairs, 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 beginning work. Seven days before the preconstruction conference, furnish three copies of the preliminary construction schedule according to Section 155.

108.02 Subcontracting. Follow the requirements of FAR Clauses 52.219-14 Limitations on Subcontracting, 52.222-11 – Subcontracts (Labor Standards), and 52.236-1 Performance of Work by the Contractor.

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 any action or lack of action of subcontractors.

Within 14 days of subcontract award, submit an SF 1413 with Part I completed. Complete other forms that may be provided by the Government to clearly 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 amount of all on-site subcontracts to date as a percentage of the original contract amount. Furnish this information on all subcontracts at lower tiers.

In FAR Clauses 52.219-8 Utilization of Small Business Concerns and 52.232-27 Prompt Payment for Construction Contracts, the subcontracts include both on-site and off-site work and supply contracts. In FAR Clause 52.219-14 Limitations on Subcontracting or in FAR Clause 52.236-1 Performance of Work by the Contractor, the percentage of work performed on-site by the Contractor will be computed as 100 percent less the combined initial dollar amount of all subcontracts involving on-site labor as a percent of the original dollar amount of the contract.

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

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

When Critical Path Method schedules are used, no time extension will be made for delays or modifications that use available float time as shown in the current construction schedule required by Section 155.

Time will not be extended for a claim that states insufficient time was provided in the contract.

When requesting a time extension, follow the applicable contract clauses. Make the request in writing and include the following:

(a) Contract clause(s) under which the request is being made.

(b) Detailed narrative description of the reasons for the requested contract time adjustment including the following:

(1) Cause of the impact affecting time;

(2) Start date of the impact;

(3) Duration of the impact;

(4) Activities affected; and

(5) Methods to be employed to mitigate the impact.

(c) Suggested new completion date or number of days supported by current and revised construction schedules according to Section 155.

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

Liquidated damages in the amount specified in Table 108-1 will be assessed for each day beyond the time allowed to complete 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 specified in Table 108-1 will be assessed for each day until work resumes at which time full liquidated damages will be assessed.

Liquidated damages in an amount equal to 20 percent of the amount specified in Table 108-1 will be assessed for each day beyond the time allowed to complete the contract beginning with the day after substantial completion and ending with the date of final completion and acceptance.

Liquidated damages will not be assessed for the following:

(a) The day of the final inspection;

(b) Days required to perform work added to the contract after substantial completion including items identified during the final inspection that were not required before that time; or

(c) Delays by the Government after all work is complete and before a formal acceptance is executed.

(d) Periods of time when all work is complete but acceptance is delayed pending the plant establishment period or similar warranty period.

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

Original Cont t Price		Daily Charge
From More Than —	**To and Including —**	
$ 0	$ 1,000,000	$ 500
1,000,000	2,000,000	1,100
2,000,000	5,000,000	2,200
5,000,000	10,000,000	2,700
10,000,000	and more	3,300

108.05 Stop Order. The CO may order the performance of the work to be stopped, either in whole or in part, for such periods deemed necessary due 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 any provision of the contract.

No adjustment in contract time or amount will be made for stop orders issued under (a) or (b) above except an adjustment in contract time, as provided by FAR Clause 52.249-10 Default (Fixed-Price Construction), may be made when the Contractor is able to demonstrate that the weather was unusually severe based on the most recent 10 years of historical data.

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 all measurements of work according to United States customary measure.

Unless otherwise specified, measure when the work is in place, complete, and accepted. 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 shown on 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.

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

Submit measurement notes to the CO within 24 hours of completing the work. For on-going work, submit measurement notes weekly. When work is not complete, identify the measurement as being an interim measurement. Submit the final measurement when the installation is completed. Measurement notes form the basis of the Government's receiving report (see Subsection 109.08(d)). For lump sum items, submit documentation to support invoiced progress payment on a monthly basis.

Use an acceptable format for measurement records. As a minimum, include the following information in all records of measurement:

(a) Project name and number;

(b) Contract item number;

(c) Date the work was performed;

(d) Location of the work;

(e) Measured quantity;

(f) Calculations made to arrive at the quantity;

(g) Supporting sketch 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, performing the calculations, and submitting them for payment that the measurement and calculations are correct to the best of their knowledge and that the quantity being measured is subject to direct payment for the identified item under the contract.

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 unless specified on the ground surface. Do not make deductions from the area computation for individual fixtures having an area of 500 square feet or less.

(b) Contract quantity. The quantity to be paid is the quantity shown 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.

(b) Cubic yard.

(1) Cubic yard in place. Measure solid volumes by a method approved by the CO or by the average end area method as follows:

(a) Take cross-sections of the original ground and use with design or staked templates or take other comparable measurements to determine the end areas. Do not measure work outside of the established lines or slopes.

(b) If any 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. Deduct any quantity outside the designated or staked limits. Use these measurements to calculate new end areas.

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

(2) Cubic yard in the hauling vehicle. 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 material in excess of 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) Cubic yard in the structure. Measure according to the lines of the structure as shown on 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) Cubic yard by metering. Use an approved metering system.

(d) Each. One entire unit. The quantity is the actual number of units completed and accepted.

(e) Gallon. The quantity may be measured by any of the following methods:

(1) Measured volume container.

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

(3) Commercially-packaged volumes.

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

(f) Hour. Measure the actual number of hours ordered by the CO and performed by the Contractor.

(g) 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.

(h) 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 item. The quantity is designated as *"All."* Estimated quantities of lump sum work shown in the contract are approximate.

(i) M-gallon. 1,000 gallons. Measure according to (e) above.

(j) Mile. 5,280 linear feet. Measure horizontally along the centerline of each roadway, approach road, or ramp.

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

(l) Square foot. Measure on a plane parallel to the surface being measured.

(m) Square yard. 9 square feet. Longitudinal and transverse measurements for area computations will be made horizontally. No deductions from the area computation will be made for individual fixtures having area of 9 square feet or less.

(n) Station. 100 linear feet. Measure horizontally along centerline or reference line of each roadway, approach road, or ramp.

(o) Ton. 2,000 pounds avoirdupois. Measure according to Subsection 109.03.

No adjustment in a contract unit 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 when asphalt material is lost from the car or the distributor, wasted, or otherwise not incorporated in the work. When 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.

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

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

When a weighing device is determined to indicate less than true mass, no additional payment will be made for material previously weighed and recorded. When a weighing device is determined to indicate more than true mass, all 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, furnish a supplier's invoice with net mass or volume converted to mass. Periodic check weighing may be required.

(c) Project weighing system. Furnish, erect, and maintain acceptable 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 range of use.

Do not use spring balances.

Install and maintain platform scales with the platform level with rigid bulkheads at each end. Make the platform of sufficient length to permit simultaneous weighing of all axle loads of the hauling vehicle. Coupled vehicles may be weighed separately or together according to Section 2.20 paragraph UR 3.3 of *NIST Handbook 44*.

Install and maintain belt-conveyor scales according to Section 2.21 of *NIST Handbook 44*.

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 all mass information. For weighed pay quantities, program the printer to provide the following information for each weighing:

(1) Project number;

(2) 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 beginning of the shift; and

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

If a printer malfunctions or breaks down, the Contractor may manually weigh and record masses for up to 48 hours provided the method of weighing meets all other contract requirements.

Furnish competent scale operators to operate the system.

When platform scales are used, randomly weigh the empty haul units at least twice per shift.

Use an approved format for the mass records. Furnish the original record(s) 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, furnish 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 acceptable manner. Include the following information as applicable:

(a) Project identification;

(b) Contract 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.

Use an approved format for the delivery record(s). Furnish the original record(s) and a written certification of the delivery of the material at the end of each shift.

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

(a) Direct payment. Payment is provided directly under a pay item shown 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 Measurement Subsection, of the Section ordering the work, references another Section for measuring 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 shown 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 contract bid schedule is full payment for performing all contract work in a complete and acceptable manner. All risk, loss, damage, or expense arising out of the nature or prosecution of the work is included in the compensation provided by the contract pay items.

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

The quantities shown 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 furnished 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 all costs according to the contract cost principles and procedures of FAR Part 31. Follow the requirements of all FAR clauses providing for an equitable price adjustment.

If agreement on price cannot be reached, the CO may determine the price unilaterally.

If the work will delay contract completion, request a time extension according to Subsection 108.03.

(a) Proposal.

(1) General. Submit a written proposal for each line item of the work or a lump sum for the total work. Identify the major elements of the work, the quantity of the element, and its contribution to the proposed price. Provide further breakdowns if requested by the CO.

When price is based on actual costs (e.g., cost-plus-fixed-fee), profit is based on the estimated cost of the work and may not exceed the statutory limit of 10 percent of the total cost. Due to the limited risk in this type of pricing arrangement, a lower profit percentage may be indicated.

(2) Data. Submit information as requested by the CO to the extent necessary to permit the CO to determine the reasonableness of the proposed price.

(3) 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, or FAR Clause 52.215-11 Price Reduction for Defective Cost or Pricing Data - Modifications, submit cost or pricing data.

Provide cost or pricing data, broken down by individual work item, for the Contractor and each major subcontractor. Include the information required by (b)(1) and (b)(2) below. When cost or pricing data is submitted before all or most of the work is performed, submit material and subcontractor quotes, anticipated labor and equipment usage, and anticipated production rates. Provide data for all proposed increases or decreases to the contract price.

Submit with the cost or pricing data a written proposal for pricing the work according to (1) above. See Table 15-2 following FAR Subpart 15.4 for guidance.

Upon completion of negotiations, certify the cost or pricing data as being accurate, complete, and current as of the date the agreement was reached.

(b) Postwork pricing. When negotiating the price of additional or changed work after all or most of the work has been performed, furnish the following:

(1) Direct costs.

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

(b) Labor. Show basic hourly wage rates, fringe benefits, applicable payroll costs (i.e., FICA, FUTA, worker's compensation, insurance, and tax levies), paid subsistence, and travel costs for each labor classification and foreman employed in the adjusted work.

(c) Equipment. Provide a complete descriptive listing of equipment including make, model, and year of manufacture. Support rented or leased equipment costs with invoices. Determine allowable ownership and operating costs for Contractor- and subcontractor-owned equipment as follows:

(1) Use actual equipment cost data when such data can be acceptably determined from the Contractor's or subcontractor's ownership and operating cost records.

(2) When actual costs cannot be determined, use the rates shown in *Construction Equipment Ownership and Operating Expense Schedules (CEOOES)* published by the U.S. Army Corps of Engineers for the area where costs are incurred. This document is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402-9325. Adjust the rates for used equipment and for other variable parameters used in the schedules.

(3) Compute proposed standby costs from acceptable ownership records or when actual costs cannot be determined, according to *CEOOES*. Do not exceed 8 hours in any 24-hour period or 40 hours in any calendar 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.

(d) Other direct costs. Furnish documentation or invoices to support any other direct costs incurred that are not included above (e.g., bonds, mobilization, demobilization, permits, royalties, etc).

(e) Production rates. Provide actual hours of performance, on a daily basis, for each labor classification and for each piece of equipment.

(f) Subcontract costs. Provide supporting data as required above.

(2) Overhead. Identify overhead rate(s) and provide supporting data, which justifies the rate(s). List the types of costs, which are included in overhead. Identify the cost pool(s) to which overhead is applied. Apply the overhead to the appropriate pool.

Limit Contractor overhead applied to subcontractor payments to 5 percent of such payments unless a higher percentage is justified.

(3) Profit. Except when precluded by the FAR, include a reasonable profit reflecting the efficiency and economy of the Contractor and subcontractors in performing the work, the contract risk type, the work difficulty, and management effectiveness and diversity.

For work priced after all or most of the work is performed, profit is limited by statute to 10 percent of the total cost. Due to the limited risk in post-work pricing, a lower profit percentage may be indicated.

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 all 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 Clauses 52.232-5 Payments under Fixed-Price Construction Contracts and 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. Full or partial progress payment will be withheld until a construction schedule or schedule update is submitted to, and accepted by, the CO.

(b) 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.

(c) Invoice requirements. Submit the invoice to the Government's designated billing office. Include the following items in the invoice:

(1) The information required in FAR Clause 52.232-27(a)(2)(i) through (a)(2)(xi).

(2) A tabulation of total quantities and unit prices of work accomplished or completed on each pay item as of the monthly closing date. Do not include any quantities unless field note documentation for those quantities was submitted by the closing date. Do not include quantities of work involving material for which test reports required under Sections 153 or 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). Provide an original signature on the certification. Facsimiles are not acceptable.

(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.

(8) Adjustments to the proposed total payment that relate to the quantity and quality of individual items of work. Adjustments for the following may be made by the Government after validation of the invoice:

(a) Retent resulting from a failure to maintain acceptable progress;

(b) Retent resulting from violations of the labor provisions;

(c) Retent pending completion of incomplete work, other *"no pay"* work, and verification of final quantities;

(d) Obligations to the Government such as excess testing cost or the cost of corrective work pursuant to FAR Clause 52.246-12(g); or

(e) Liquidated damages for failure to complete work on time.

(d) Government's receiving report. The Government's receiving report will be developed using the measurement notes received by the CO and determined acceptable. Within 7 days after the closing date, the CO will be available by appointment at the Government's designated billing office to advise the Contractor of quantities and unit prices appearing on the Government's receiving report.

(e) Processing progress payment requests. No payment will be made for work unless field note documentation for the work was provided by the closing date.

(1) Proper invoices. If the invoice meets the requirements of Subsection 109.08(c), 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(c), 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 is defective, and the Contractor will be notified according to FAR Clause 52.232-27(a)(2). Defective invoices will be returned to the Contractor within 7 days after receipt by the Government's designated billing office. Correct and resubmit returned invoices. If the defects are minor, the Contractor may elect, in writing, to accept the quantities and unit 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, provided the material meets the requirements of the contract and is delivered on, or in the vicinity of, the project site or stored in acceptable storage places.

Partial payment for material does not constitute acceptance of such material for use in completing items of work. Partial payments will not be made for living or perishable material until incorporated into the project.

Partial payments for 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.

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

Upon final acceptance and verification of final pay records, the Government will send, by certified mail, a final voucher (SF 1034) 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 shall constitute and be deemed execution of the documents and the release of all 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 all work necessary before beginning work at the project site. Mobilization includes the obtaining of permits, insurance, and bonds.

Measurement

151.02 Measure mobilization according to Subsection 109.02.

Payment

151.03 The accepted quantity, measured as provided in Subsection 109.02, will be paid at the contract price per unit of measurement for the Section 151 pay item shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

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

> **(a)** Bond premiums will be reimbursed according to FAR Clause 52.232-5 Payments Under Fixed-Price Construction Contracts, after receipt of the evidence of payment.
>
> **(b)** When 5 percent of the original contract amount is earned from other bid items, 50 percent of the mobilization item, or 5 percent of the original contract amount, whichever is less, will be paid.
>
> **(c)** When 10 percent of the original contract amount is earned from other bid items, 100 percent of the mobilization item, or 10 percent of the original contract amount, whichever is less, will be paid.
>
> **(d)** Any portion of the mobilization item in excess of 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 furnishing qualified personnel and necessary equipment and material to survey, stake, calculate, and record data for the control of work. See FAR Clause 52.236-17 Layout of Work.

Personnel, equipment, and material shall conform to the following:

> **(a) Personnel.** Furnish technically qualified survey crews experienced in highway construction survey and staking. Provide personnel capable of performing in a timely and accurate manner. An acceptable crew supervisor shall be on the project whenever surveying/staking is in progress.
>
> **(b) Equipment.** Furnish survey instruments and supporting equipment capable of achieving the specified tolerances.
>
> **(c) Material.** Furnish acceptable tools, supplies, and stakes of the type and quality normally used in highway survey work and suitable for the intended use. Furnish stakes and hubs of sufficient length to provide a solid set in the ground with sufficient surface area above ground for necessary legible markings.

Construction Requirements

152.02 General. Include staking activities in the construction schedule submitted according to Section 155. Include the dates and sequence of each staking activity. The Government will set initial reference lines, will set horizontal and vertical control points, and will furnish the data for use in establishing control for completion of each element of the work. Data relating to horizontal and vertical alignment, theoretical slope stake catch points, and other design data will be furnished.

Before beginning construction, notify the CO of any missing initial reference lines, control points, or stakes. The Government will reestablish initial reference lines, control points, and stakes missing before the beginning of construction.

Perform additional calculations for convenient use of Government-furnished data. Provide immediate notification of apparent errors in the initial staking or in the furnished data.

Preserve all initial reference and control points. After beginning construction, replace all destroyed or disturbed initial reference or control points necessary to the work.

Before surveying or staking, discuss and coordinate the following with the CO:

(a) Surveying and staking methods;

(b) Stake marking;

(c) Grade control for courses of material;

(d) Referencing;

(e) Structure control; and

(f) Any other procedures and controls necessary for the work.

Survey and establish controls within the tolerances shown in Table 152-1.

Prepare field notes in an approved format. Furnish all survey notes at least weekly. All field notes and supporting documentation become the property of the Government upon completion of the work.

Start work only after staking for the affected work is accepted.

The construction survey and staking work may be spot-checked for accuracy, and unacceptable portions of work may be rejected. Resurvey rejected work, and correct work that is not within the tolerances specified in Table 152-1. Acceptance of the construction staking does not relieve the Contractor of responsibility for correcting errors discovered during the work and for bearing all additional costs associated with the error.

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

152.03 Survey and Staking Requirements. Perform all survey, staking, recording of data, and calculations as necessary to construct the project from the initial layout to final completion. Reset stakes as many times as necessary to construct the work.

(a) Control points. Relocate initial horizontal and vertical control points in conflict with construction to areas that will not be disturbed by construction operations. Furnish the coordinates and elevations for the relocated points before the initial points are disturbed.

(b) Roadway cross-sections. Take roadway cross-sections normal to centerline. When the centerline curve radius is less than or equal to 500 feet, take cross-sections at a maximum centerline spacing of 25 feet. When the centerline curve radius is greater than 500 feet, take cross-sections at a maximum centerline spacing of 50 feet. Take additional cross-sections at significant breaks in topography and at changes in the typical section. Along each cross-section, measure and record points at breaks in topography, but no further apart than 20 feet. Measure and record points to at least the anticipated slope stake and reference locations. Reduce all cross-section distances to horizontal distances from centerline.

(c) Slope stakes and references. Set slope stakes and references on both sides of centerline at the cross-section locations. Establish slope stakes in the field as the actual point of intersection of the design roadway slope with the natural ground line. Set slope stake references outside the clearing limits. Include all reference point and slope stake information on the reference stakes. When initial references are provided, slope stakes may be set from these points with verification of the slope stake location with field measurements. Recatch slope stakes on any section that does not match the staking report within the tolerances established in Table 152-1. Take roadway cross-section data between centerline and the new slope stake location. Set additional references even when initial references are provided.

(d) Clearing and grubbing limits. Set clearing and grubbing limits on both sides of centerline at roadway cross-section locations.

(e) Centerline reestablishment. Reestablish centerline from instrument control points. The maximum spacing between centerline points is 25 feet when the centerline curve radius is less than or equal to 500 feet. When the centerline curve radius is greater than 500 feet, the maximum distance between centerline points is 50 feet.

(f) Grade finishing stakes. Set grade finishing stakes, for grade elevations and horizontal alignment, on centerline and on each shoulder at roadway cross-section locations. Set stakes at the top of subgrade and the top of each aggregate course.

Where turnouts are constructed, set stakes on centerline, on each normal shoulder, and on the shoulder of the turnout. In parking areas, set hubs at the center and along the edges of the parking area. Set stakes in all ditches to be paved.

The maximum longitudinal spacing between stakes is 25 feet when the centerline curve radius is less than or equal to 500 feet. When the centerline curve radius is greater than 500 feet, the maximum longitudinal spacing between stakes is 50 feet. The maximum transverse spacing between stakes is 20 feet. Use brushes or guard stakes at each stake.

(g) Culverts. Stake culverts to fit field conditions. The location of culverts may differ from the plans. Perform the following:

(1) Survey and record the ground profile along the culvert centerline.

(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, the flow line, the roadway section, and the culvert including end treatments and other appurtenances. Show elevations, grade, culvert length, and degree of elbow.

(5) Submit the plotted field-design cross-section for approval of final culvert length and alignment.

(6) When the field design has been approved, set drainage structure survey stakes, reference stakes, and stake inlet and outlet ditches to make the structure functional.

(7) Stake or grade ditches to make the culvert functional.

(h) Bridges. Set adequate horizontal and vertical control and reference points for all bridge substructure and superstructure components. Establish and reference the bridge chord or the bridge tangent. Also establish and reference the centerline of each pier, bent, and abutment.

(i) Retaining walls. Survey and record profile measurements along the face of the proposed wall and 5 feet in front of the wall face. Every 25 feet along the length of the wall and at all major breaks in terrain take cross-sections within the limits designated by the CO. For each cross-section, measure and record points every 25 feet and at all major breaks in terrain. Set adequate references and horizontal and vertical control points.

(j) Borrow and waste sites. Perform the work essential for initial layout and measurement of the borrow or waste site. Establish a referenced baseline, site limits, and clearing limits. Survey and record initial and final cross-sections.

(k) Permanent monuments and markers. Perform all survey and staking necessary to establish permanent monuments and markers. Set permanent monuments according to Section 621.

(l) Miscellaneous survey and staking. Perform all surveying, staking, and recording of data essential for establishing the layout and control of the following, as applicable:

(1) Approach roads and trails;

(2) Curb and gutter;

(3) Guardrail;

(4) Parking areas;

(5) Paved waterways;

(6) Special ditches;

(7) Turf establishment;

(8) Utilities;

(9) Signs, delineators, and object markers; and

(10) Pavement markings.

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

Staking Phase	Horizontal	Vertical
Existing Government network control points	±0.06 feet	±0.035 feet × $\sqrt{M}$ [2]
Local supplemental control points set from existing Government network points	±0.03 feet	±0.01 feet × $\sqrt{N}$ [3]
Centerline points [4] — (PC), (PT), (POT), and (POC) including references	±0.03 feet	±0.03 feet
Other centerline points	±0.16 feet	±0.16 feet
Cross-section points and slope stakes [5]	±0.16 feet	±0.16 feet
Slope stake references [5]	±0.16 feet	±0.16 feet
Culverts, ditches, and minor drainage structures	±0.16 feet	±0.06 feet
Retaining walls and curb and gutter	±0.06 feet	±0.03 feet
Bridge substructures	±0.03 feet [6]	±0.03 feet
Bridge superstructures	±0.03 feet [6]	±0.03 feet
Clearing and grubbing limits	±2.00 feet	—
Roadway subgrade finish stakes [7]	±0.16 feet	±0.03 feet
Roadway finish grade stakes [7]	±0.16 feet	±0.03 feet

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

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

Measurement

152.05 Measure the Section 152 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure grade finishing stakes one time for the subgrade and one time for each aggregate course.

Do not measure resetting stakes.

For miscellaneous survey and staking paid by the hour, the minimum survey crew size is 2 persons. Do not measure time spent in making preparations, traveling to and from the project site, performing calculations, plotting cross-sections and other data, processing computer data, and other efforts necessary to successfully accomplish construction survey and staking.

Payment

152.06 The accepted quantities, as provided above, 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.

Payment for lump sum items will be prorated based on the total work completed.

Section 153. — CONTRACTOR QUALITY CONTROL

Description

153.01 This work consists of obtaining samples for Contractor quality control testing, performing tests for Contractor quality control, providing inspection, and exercising management control to ensure that work conforms to the contract requirements. See FAR Clause 52.246-12 Inspection of Construction.

Construction Requirements

153.02 Contractor Quality Control Plan. Before the start of the work, submit a written quality control plan for acceptance. With prior approval, submission of a quality control plan for items of work not immediately scheduled to begin may be deferred.

Submit the following with the quality control plan:

(a) Process control testing. List the material to be tested by pay item, tests to be conducted, the location of sampling, and the frequency of testing.

(b) Inspection/control procedures. Address each of the following subjects in each phase of construction:

(1) Preparatory phase.

(a) Review all contract requirements.

(b) Ensure compliance of component material to the contract requirements.

(c) Coordinate all submittals including certifications.

(d) Ensure capability of equipment and personnel to comply with the contract requirements.

(e) Ensure preliminary testing is accomplished.

(f) Coordinate surveying and staking of the work.

(2) Start-up phase.

(a) Review the contract requirements with personnel performing the work.

(b) Inspect start-up of work.

(c) Establish standards of workmanship.

(d) Provide training as necessary.

(e) Establish detailed testing schedule based on the production schedule.

(3) Production phase.

(a) Conduct intermittent or continuous inspection during construction to identify and correct deficiencies.

(b) Inspect completed work before requesting Government inspection acceptance.

(c) Provide feedback and system changes to prevent repeated deficiencies.

(c) Description of records. List the records to be maintained.

(d) Personnel qualifications.

(1) Document the name, authority, relevant experience, and qualifications of person with overall responsibility for the inspection system.

(2) Document the names, authority, and relevant experience of all personnel directly responsible for inspection and testing.

(e) Subcontractors. Include the work of all subcontractors. If a subcontractor is to perform work under this Section, detail how that subcontractor will interface with the Contractor's and other subcontractor's organizations.

Modifications or additions may be required to any part of the plan that is not adequately covered. Acceptance of the quality control plan will be based on the inclusion of the required information. Acceptance does not imply any warranty by the Government that the plan will result in consistent contract compliance. It remains the responsibility of the Contractor to demonstrate such compliance.

Do not begin the work until the quality control plan covering that work is accepted.

Supplement the plan as work progresses and whenever quality control or quality control personnel changes are made.

153.03 Testing. Perform testing according to the accepted quality control plan. Keep laboratory facilities clean and maintain all equipment in proper working condition. Allow unrestricted access for inspection and review of the facility.

153.04 Records. Maintain complete testing and inspection records by pay item number and make them accessible to the CO.

For each day of work, prepare an *"Inspector's Daily Record of Construction Operations"* (Form FHWA 1413) or an approved alternate form. Detail inspection results including deficiencies observed and corrective actions taken. Include the following certification signed by the person with overall responsibility for the inspection system:

> "It is hereby certified that the information contained in this record is accurate and that all work documented herein complies with the requirements of the contract. Any exceptions to this certification are documented as a part of this record."

Submit the record and certification within one working day of the work being performed. If the record is incomplete, in error, or otherwise misleading, a copy of the record will be returned with corrections noted. When chronic errors or omissions occur, correct the procedures by which the records are produced.

Maintain linear control charts that identify the project number, pay item number, test number, each test parameter, the upper and lower specification limit applicable to each test parameter, and the test results. Use the control charts as part of the quality control system to document the variability of the process, to identify production and equipment problems, and to identify potential pay factor adjustments.

Post control charts in an accessible location and keep them up-to-date. Cease production and make corrections to the process when problems are evident.

153.05 Acceptance. The Contractor's quality control system will be evaluated under Subsection 106.02 based on the demonstrated ability of the quality control system to result in work meeting the contract requirements.

If the Government's testing and inspection indicate that the Contractor's quality control system is ineffective, make immediate improvements to the system to correct these inadequacies. Furnish notification in writing of improvements and modifications to the system.

Measurement and Payment

153.06 Do not measure Contractor quality control for payment.

Section 154. — CONTRACTOR SAMPLING AND TESTING

Description

154.01 This work consists of obtaining samples for testing. When there is a contract pay item for Contractor testing included in the bid schedule, it also consists of testing and reporting required test results. It does not include Contractor quality control testing required under Section 153. However, include the work required under this Section in the Section 153 quality control plan.

Construction Requirements

154.02 Sampling. Sample material to be tested according to the Sampling and Testing Requirements tables included at the end of each section. The sampling schedules and times will be provided by the CO using a random number system. In addition, sample any material that appears defective or inconsistent with similar material being produced unless such material is voluntarily removed and replaced or corrected.

Sample and split samples according to AASHTO or other acceptable procedures. Allow the CO the opportunity to witness all sampling. Immediately perform splits when required. Deliver the Government's portion of the sample or split sample in an acceptable container suitable for shipment. Label all samples with the following information:

(a) Project number;

(b) Source of material;

(c) Pay item number;

(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.

154.03 Testing. When there is a contract pay item for Contractor testing included in the bid schedule, perform all tests required by the Sampling and Testing Requirements tables at the end of each section. Allow the CO the opportunity to witness all testing. Testing of trial samples may be required to demonstrate testing competence.

154.04 Records. Report test results on forms containing all sample information required by Subsection 154.02. Label clearly all interim measurements used to determine the results. Attach work sheets used to determine test values to the test result forms when submitted. When tests are on material being incorporated in the work, report test results within 24 hours except as specified in the Sampling and Testing Requirements tables. Payment for work may be delayed or the work suspended until test results are provided.

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

Measurement

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

Payment

154.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 154 pay item 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 will be paid as follows:

> **(a)** 25 percent of the item amount, not to exceed 0.5 percent of the original contract amount, will be paid after all the testing facilities are in place, qualified sampling and testing personnel are identified, and the work being tested has started.
>
> **(b)** Payment for the remaining portion of the item amount will be prorated based on the total work completed.

Payment for all or part of this item may be retained if Government verification testing invalidates the Contractor testing.

Section 155. — SCHEDULES FOR CONSTRUCTION CONTRACTS

Description

155.01 This work consists of scheduling and monitoring all construction activities. See FAR Clause 52.236-15 Schedules for Construction Contracts.

Construction Requirements

155.02 General. Submit 3 copies of a preliminary construction schedule at least 7 days before the preconstruction conference.

A preliminary construction schedule is a written narrative with a detailed breakdown of all contract activities for the first 45 days after the notice to proceed is issued. Within 7 days after the preconstruction conference, the preliminary construction schedule will be accepted or rejected. If rejected, submit a revised schedule within 3 days. Do not begin work, except mobilization, traffic control, and Section 637 work, without an accepted preliminary construction schedule.

Use either the Bar Chart Method (BCM) or the Critical Path Method (CPM) described below to develop the construction schedule for the total contract work. Preface each construction schedule as follows:

(a) Project name;

(b) Contract number;

(c) Contractor;

(d) Original contract time allowed or completion date;

(e) Type of construction schedule (initial or update);

(f) Effective date of the schedule;

(g) Percent work complete; and

(h) Percent time used.

Submit 3 copies of the construction schedule within 30 days after the notice to proceed is issued. Allow 14 days for acceptance or rejection of the construction schedule or a revised schedule. If rejected, submit a revised schedule within 7 days. No progress payment will be made for any work until a construction schedule is submitted to the CO and accepted by the CO.

Do not show conflicts with any scheduled activities, limits on operations, order of work requirements, interim or final completion dates, or other contract restrictions.

Show completion of the work within the contract time.

155.03 Bar Chart Method (BCM). The BCM construction schedule consists of a progress bar chart and a written narrative.

(a) Progress bar chart. The following applies to the initial submission and all updates:

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

(2) Define and relate activities to the contract pay items.

(3) Show all activities in the order the work is to be performed including submittals, submittal reviews, fabrication, and delivery.

(4) Show all critical (major) activities that are controlling factors in the completion of the work.

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

(6) Show the total expected time to complete all work.

(7) Provide enough space for each activity to permit 2 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.

(b) Written narrative. Furnish a written narrative of the activities displayed in the progress bar chart.

155.04 Critical Path Method (CPM). The CPM construction schedule consists of a diagram, a tabulated schedule, and a written narrative.

(a) Diagram. Use the *"activity-on-arrow"* format for the arrow diagrams or the *"activity-on-node"* format for precedence diagrams. The following applies to the initial submission and all updates:

(1) Use a time scale to graphically show the percent of work scheduled for completion by any given date during the contract time.

(2) Define and relate activities to the contract pay items.

(3) Show the sequence and interdependence of all activities including submittals, submittal reviews, fabrication, and deliveries.

(4) Show all activity nodes, activity descriptions, and durations.

(5) Show all network dummies (for arrow diagrams only).

(6) Identify the critical path.

(b) Tabulated schedule. The following requirements apply to the tabulated schedule:

(1) For arrow diagrams, show activity beginning and ending node numbers. For precedence diagrams, list activities and show lead or lag times.

(2) Show activity durations.

(3) Show activity descriptions.

(4) Show early start and finish dates.

(5) Show late start and finish dates.

(6) Show status (critical or not).

(7) Show total float.

(c) Written narrative. Furnish a written narrative of the activities displayed in the schedule diagram.

155.05 Written Narrative. The following applies to the written narrative:

(a) Estimate starting and completion 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 by pay item quantities (e.g., cubic yards of excavation per day/week).

(e) Describe work days per week, holidays, number of shifts per day, and number of hours per shift.

(f) Estimate any periods during which an activity is idle or partially idle. Show the beginning and end dates for reduced production or idle time.

(g) Describe expected and critical delivery dates for equipment or material that can affect timely completion of the project.

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

(i) Identify the vendor, supplier, or subcontractor to perform the activity. State all assumptions made in the scheduling of the subcontractor's or supplier's work.

155.06 Schedule Updates. Review the construction schedule to verify finish dates of completed activities, remaining duration of uncompleted activities, any proposed logic, and time estimate revisions. Keep the CO informed of the current construction schedule and all logic changes.

Submit 3 copies of an updated construction schedule for acceptance at least every 8 weeks or when:

(a) A delay occurs in the completion of a critical (major) activity;

(b) A delay occurs which causes a change in the critical path for CPM schedules or a change in a critical activity for BCM schedules;

(c) The actual prosecution of the work is different from that represented on the current construction schedule;

(d) There is an addition, deletion, or revision of activities caused by a contract modification; or

(e) There is a change in the schedule logic.

Allow 7 days after receipt for acceptance of the updated construction schedule or a return for revisions.

No progress payment will be made for any work until an updated construction schedule has been submitted to, and accepted by, the CO.

155.07 Acceptance. Construction schedules will be evaluated under Subsection 106.02.

Measurement

155.08 Measure the Section 155 items listed in the bid schedule according to Subsection 109.02.

Payment

155.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 155 pay item 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 will be paid as follows:

(a) 25 percent of the item amount, not to exceed one percent of the original contract amount, will be paid after the construction schedule is accepted.

(b) Payment of the remaining portion of the lump sum will be prorated based on the total work completed.

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.

Material

156.02 Conform to the following Section:

Temporary traffic control	635

Construction Requirements

156.03 Accommodating Traffic During Work. Accommodate traffic according to the contract traffic control plan, MUTCD, Section 635, and this Section. The Contractor may submit an alternate traffic control proposal. Submit alternate traffic control proposals according to Subsection 104.03 for acceptance at least 30 days before intended use.

Perform work in a manner that ensures the safety and convenience of the public and protects 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 106.07(b).

156.04 Maintaining Roadways During Work. Perform roadway maintenance as follows:

(a) Construct and remove diversion roads and bridges as required by the traffic control plan.

(b) Maintain intersections with trails, roads, streets, businesses, parking lots, residences, garages, farms, and other features.

(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 will be performed at the maintaining agency's discretion. Allow the maintaining agency access to perform snow removal.

(d) Maintain a dust-free traveled way such that visibility and air quality are not affected and a hazardous condition is not created.

(e) Remove accumulations of soil and other material from traveled way.

(f) Maintain the roadway, detours, and 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 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 all 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, restrict operations as follows:

(a) Operate equipment in the direction of traffic, where practical.

(b) For shoulder drop-offs in excess of 2 inches, provide *"Low Shoulder"* warning signs. For shoulder drop-offs in excess of 4 inches, provide a 1V:3H fillet with *"Low Shoulder"* warning signs. Complete the construction of shoulders adjacent to traffic lanes to the same elevation within 14 days.

(c) Provide minimum lane widths of 10 feet. Use barricades, drums, or other acceptable devices to delineate traffic lanes through areas where the edge of pavement or intended path has been obliterated by construction operations.

(d) Locate staging areas at least 30 feet from the traveled way or behind acceptable traffic barriers. Obtain approval of the location and access to staging areas. Store unused traffic control devices at staging areas.

(e) Park equipment at least 30 feet from the traveled way or behind acceptable traffic barriers.

(f) Provide parking areas for employees' personal vehicles in approved areas.

(g) Provide two-way radio communications between flaggers and also between flaggers and pilot cars unless flaggers are able to see each other and communicate. Citizen band radios are not acceptable. Make radio equipment available to the CO as necessary.

(h) Where switching traffic to a completed lane, provide adequate personnel and equipment to set or relocate traffic control devices.

(i) Limit construction-caused delays to public traffic to a maximum of 30 minutes per passage through the project.

(j) 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 to minimize risk to the public.

156.07 Nighttime Operations. Perform construction operations during the hours of daylight (½ hour after sunrise to ½ hour before sunset).

Where night operations are permitted, submit a night lighting system for approval. Include the light types, locations, and the manner in which the lights will be moved. Submit the proposed system at least 14 days before use. Use an independent source other than vehicle headlights. Do not use incandescent lights. Furnish 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. Provide lighting at each flagger location. Equip all vehicles with an exterior flashing yellow dome light.

156.08 Traffic and Safety Supervisor. Provide a traffic and safety supervisor who is certified by a State highway agency or other acceptable certification program. Do not designate the superintendent as the traffic safety supervisor. Furnish the traffic safety supervisor's name, address, and 24-hour telephone number(s) at the preconstruction conference. At all times during the contract, including periods of suspensions and work stoppages, perform all of the following:

(a) Implement the traffic control plans.

(b) Coordinate traffic control operations, including 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 traffic control maintenance operations with the CO.

(f) Ensure unused traffic control devices are properly handled and stored.

(g) Conduct weekly traffic safety meetings for construction workers, and invite the CO to these weekly meetings.

(h) Furnish 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, all changes or corrective actions taken to ensure the safe passage of public traffic through the project.

156.09 Acceptance. Public traffic work will be evaluated under Subsection 106.02.

Traffic control devices and services will be evaluated under Section 635.

Measurement and Payment

156.10 See Subsection 109.05.

Measure traffic control under Section 635.

Measure dust abatement under Section 158 or 306.

Measure diversion construction, required by the contract, under the applicable Sections.

Section 157. — SOIL EROSION CONTROL

Description

157.01 This work consists of furnishing, constructing, and maintaining permanent and temporary erosion and sediment control measures.

Material

157.02 Conform to the following Subsections:

Backfill material	704.03
Erosion control bales, wattles, logs, and rolls	713.13
Erosion control culvert pipe	713.15
Fertilizer	713.03
Geotextile	714.01
Mulch	713.05
Plastic lining	725.19
Riprap	251.02
Sandbags	713.14
Seed	713.04
Silt fence	713.16
Water	725.01

Construction Requirements

157.03 General. Provide permanent and temporary erosion control measures to minimize erosion and sedimentation during and after construction according to the contract erosion control plan, contract permits, Section 107, and this Section. Contract permits amend the requirements of this Section. Do not modify the type, size, or location of any control or practice without approval.

The contract erosion control plan reflects special concerns and measures to protect resources. An alternate erosion control proposal, with all necessary permits, may be submitted for acceptance according to Subsection 104.03. Submit alternate erosion control proposals at least 30 days before their intended use.

When erosion control measures are not functioning as intended, immediately take corrective action.

157.04 Controls and Limitations on Work. Before grubbing and grading, construct all erosion controls around the perimeter of the project including filter barriers, diversion, and settling structures.

Limit the combined grubbing and grading operations area to 350,000 square feet of exposed soil at one time.

Construct erosion control and sediment control measures as follows:

(a) Construct temporary erosion controls in incremental stages as construction proceeds.

(b) Construct temporary slope drains, diversion channels, and earth berms to protect disturbed areas and slopes.

(c) Unless a specific seeding season is identified in the contract, apply permanent turf establishment to the finished slopes and ditches within 14 days according to Sections 624 and 625.

(d) Apply temporary turf establishment, mulch, or other approved measures on disturbed areas within 14 days after the last disturbance except where:

(1) The area will be disturbed within 21 days after last disturbance.

(2) When initial stabilization is precluded by snow cover or by seasonal arid conditions in arid or semi-arid areas (average annual rainfall of 20 inches or less).

(e) Construct outlet protection as soon as culverts or other structures are complete.

(f) Construct permanent erosion controls including waterway linings and slope treatments as soon as practical or upon completion of the roadbed.

(g) Construct and maintain erosion controls on and around soil stockpiles to prevent soil loss.

(h) Following each day's grading operations, shape earthwork to minimize and control erosion from storm runoff.

157.05 Filter Barriers. Construct silt fence, bales, wattles, logs, rolls, and brush barriers for filtering sediment from runoff and reducing the velocity of sheet flow. Conserve brush from clearing operations to construct brush barriers.

157.06 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.

157.07 Outlet Protection. Construct riprap aprons or basins to reduce water velocity and prevent scour at the outlet of permanent and temporary erosion control measures. Construct riprap according to Section 251.

157.08 Water Crossings. Construct temporary culvert pipe at temporary crossings where construction vehicles cross a live waterway.

157.09 Diversions. Construct temporary channels, temporary culverts, earth berms, or sandbags to divert water around disturbed areas and slopes. Use temporary channels, temporary culverts, pumps, sandbags, or other methods to divert the flow of live streams for permanent culvert installations and other work. Stabilize channels according to Subsection 157.10. Provide outlet protection.

157.10 Waterway and Slope Protection and Stabilization. Use plastic lining, riprap, check dams, erosion control blankets and mats, and temporary slope drains as follows:

(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. Lap transverse joints a minimum of 36 inches in the direction of flow. Do not use longitudinal joints. Anchor the lining in place using riprap.

(b) Riprap. Construct riprap for channel lining according to Section 251.

(c) Check dams. Construct riprap, sandbags, or earth berms for temporary dams to reduce the velocity of runoff in ditches and swales.

(d) Rolled erosion control products. Use rolled erosion control products to stabilize waterways and slopes before or after temporary or permanent seeding. Install according to Section 629.

(e) Temporary slope drains. Use drainpipe, riprap, or plastic lined waterway for temporary slope drains to channel runoff down slopes. Channel water into the slope drain with an earth berm constructed at the top of a cut or fill. Anchor slope drains to the slope. Provide outlet protection.

157.11 Temporary Turf Establishment. Apply seed, fertilizer, 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	35
Fertilizer	335
Mulch	1350

157.12 Inspection and Reporting. Inspect all erosion control facilities at least every 7 days, within 24 hours after more than 3/8 inch of rain in a 24-hour period, and as required by the contract permits.

Within 24 hours, furnish inspection reports to the CO which include all of the following:

(a) Summary of the inspection;

(b) Names of personnel making the inspection;

(c) Date and time of inspection;

(d) Observations made; and

(e) Corrective action necessary, action taken, and date and time of action.

157.13 Maintenance and Cleanup. Maintain temporary erosion control measures in working condition until the project is complete or the measures are no longer needed. Clean erosion control measures when half full of sediment. Use the sediment in the work, if acceptable, or dispose of it according to Subsection 204.14.

Replace erosion control measures that cannot be maintained and those that are damaged by construction operations.

Remove and dispose of temporary erosion control measures when the vegetation is satisfactorily established and drainage ditches and channels are lined and stabilized. Remove and dispose of erosion control measures according to Subsection 203.05.

Restore the ground to its natural or intended condition and provide permanent erosion control measures.

157.14 Acceptance. Material for soil erosion control measures will be evaluated under Subsections 106.02 and 106.03.

Construction, maintenance, and removal of soil erosion control measures will be evaluated under Subsections 106.02 and 106.04.

Geotextile will be evaluated under Section 207.

Measurement

157.15 Measure the Section 157 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Do not measure replacement items.

Measure temporary turf establishment by the acre on the ground surface. When measurement is by the pound, weigh the seed in pounds.

Measure excavation for diversion channels and sediment basins under Section 204.

Measure riprap under Section 251.

Measure permanent paved waterways under Section 608.

Measure permanent slope paving under Section 616.

Measure topsoil under Section 624.

Measure permanent turf establishment under Section 625.

Measure rolled erosion control products under Section 629.

Payment

157.16 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 made as follows:

(a) 50 percent of the unit bid price will be paid upon installation.

(b) An additional 25 percent of the unit bid price will be paid following completion of 50 percent of the contract amount.

(c) Payment of the remaining portion of the unit bid price will be paid when the temporary erosion control measures are removed from the project.

Section 158. — WATERING FOR DUST CONTROL

Description

158.01 This work consists of furnishing and applying water for the control of dust caused by the work and public travel.

Material

158.02 Conform to the following Subsection:

Water	725.01

Construction Requirements

158.03 General. Provide an adequate water supply and apply water needed at all hours (including nights, weekends, and periods of nonwork) as necessary to control dust. Uniformly apply water using pressure-type distributors, pipelines equipped with spray systems, or hoses with nozzles.

(a) Project dust control for public benefit. Control dust within the construction limits at all hours when the project is open to public traffic. When the project is not open to public traffic, control dust in areas of the project which neighbor inhabited residences or places of business. Control dust on approved, active detours established for the project. Apply water at the locations, rates, and frequencies ordered by the CO.

(b) Other dust control. Control dust on active haul roads, in pits and staging areas, and on the project during all periods not covered in (a) above.

158.04 Acceptance. Furnishing and placing water will be evaluated under Subsection 106.02.

Measurement

158.05 Measure the Section 158 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure water for dust control by the cubic yard 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 item 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 on the plans.

Material

201.02 Conform to the following Subsections:

Backfill material	704.03
Tree wound dressing	713.08(g)

Construction Requirements

201.03 General. Construct erosion control measures according to Section 157. Perform work within designated limits. Do not damage vegetation designated to remain. If vegetation designated to remain is damaged or destroyed, repair or replace the vegetation in an acceptable manner. Where possible, preserve all vegetation adjacent to bodies of water. Treat cuts or scarred surfaces of trees and shrubs with tree wound dressing.

201.04 Clearing. Within the clearing limits, clear trees, brush, downed timber, and other vegetation as follows:

(a) Cut all trees so they fall within the clearing limits.

(b) In areas of cut slope rounding, cut stumps flush with or below the final groundline.

(c) In areas outside the excavation, embankment, and slope rounding limits, cut stumps to within 6 inches of the ground.

(d) Trim tree branches that extend over the road surface and shoulders to attain a clear height of 20 feet. If required, remove other branches to present a balanced appearance. Trim according to accepted tree surgery practices. Treat wounds with tree wound dressing.

201.05 Grubbing. Grub deep enough to remove stumps, roots, buried logs, moss, turf, or other vegetative debris as follows:

(a) Grub all areas to be excavated except for cut slope rounding areas.

(b) Grub all embankment areas. Undisturbed stumps may be left in place if they protrude less than 6 inches above the original ground and will be covered with more than 4 feet of embankment.

(c) Grub pits, channel changes, and ditches only to the depth necessary for the excavation.

(d) Backfill stump holes and other grubbing holes with backfill material to the level of the surrounding ground according to Subsection 209.10. Compact backfill according to Subsection 209.11.

201.06 Disposal. Merchantable timber is the Contractor's property. Dispose of clearing and grubbing debris according to Subsection 203.05.

201.07 Acceptance. Clearing and grubbing will be evaluated under Subsection 106.02.

Material for tree wound dressing will be evaluated under Subsection 106.03.

Backfilling and compacting of stumps and grubbing holes will be evaluated under Section 209.

Measurement

201.08 Measure the Section 201 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 identified in the contract.

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. It includes scalloping clearing lines, clearing vistas, thinning vegetation, special clearing and grubbing, and the removal of individual trees and stumps.

202.02 Definitions.

(a) Selective clearing. Clearing where some trees and vegetation is designated to remain.

(b) Selective clearing and grubbing. Clearing and grubbing where some trees and vegetation is 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 (a) through (c) above.

Construction Requirements

202.03 General. Clear and grub according to Section 201 except as modified herein. 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. Dispose of clearing and grubbing debris according to Subsection 203.05.

202.04 Selective Clearing. Clear and dispose of all trees, snags, brush, downed timber, and other vegetation designated to be removed.

202.05 Selective Clearing and Grubbing. Clear, grub, and dispose of all trees, snags, brush, downed timber, stumps, roots, buried logs, moss, turf, grass, and other vegetation designated to be removed.

202.06 Special Clearing and Grubbing. Clear, grub, and dispose of all trees, snags, brush, downed timber, stumps, roots, buried logs, moss, turf, grass, and other vegetation.

202.07 Removal of Individual Trees or Stumps. Remove and dispose of all designated trees or stumps.

202.08 Acceptance. Additional clearing and grubbing work will be evaluated under Subsection 106.02 and Section 201.

Measurement

202.09 Measure the Section 202 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure removal of individual trees based on the average diameter at the cutoff. Do not measure trees less than 6 inches in diameter at the cutoff.

Payment

202.10 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 salvaging, removing, and disposing of buildings, fences, structures, pavements, culverts, utilities, curbs, sidewalks, and other obstructions.

Material

203.02 Conform to the following Section and Subsection:

Backfill material	704.03
Concrete	601

Construction Requirements

203.03 Salvaging Material. Salvage, with reasonable care, all material designated to be salvaged. Salvage in readily transportable sections or pieces. Replace or repair all members, pins, nuts, plates, and related hardware damaged, lost, or destroyed during the salvage operation. Wire all loose parts to adjacent members or pack them in sturdy boxes with the contents clearly marked.

Match mark members of salvaged structures. Furnish one set of drawings identifying the members and their respective match marks.

Stockpile salvaged material at a designated area on the project.

203.04 Removing Material. Saw cut sidewalks, curbs, pavements, and structures when partial removal is required.

Construct structurally adequate debris shields to contain debris within the construction limits. Do not permit debris to enter waterways, travel lanes open to public traffic, or areas designated not to be disturbed.

Raze and remove all buildings, foundations, pavements, sidewalks, curbs, fences, structures, and other obstructions interfering with the work and not designated to remain.

Where part of an existing culvert is removed, remove the entire culvert upstream from the removal. The remaining downstream culvert may be left in place if no portion of the culvert is within 4 feet of the subgrade, embankment slope, or new culvert or structure; and the culvert ends are sealed with concrete.

Remove structures and obstructions in the roadbed to 3 feet below subgrade elevation. Remove structures and obstructions outside the roadbed to 2 feet below finished ground or to the natural stream bottom.

Abandon existing manholes, inlets, catch basins, and spring boxes according to Subsection 604.07.

Except in excavation areas, backfill and compact cavities left by structure removal with backfill material to the level of the finished ground. Backfill excavated areas according to Subsection 209.10. Compact backfill according to Subsection 209.11.

203.05 Disposing of Material. Dispose of debris and unsuitable and excess material as follows:

(a) Remove from project. Recycle or dispose of material legally off the project. Furnish a statement documenting the nature and quantity of material processed or sold for recycling. Otherwise, furnish a signed copy of the disposal agreement before disposal begins.

(b) Burn. Obtain necessary burning permits. Furnish a copy of the burning permits before burning begins.

Burn using high intensity burning processes that produce few emissions. Examples include incinerators, high stacking, or pit and ditch burning with forced air supplements. Provide a competent watchperson during the burning operations.

When burning is complete, extinguish the fire so no smoldering debris remains. Dispose of unburned material according to (a) above.

(c) Bury. Bury debris in trenches or pits in approved areas within the right-of-way. Do not bury debris inside the roadway prism limits, beneath drainage ditches, or in any areas subject to free-flowing water.

Place debris in alternating layers of 4 feet of debris covered with 2 feet of earth material. Distribute stumps, logs, and other large pieces to form a dense mass and minimize air voids. Cover the top layer of buried debris with at least 1 foot of compacted earth. Grade and shape the area. Seed and mulch disposal areas on Government property according to Section 625.

(d) Hazardous material. Furnish a copy of all disposal permits. Dispose of material according to Federal, State, and local regulations.

203.06 Acceptance. Removal of structures and obstructions will be evaluated under Subsection 106.02.

Backfilling and compacting cavities left by structures will be evaluated under Section 209.

Concrete will be evaluated under Section 601.

Measurement

203.07 Measure the Section 203 items listed in the bid schedule according to Subsection 109.02.

Payment

203.08 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 includes furnishing, 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. All material excavated from within the right-of-way or easement areas, except subexcavation covered in (2) below 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 groundline in embankment sections. Subexcavation does not include the work required by Subsections 204.05, 204.06(b), and 204.06(c).

(3) Borrow excavation. Material used for embankment construction that is obtained from outside the roadway prism. Borrow excavation includes unclassified borrow, select borrow, and select topping.

(b) Embankment construction. Embankment construction consists of placing and compacting roadway or borrow excavation. This work includes:

(1) Preparing foundation for embankment;

(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 and unsuitable roadway excavation and subexcavation that cannot be used.

Material

204.03 Conform to the following Subsections:

Backfill material	704.03
Select borrow	704.07
Select topping	704.08
Topping	704.05
Unclassified borrow	704.06
Water	725.01

Construction Requirements

204.04 Preparation for Roadway Excavation and Embankment Construction. Clear the area of vegetation and obstructions according to Sections 201 and 203.

204.05 Conserved Topsoil. Conserve topsoil from roadway excavation and embankment foundation areas. Stockpile conserved topsoil in low windrows immediately beyond the rounding limits of cut and embankment slopes or in other approved locations. Separate topsoil from other excavated material.

Place conserved topsoil on completed slopes according to Section 624.

204.06 Roadway Excavation. Excavate as follows:

(a) General. Do not disturb material and vegetation outside the construction limits.

Incorporate only suitable material into embankments. Replace any shortage of suitable material caused by premature disposal of roadway excavation. Dispose of unsuitable or excess excavation material according to Subsection 204.14.

At the end of each day's operations, shape to drain and compact the work area to a uniform cross-section. Eliminate all ruts and low spots that could hold water.

(b) Rock cuts. Blast rock according to Section 205. Excavate rock cuts to 6 inches below subgrade within the roadbed limits. Backfill to subgrade with topping or with other suitable material. Compact the material according to Subsection 204.11.

(c) Earth cuts. Scarify earth cuts to 6 inches below subgrade within the roadbed limits. Compact the scarified material according to Subsection 204.11.

204.07 Subexcavation. Excavate material to the limits designated by the CO. Take cross-sections according to Section 152. Prevent unsuitable material from becoming mixed with the backfill. Dispose of unsuitable material according to Subsection 204.14. Backfill the subexcavation with topping, or other suitable material. Compact the material according to Subsection 204.11.

204.08 Borrow Excavation. Use all suitable roadway excavation in embankment construction. Do not use borrow excavation when it results in excess roadway excavation. Deduct excess borrow excavation from the appropriate borrow excavation quantity.

Obtain borrow source acceptance according to Subsection 105.02. Develop and restore borrow sources according to Subsection 105.03. Do not excavate beyond the established limits. When applicable, shape the borrow source to permit accurate measurements when excavation is complete.

204.09 Preparing Foundation for Embankment Construction. Prepare foundation for embankment construction as follows:

(a) Embankment less than 4 feet high 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) Embankments 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 all 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 not capable of supporting equipment. Dump successive loads of embankment material in a uniformly distributed layer to construct the lower portion of the embankment. Limit the layer thickness to the minimum depth necessary to support the equipment.

(d) Embankment on an existing slope steeper than 1V:3H. Cut horizontal benches in the existing slope to a sufficient width to accommodate placement and compaction operations and equipment. Bench the slope as the embankment is placed and compacted in layers. Begin each bench at the intersection of the original ground and the vertical cut of the previous bench.

204.10 Embankment Construction. Incorporate only suitable roadway excavation material into the embankment. When the supply of suitable roadway excavation is exhausted, furnish unclassified borrow to complete the embankment. Construct embankments as follows:

(a) General. At the end of each day's operations, shape to drain and compact the embankment surface to a uniform cross-section. Eliminate all 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 layer 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.

Where placing embankment on one side of abutments, wing walls, piers, or culvert headwalls, compact the material using methods that prevent excessive pressure against the structure.

Where placing embankment material on both sides of a concrete wall or box structure, conduct operations so compacted embankment material is at the same elevation on both sides of the structure.

Where structural pilings are placed in embankment locations, limit the maximum particle size to 4 inches.

(b) Embankment within the roadway prism. Place embankment material in horizontal layers not exceeding 12 inches in compacted thickness. Incorporate oversize boulders or rock fragments into the 12-inch layers by reducing them in size or placing them individually as required by (c) below. Compact each layer according to Subsection 204.11 before placing the next layer.

Material composed predominately of boulders or rock fragments too large for 12-inch layers may be placed in layers up to 24 inches thick. Incorporate oversize boulders or rock fragments into the 24-inch layer by reducing them in size or placing them individually according to (c) below. Place sufficient earth and smaller rocks to fill the voids. Compact each layer according to Subsection 204.11 before placing the next layer.

(c) Individual rock fragments and boulders. Place 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 nesting.

(3) Place layers of embankment material around each rock to a depth not greater than that permitted by (b) above. Fill all the voids between rocks.

(4) Compact each layer according to Subsection 204.11 before placing the next layer.

(d) Embankment outside of roadway prism. Where placing embankment outside the staked roadway prism, place material in horizontal layers not exceeding 24 inches in compacted thickness. Compact each layer according to Subsection 204.11.

204.11 Compaction. For the purpose of compaction, use AASHTO T 27 to determine the amount of material retained on a No. 4 sieve. Compact as follows:

(a) More than 80 percent retained on a No. 4 sieve. Adjust the moisture content to a level suitable for compaction. Fill the interstices around rock with earth or other fine material as practical. Use compression-type rollers at speeds less than 6 feet per second and vibratory rollers at speeds less than 3 feet per second. Compact each layer of material full width with one of the following and until there is no visible evidence of further consolidation.

(1) Four roller passes of a vibratory roller having a minimum dynamic force of 40,000 pounds impact per vibration and a minimum frequency of 1000 vibrations per minute.

(2) Eight roller passes of a 20-ton compression-type roller.

(3) Eight roller passes of a vibratory roller having a minimum dynamic force of 30,000 pounds impact per vibration and a minimum frequency of 1000 vibrations per minute.

Increase the compactive effort for layers deeper than 12 inches as follows:

- For each additional 6 inches or fraction thereof, increase the number of roller passes in (1) above by four passes.
- For each additional 6 inches or fraction thereof, increase the number of roller passes in (2) and (3) above, by eight passes.

(b) 50 to 80 percent retained on a No. 4 sieve. 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. 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 rollers at speeds less than 6 feet per second and vibratory rollers at speeds less than 3 feet per second. Compact each layer of material full width according to (a) above.

(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.

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 layer 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. When required, use AASHTO T 224 to correct for coarse particles.

204.12 Ditches. Slope, grade, and shape ditches. Remove all projecting roots, stumps, rock, or similar matter. Maintain all ditches in an open condition and free from leaves, sticks, and other debris.

Form furrow ditches by plowing or using other acceptable methods to produce a continuous furrow. Place all 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, ditcher, 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 all earth slopes with uniform roughened surfaces, except as described in (b) below, with no noticeable break as viewed from the road. Except in solid rock, round tops and bottoms of all slopes including the slopes of drainage ditches. Round material overlaying solid rock to the extent practical. Scale all rock slopes.

If a slide or slipout occurs on a cut or embankment slope, remove or replace the material, and repair or restore all damage to the work. Bench or key the slope to stabilize the slide. Reshape the cut or embankment slope to an acceptable condition.

(b) Stepped slopes. Where required by the contract, construct steps on slopes of 1⅓V:1H to 1V:2H. Construct the steps approximately 18 inches high. Blend the steps into natural ground at the end of the cut. If the slope contains nonrippable rock outcrops, blend steps into the rock. Remove loose material found in transitional area. Except for removing large rocks that may fall, scaling stepped slopes is not required.

(c) 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.

(d) Finishing. Remove all 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 that are compacted according to Subsection 204.11(b) and (c) to within ±0.05 feet of the staked line and grade. Finish roadbeds that are compacted according to Subsection 204.11(a) to within ±0.10 feet of the staked line and grade. Finish ditch cross-sections to within ±0.10 feet of the staked line and grade. Maintain proper ditch drainage.

204.14 Disposal of Unsuitable or Excess Material. Dispose of unsuitable or excess material legally off the project.

When 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 and testing requirements.

Material for embankment and conserved topsoil will be evaluated under Subsections 106.02 and 106.04.

Excavation and embankment construction will be evaluated under Subsections 106.02 and 106.04.

Clearing and removal of obstructions will be evaluated under Sections 201 and 203.

Placing of conserved topsoil will be evaluated under Section 624.

Measurement

204.16 Measure the Section 204 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;

(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 shown in the bid schedule;

(d) Ditches, except furrow ditches measured under a separate bid item;

(e) Conserved topsoil;

(f) Borrow material used in the work when a pay item for borrow is not shown in the bid schedule;

(g) Loose scattered rocks removed and placed as required within the roadway;

(h) Conserved material taken from stockpiles and used in Section 204 work except topsoil measured under Section 624; and

(i) Slide and slipout 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 when stepping cut slopes;

(g) Material excavated when rounding cut slopes;

(h) Preparing foundations for embankment construction;

(i) Material excavated when benching for embankments;

(j) Slide or slipout material attributable to the Contractor's method of operation;

(k) Conserved material taken from stockpiles constructed at the option of the Contractor; and

(l) Material excavated outside the established slope limits.

(3) When both roadway excavation and embankment construction pay items are shown in the bid schedule, measure roadway excavation only for the following:

(a) Unsuitable material below subgrade in cuts and unsuitable material beneath embankment areas when a pay item for subexcavation is not shown in the bid schedule;

(b) Slide and slipout material not attributable to the Contractor’s method of operations; and

(c) Drainage ditches, channel changes, and diversion ditches.

(b) Unclassified borrow, select borrow, and select topping. When measuring by the cubic yard measure in its original position. If borrow excavation is measured by the cubic yard in place, take initial cross-sections of the ground surface after stripping overburden. Upon completion of excavation and after the borrow source waste material is returned to the source, retake cross-sections before replacing the overburden.

Do not measure borrow excavation used in place of excess roadway excavation.

(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 embankments;

(b) Material used to backfill subexcavated areas, 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; and

(c) Material used to round fill slopes.

(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 over burden. Upon completion of the waste placement, retake cross-sections before replacing overburden.

(f) Slope scaling. Measure slope scaling by the cubic yard in the hauling vehicle.

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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Topping (704.05)	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type	Processed material before incorporating in work	Yes, when requested	Before using in work
		Moisture-density	—	AASHTO T 180, method D(1) or T 99, method C(1)	1 per soil type but not less than 1 per 13,000 yd^3	"	"	"
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 6000 yd^2 but not less than 1 per layer	In-place	—	—
Select topping (704.08)	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type but not less than 1 for each day of production	Processed material before incorporating in work	Yes, when requested	Before using in work
		Gradation	—	AASHTO T 27 & T 11	"	"	"	"
		Liquid limit	—	AASHTO T 89	"	"	"	"
		Moisture-density	—	AASHTO T 180, method D(1) or T 99, method C(1)	1 per soil type but not less than 1 per 13,000 yd^3	"	"	"
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 6000 yd^2 but not less than 1 per layer	In-place	"	Before placing next layer

(1) Minimum of 5 points per proctor

Table 204-1 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Unclassified borrow (704.06)	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type	Processed material before incorporating in work	Yes, when requested	Before using in work
		Moisture-density	—	AASHTO T 180, method D(1) or T 99, method C(1)	1 per soil type but not less than 1 per 13,000 yd^3	“	“	“
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 but not less than 1 per layer	In-place	—	Before placing next layer
Select borrow (704.07)	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type but not less than 1 for each day of production	Processed material before incorporating in work	Yes, when requested	24 hours
		Gradation	—	AASHTO T 27 & T 11	“	“	“	“
		Liquid limit	—	AASHTO T 89	“	“	“	“
		Moisture-density	—	AASHTO T 180, method D(1) or T 99, method C(1)	1 per soil type but not less than 1 per 13,000 yd^3	“	“	“
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 but not less than 1 per layer	In-place	“	Before placing next layer

(1) Minimum of 5 points per proctor.

Table 204-1 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Earth embankment (204.11)	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type	Source of Material	Yes, when requested	Before using in work
		Moisture-density	—	AASHTO T 180, method D(1) or T 99, method C(1)	1 per soil type but not less than 1 per 13,000 yd^3	"	"	"
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 3500 yd^2 but not less than 1 per layer	In-place	—	Before placing next layer
Top of subgrade (204.11)	Measured and tested for conformance (106.04)	Compaction	—	AASHTO T 310 or other approved procedures	1 per 2500 yd^2	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Section 205. — ROCK BLASTING

Description

205.01 This work consists of fracturing rock and constructing stable final rock cut faces using controlled blasting and production blasting techniques.

Controlled blasting uses explosives to form a shear plane in the rock along a specified backslope. Controlled blasting includes presplitting and cushion blasting.

Production blasting uses explosives to fracture rock.

Material

205.02 Conform to the following Subsection:

Explosives and blasting accessories	725.25

Construction Requirements

205.03 Regulations. Furnish copies or other proof of all-applicable permits and licenses. Comply with Federal, State, and local regulations on the purchase, transportation, storage, and use of explosive material. Federal regulations include the following:

(a) Safety and health. OSHA, 29 CFR Part 1926, Subpart U.

(b) Storage, security, and accountability. Bureau of Alcohol, Tobacco, and Firearms (BATF), 27 CFR Part 181.

(c) Shipment. DOT, 49 CFR Parts 171-179, 390-397.

(d) National Park Service regulations. For projects in National Parks, also comply with NPS Director’s Order #65, Explosives Use and Blasting Safety.

205.04 Blaster-in-Charge. Designate in writing a blaster-in-charge. Submit evidence that the blaster-in-charge has a valid State blaster’s license or other license accepted by the State where the project is located and issued by an equivalent licensing body for the type of blasting required.

205.05 Blasting Plans. Blasting plans are for quality control and record keeping purposes and are to be signed by the blaster-in-charge. The review and acceptance of blasting plans does not relieve the Contractor of the responsibility for using existing drilling and blasting technology, and for obtaining the required results.

Do not deliver explosives to the project until the general blasting plan is accepted.

(a) General blasting plan. Submit a general blasting plan for acceptance at least 14 days before drilling operations begin. Include, as a minimum, the following safety and procedural details:

(1) Working procedures and safety precautions for storing, transporting, handling, and detonating explosives.

(2) Proposed product selection for both dry and wet holes. Furnish Manufacturer's Material Safety Data Sheets for all explosives, primers, initiators, and other blasting devices.

(3) Typical plan and section views for both production and controlled blasting, including maximum length of the shot, burden, hole spacing, hole inclination, hole depth, hole diameter, subdrill depth, and powder factor.

(4) Proposed initiation and delay methods and delay times.

(5) Proposed format for providing all the required information for the site specific blasting plans.

(b) Site-specific blasting plans. After the general blasting plan is accepted, submit site-specific blasting plans for acceptance before drilling operations begin. Allow up to three days for review of these plans. Include the following information in the site-specific blasting plan.

(1) Site drawings showing a scaled map of the blast area and cross-sectional views which indicate beginning and ending stations, free face location, hole spacing, hole diameter, hole depth, burden, hole inclination, and subdrill depth. Include on the drawings any significant joints or bedding planes within the blast zone and incorporate this geology into the blast design.

(2) Where blasting may affect nearby structures or utilities, provide method of monitoring and controlling blast vibrations according to Subsection 205.06.

(3) Loading pattern diagram showing the location and amount of each type of explosive to be used in the holes including primer and initiators and the location, type, and depth of stemming, column heights, and overall powder factor for each type of loading.

(4) Delay and initiation diagram showing delay pattern, sequence, and delay times.

205.06 Preblast condition survey and vibration monitoring and control. When blasting near buildings, structures, or utilities that may be subject to damage from ground or airblast vibrations, provide a blast vibration specialist. Provide a specialist with at least 5 consecutive years experience in vibration monitoring for at least 3 projects. Fourteen days before blasting, submit the name and qualifications of the blast vibration specialist including the following:

(a) Project names, locations, and services performed.

(b) Name and phone number of owner/agency contact who can verify the experience of the specialist.

Before blasting, arrange for a preblast condition survey of nearby buildings, structures, or utilities, which could be at risk from blasting damage. Use a survey method acceptable to the Contractor's insurance company. Damage resulting from blasting is the Contractor's responsibility. Make all preblast condition survey records available to the CO. Notify the CO and occupants of nearby buildings at least 24 hours before blasting.

Control vibrations with properly designed delay sequences and allowable charge weights per delay when blasting near buildings, structures, or utilities that may be subject to damage from blast-induced vibrations. Base allowable charge weights per delay by carrying out trial blasts and measuring vibration levels. Conduct test blasts with blast plan modifications that limit ground and airblast vibrations to a level that will not cause damage to nearby buildings, structures, or utilities as determined by the blast vibration specialist.

When vibration damage to buildings, structures, or utilities is possible, monitor each blast with approved seismographs and airblast monitoring equipment located at acceptable locations. Use seismographs capable of recording particle velocity for three mutually perpendicular components of vibration. The blast vibration specialist shall interpret the seismograph records and airblast records to ensure that the data is effectively used in the control of the blasting operations.

205.07 Test Blasting. Drill, blast, and excavate one or more test sections as proposed in the blasting plan before full-scale drilling and blasting. Test blasts may be made away from or at the final slope line.

Space blast holes for the cushion (trim) method of controlled blasting no more than 60 inches apart for the initial test blast. Space blast holes for the presplitting method of controlled blasting no more than 30 inches apart for the initial test blast. Adjust the spacing as approved. Use the approved spacing in the full-scale blasting or subsequent test blasts if necessary.

A test blast is unacceptable when it results in fragmentation beyond the final rock face, fly rock, excessive vibration, air blast, overbreak, damage to the final rock face, or overhang. When a test blast is unacceptable, revise the blasting plan and make an additional test blast.

205.08 Blasting.

(a) General. Drill and blast according to the blasting plan.

Before drilling, remove overburden soil and loose rock along the top of the excavation for at least 30 feet beyond the hole drilling limits or to the end of the cut.

Cap all holes to prevent unwanted backfill. Place a stake next to each hole with hole number and total depth drilled.

Use the types of explosives and blasting accessories necessary to obtain the required results. A bottom charge may be larger than the line charges if no overbreak results.

Free blast holes of obstructions for their entire depth. Place charges without caving the blast hole walls. Stem the upper portion of all blast holes with dry sand or other granular material passing the 3/8-inch sieve. Do not stem the hole with drill cuttings.

Following a blast, stop work in the entire blast area, and check for misfires before allowing worker to return to excavate the rock.

Remove or stabilize all cut face rock that is loose, hanging, or potentially dangerous. Scale by hand or machine methods as approved by the CO. Leave minor irregularities or surface variations in place if they do not create a hazard. Drill the next lift only after the cleanup work and stabilization work is complete.

If blasting operations cause fracturing of the final rock face, repair or stabilize it in an approved manner at no cost to the Government. Repair or stabilization may include removal, rock bolting, rock dowels, or other stabilization techniques.

Halt blasting operations when any of the following occur and perform additional test blast:

(1) Slopes are unstable;

(2) Slopes exceed tolerances or overhangs are created;

(3) Backslope damage occurs;

(4) Safety of the public is jeopardized;

(5) Property or natural features are endangered;

(6) Fly rock is generated; or

(7) Excessive ground or airblast vibrations occur in an area where damage to buildings, structures, or utilities is possible.

(b) Drill logs. Submit drill logs. Include the following:

(1) Blast plan map showing designated hole numbers; and

(2) Individual hole logs completed and signed by the driller that show total depth drilled, depths and descriptions of significant conditions encountered during drilling that may affect loading such as water or voids, and date drilled.

(c) Controlled blasting. When test blasts indicate the need for controlled blasting, use controlled blasting methods to form the final rock cut faces when the rock height is more than 10 feet above ditch grade and the staked slope is 2V:1H or steeper.

Controlled blasting includes only those holes drilled on the row furthest from the free face and that are drilled on the design slope.

Use downhole angle or fan drill blast holes for pioneering the tops of rock cuts or preparing a working platform for controlled blasting. Use the blast hole diameter and hole spacing established for controlled blasting during the test blasts.

Drill controlled blast holes not greater than 4 inches in diameter along the final rock face line. Drill controlled blast holes within 3 inches of the proposed surface location. Drill controlled blast holes at least 30 feet beyond the production holes to be detonated or to the end of the cut.

Use drilling equipment with mechanical or electrical-mechanical devices that accurately control the angle the drill enters the rock. Select a lift height and conduct drilling operations so the blast hole spacing and downhole alignment does not vary more than 9 inches from the proposed spacing and alignment. When more than 5 percent of the holes exceed the variance, reduce the lift height and modify the drilling operations until the blast holes are within the allowable variance. Maximum lift height is 50 feet.

A 12-inch offset is allowed for a working bench at the bottom of each lift for drilling the next lower controlled blasting hole pattern. Adjust the drill inclination angle or the initial drill collar location so the required ditch cross-section is obtained when the bench is used.

Drilling 20 inches below the ditch bottom is allowed for removing the toe.

Do not use bulk ammonium nitrate and fuel oil for controlled blasting.

Where presplitting, delay the nearest production blast row at least 25 milliseconds after blasting the presplit line. Presplit a minimum of 30 feet ahead of production blasting zone.

Where cushion (trim) blasting, delay the cushion blast row from 25 to 75 milliseconds after blasting the nearest production row.

(d) Production blasting. Drill the row of production blast holes closest to the controlled blast line parallel and no closer than 6 feet to the controlled blast line. Do not drill production blast holes lower than the bottom of the controlled blast holes.

Detonate production holes on a delay sequence toward a free face.

205.09 After Blast Reports. Within 3 days after a blast and before the next blast, submit an after-blast report that includes the following:

(a) Results of the blast and whether or not blasting objectives were met. If blasting objectives were not met, submit proposed changes to future site-specific blasting plans that will produce acceptable results and proposed repair or stabilization plan for unstable or blast damaged backslopes.

(b) Blasting logs that include the following:

(1) All actual dimensions of the shot including blast hole depths, hole diameter, burden, spacing, subdrilling, stemming, powder loads, and timing; and

(2) A drawing or sketch showing the direction of the face, or faces, and the physical shot layout.

(c) If a seismograph was used, provide the following:

(1) Identification of instrument used;

(2) Name of qualified observer and interpreter;

(3) Distance and direction of recording station from blast area;

(4) Type of ground recording station and material on which the instrument is sitting;

(5) Maximum particle velocity in each direction;

(6) A dated and signed copy of the seismograph readings; and

(7) Post-blast condition survey.

(d) Results of airblast monitoring.

(e) Results of post blast condition survey.

205.10 Acceptance. Material for rock blasting will be evaluated under Subsections 106.02 and 106.03.

Rock blasting work and services will be evaluated under Subsections 106.02 and 106.04.

Measurement

205.11 Measure the Section 205 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure controlled blasting by the square foot of face shot as shown in the blasting plan. Measure controlled blast hole by the linear foot based on the actual length of drilling as recorded in the blasting log. Do not measure vertical holes or horizontal holes.

Do not measure production blasting.

Payment

205.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 205 pay item 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 GEOTEXTILES

Description

207.01 This work consists of furnishing and placing a geotextile as a permeable separator, stabilizer, or permanent erosion control measure.

Geotextile types are designated as shown in Subsection 714.01.

Material

207.02 Conform to the following Subsection:

Geotextile	714.01

Construction Requirements

207.03 General. Where placing a geotextile on native ground, cut the trees and shrubs flush with the ground surface. Do not remove the topsoil and vegetation mat. Remove all sharp objects and large rocks. Fill depressions or holes with suitable material to provide a firm foundation.

Replace or repair all geotextile that is torn, punctured, or muddy. Remove the damaged area and place a patch of the same type of geotextile overlapping 3 feet beyond the damaged area.

207.04 Separation and Stabilization Applications. Where placing a geotextile on a subgrade, prepare the subgrade according to Subsections 204.13(c) and (d).

Place the geotextile smooth and free of tension, stress, or wrinkles. Fold or cut the geotextile to conform to curves. Overlap in the direction of construction. Overlap the geotextile a minimum of 2 feet at the ends and sides of adjoining sheets, or sew the geotextile joints according to the manufacturer's recommendations. Do not place longitudinal overlaps below anticipated wheel loads. Hold the geotextile in place with pins, staples, or piles of cover material.

End dump the cover material onto the geotextile from the edge of the geo-textile or from previously placed cover material. Do not operate equipment directly on the geotextile. Spread the end-dumped pile of cover material maintaining a minimum lift thickness of 12 inches. Compact the cover material with rubber-tired or nonvibratory smooth drum rollers. Avoid sudden stops, starts, or turns of the construction equipment. Fill all ruts from construction equipment with additional cover material. Do not regrade ruts with placement equipment.

Place subsequent lifts of cover material in the same manner. Vibratory compactors may be used for compacting subsequent lifts. If foundation failures occur, repair the damaged areas and revert to the use of nonvibratory compaction equipment.

207.05 Permanent Erosion Control Applications. Place and anchor the geotextile on an approved smooth-graded surface. 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 the geotextile a minimum of 12 inches at the ends and sides of adjoining sheets or sew the geotextile joints according to the manufacturer's recommendations. Overlap the uphill or upstream sheet over the downhill or downstream sheet. Offset end joints of adjacent sheets a minimum of 5 feet. Pins may be used to hold the geotextile sheets in place. Space pins along the overlaps at approximately 3-foot centers.

Place aggregate, slope protection, or riprap on the geotextile starting at the toe of the slope and proceed 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 3 feet. In underwater applications, place the geotextile and cover material in the same day.

207.06 Acceptance. Material for earthwork geotextile will be evaluated under Subsections 106.02, 106.03, and 714.01.

Earthwork geotextile installation will be evaluated under Subsections 106.02 and 106.04.

Measurement

207.07 Measure the Section 207 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Payment

207.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 207 pay item 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. The work includes preserving channels, shoring and bracing, constructing cofferdams, sealing foundations, dewatering, excavating, preparing foundations, backfilling, and subsequent removal of safety features and cofferdams.

Material

208.02 Conform to the following Sections and Subsections:

Concrete	552
Foundation fill	704.01
Grout	725.22(e)
Seal concrete	552
Structural backfill	704.04

Construction Requirements

208.03 Preparation for Structure Excavation. Clear the area of vegetation and obstructions according to Sections 201 and 203.

208.04 General. Excavate trenches or foundation pits to a width and length that allows room for work. When excavation is complete, request approval as to the character and suitability of the foundation material. The foundation shall provide a firm foundation of uniform density throughout its length and width.

Where necessary to blast rock, blast according to Section 205.

Follow OSHA safety regulations (29 CFR, Part 1926, Subpart P, Excavation) for sloping the sides of excavations, using shoring and bracing, and for using other safety features. When sides of excavations are sloped for safety considerations, provide one copy of the design that demonstrates conformity with OSHA regulations. Where support systems, shield systems, or other protective systems are to be used, design the shoring according to Section 562 and submit working drawings and construction details according to Subsection 104.03.

Remove safety features when no longer necessary. Remove shoring and bracing to at least 2 feet below the surface of the finished ground.

Saw cut existing pavements or concrete structures adjacent to the area to be excavated that are designated to remain.

Conserve suitable material for structural backfill from excavated material. Do not deposit excavated material in or near a waterway. Do not stockpile excavated material or allow equipment closer than 2 feet from the edge of the excavation.

Dispose of unsuitable or excess material according to Subsection 204.14. If approved, suitable material may be used in embankment construction.

Remove all water as necessary to perform work.

208.05 Channel Preservation. Perform work in or next to a running waterway as follows:

(a) Excavate inside cofferdams, sheeting, or other separations such as dikes or sandbags;

(b) Do not disturb the natural bed of the waterway adjacent to the work; and

(c) Backfill the excavation with structural backfill to original groundline.

208.06 Cofferdams. Use cofferdams when excavating under water or when the excavation is affected by groundwater.

Submit working drawings showing proposed methods and construction details of cofferdams according to Subsection 104.03 and Section 562. Cofferdams shall:

(a) Extend below the bottom of the footing;

(b) Be braced to withstand pressure without buckling and secured in place to prevent tipping or movement;

(c) Be as watertight as practicable;

(d) Provide sufficient clearance for the placement of forms and the inspection of their exteriors;

(e) Provide for dewatering;

(f) Protect fresh concrete against damage from sudden rises in water elevation; and

(g) Prevent damage to the foundation by erosion.

When no longer required, remove all cofferdam material down to the natural bed of the waterway. Remove cofferdam material outside the waterway to a minimum of 2 feet below the surface of the finished ground.

208.07 Foundation Seal. Where a foundation area cannot be pumped reasonably free of water, provide a foundation seal of seal concrete. Design seal concrete according to Subsection 552.03.

Furnish and place seal concrete according to Section 552. While placing a foundation seal, maintain the water level inside the cofferdam at the same level as the water outside the cofferdam. Where a foundation seal is placed in tidal water, vent or port the cofferdam at low water level.

Do not dewater a concrete-sealed cofferdam until the concrete strength is sufficient to withstand the hydrostatic pressure.

208.08 Dewatering. While placing concrete, locate and operate the pumps outside the foundation form. If pumping is permitted from the interior of any foundation enclosure, pump in a manner to avoid removal or disturbance of concrete material.

208.09 Foundation Preparation. Prepare footing foundations as follows:

(a) Footings placed on bedrock. Cut the bottom of the excavation to the specified elevation: level, stepped, or serrated. Clean the foundation surface of loose or disintegrated material. Clean and grout all seams and crevices.

(b) Footings placed on an excavated surface other than bedrock. Do not disturb the bottom of the foundation excavation. Remove material to foundation grade, and compact the foundation immediately before concrete 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 all space between the limits of the footing and the remaining undisturbed material with concrete. If the excavation is below the top of the footing, fill only to the top of the excavation. 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, and replace it with foundation fill. Place foundation fill material in horizontal layers that, when compacted, do not exceed 6 inches in depth. Compact each layer according to Subsection 208.11.

(e) Foundations using piles. Excavate to the foundation elevation and drive the piles. Remove all loose and displaced material, and reshape the bottom of the excavation to the foundation elevation. Smooth and compact the bed to receive the footing.

208.10 Backfill. Backfill with structural backfill material.

Place backfill in horizontal layers that do not exceed 6 inches in compacted thickness. Compact each layer according to Subsection 208.11.

Bring structural backfill up evenly on all sides of the structure as appropriate. Extend each layer to the limits of the excavation or to natural ground.

Do not place structural backfill against concrete less than 7-days-old or until 80 percent of the design strength is achieved.

208.11 Compacting. Determine optimum moisture content and maximum density according to AASHTO T 99, method C. Adjust the moisture content of the backfill material to a moisture content suitable for compaction.

Compact material placed in all layers to at least 95 percent of the maximum density. Determine the inplace density and moisture content according to AASHTO T 310 or other approved test procedures.

208.12 Acceptance. See Table 208-1 for sampling and testing requirements.

Material for structural backfill and foundation fill will be evaluated under Subsections 106.02 and 106.04.

Structure excavation and backfill work will be evaluated under Subsections 106.02 and 106.04.

Shoring, bracing, and cofferdams will be evaluated under Subsections 106.02 and 106.04.

Clearing and removal of obstructions will be evaluated under Sections 201 and 203.

Seal concrete will be evaluated under Section 552.

Measurement

208.13 Measure the Section 208 items listed in the bid schedule according to Subsection 109.02 and the following.

Measure structural excavation by the cubic yard in its original position. Do not include the following volumes in structure excavation:

(a) Material excavated outside vertical planes located 18 inches outside and parallel to the limits of the footings or foundations;

(b) Any 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 measurements of the original ground; or

(e) Material rehandled, except when the contract specifically requires excavation after embankment placement.

Measure foundation fill and structural backfill by the cubic yard in place for the volume placed inside vertical planes located 18 inches outside and parallel to the limits of the footings or foundations.

Measure seal concrete under Section 552.

Payment

208.14 The accepted quantities measured as provided in Subsection 109.02 and above, 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 on 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.

Table 208-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Foundation fill (704.01)	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type	Source of material	Yes, when requested	Before using in work
		Gradation	—	AASHTO T 27 & T 11	"	"	"	"
		Moisture-density	—	AASHTO T 99, method C(1)	"	"	"	"
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 300 yd^3	In-place	—	Before placing next layer
Structural backfill (704.04)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per soil type	Source of material	Yes, when requested	Before using in work
		Liquid limit	—	AASHTO T 89	"	"	"	"
		Moisture-density	—	AASHTO T 99, method C(1)	"	"	"	"
		Compaction	—	AASHTO T 310 or other approved procedures	2 per lift	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Section 209. — STRUCTURE EXCAVATION AND BACKFILL

Description

209.01 This work consists of excavating material for the construction of all structures except those specifically designated under Section 208. The work includes preserving channels, shoring and bracing, sealing foundations, dewatering, excavating, preparing foundations, bedding, and backfilling.

Material

209.02 Conform to the following Sections and Subsections:

Backfill material	704.03
Bedding material	704.02
Concrete	601
Foundation fill	704.01
Lean concrete backfill	614
Seal concrete	552
Unclassified borrow	704.06

Construction Requirements

209.03 Preparation for Structure Excavation. Clear the area of vegetation and obstructions according to Sections 201 and 203.

209.04 General. Excavate trenches or foundation pits according to Subsection 208.04. Excavate to foundation grade without unduly disturbing the trench or foundation surface. Foundation grade is the elevation at the bottom of any bedding for installing the structure. Compact the foundation.

209.05 Channel Preservation. Preserve channels according to Subsection 208.05 except excavate inside separations such as dikes or sandbags.

209.06 Foundation Seal. Where necessary for a foundation seal, construct a foundation seal according to Subsection 208.07.

209.07 Dewatering. Where necessary to dewater, dewater according to Subsection 208.08.

209.08 Foundation Preparation. Excavate any unsuitable material present at foundation grade, and replace it with foundation fill. Place and compact the foundation fill material according to Subsection 208.09(d).

Where a footing is required to be keyed into undisturbed material, prepare foundation and construct footing according to Subsection 208.09(c).

209.09 Bedding. Place bedding as follows:

(a) For box culverts and structures other than pipe culverts. Construct bedding when required by the contract. Place and shape bedding material in compacted layers not exceeding 6 inches in depth. Compact each layer according to Subsection 209.11.

(b) For pipe culverts. Level the foundation. Place un-compacted bedding material over the foundation in a layer of uniform thickness. For pipe with diameters of 12 to 54 inches, the bedding thickness is 4 inches. For pipe diameters larger than 54 inches, the bedding thickness is 6 inches. For belled joints, recess the bedding to receive the joints. Place the culvert on un-compacted bedding layer. Backfill according to Subsection 209.10(b).

209.10 Backfill. Backfill as follows:

(a) General. Place backfill in horizontal layers that, when compacted, do not exceed 6 inches in depth. Compact each layer according to Subsection 209.11.

Bring backfill up evenly on all sides of the structure, and extend each layer to the limits of the excavation or to natural ground.

Do not place backfill against concrete less than 7-days-old or until 80 percent of the design strength is achieved.

(b) Pipe culverts. Place and compact material in evenly balanced layers on each side of each pipe culvert. Backfill according to one of the following:

(1) Pipe culverts with compacted backfill. Place and compact backfill material to a height of 12 inches above the top of the pipe. Complete the backfilling of the trench with suitable roadway excavation or unclassified borrow.

Place the material in layers that, when compacted, do not exceed 6 inches in thickness. Compact each layer according to Subsection 209.11.

(2) Pipe culverts with lean concrete backfill. Place and stake pipe to prevent floating and movement. Backfill using lean concrete according to Section 614.

(c) Arch culverts with headwalls. Backfill according to one of the following:

(1) Before headwalls are in place. Place and compact the first backfill material midway between the ends of the arch. Place and compact backfill material in layers on both sides of the arch to form as narrow a ramp as possible. Build the ramp evenly on both sides until reaching the top of the arch. Place the remainder of the backfill material from the top of the ramp working both ways to the ends. Compact the backfill material evenly in layers on both sides of the arch.

(2) After headwalls are in place. Place and compact the first backfill material adjacent to one headwall. Place and compact backfill material evenly in layers on both sides of the arch adjacent to the headwall until reaching the top of the arch. Place remainder of the backfill material from the top of the arch working toward the other headwall. Compact the backfill material evenly in layers on both sides of the arch.

(d) Patching existing pavement areas. Construct the top 15 inches with 12 inches of crushed aggregate according to Section 301 and 3 inches of asphalt concrete according to Section 404 or 417.

209.11 Compacting. Determine optimum moisture content and maximum density according to AASHTO T 99, method C. Adjust the moisture content of the backfill material to a moisture content suitable for compaction.

Compact material placed in all layers to at least 95 percent of the maximum density. Determine the inplace 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 is incapable of being tested or compacted to maximum values determined by AASHTO T 99. For these materials, fill the voids around the rock in each layer with earth or other fine material. Compact each layer, full width, until there is no visible evidence of further consolidation.

209.12 Acceptance. See Table 209-1 for sampling and testing requirements.

Material for backfill, bedding, and foundation fill will be evaluated under Subsections 106.02 and 106.04, except concrete for bedding or backfill will be evaluated according to Section 601.

Structural excavation and backfill work will be evaluated under Subsections 106.02 and 106.04.

Shoring, bracing, and cofferdams will be evaluated under Subsections 106.02 and 106.04.

Clearing and removal of obstructions will be evaluated under Sections 201 and 203.

Seal concrete will be evaluated under Section 552.

Measurement and Payment

209.13 See Subsection 109.05.

Do not measure structure excavation and backfill for payment.

Measure foundation fill under Section 208.

Measure seal concrete under Section 552.

Table 209-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Backfill material (704.03)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per soil type	Source of material	Yes	Before using in work
		Moisture-density	—	AASHTO T 99, method C(1)	“	“	“	“
		Compaction	—	AASHTO T 310 or other approved procedures	2 per lift	In-place	—	Before placing next layer
Bedding material (704.02)	Measured and tested for conformance (106.04)	Moisture-density	—	AASHTO T 99, method C(1)	1 per soil type	Source of material	Yes	Before using in work
		Compaction	—	AASHTO T 310 or other approved procedures	2 per lift	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Table 209-1 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Foundation fill (704.01)	Measured and tested for conformance (106.04)	Moisture-density	—	AASHTO T 99, method C(1)	1 per soil type	Source of material	Yes	Before using in work
		Compaction (204.11)	—	AASHTO T 310 or other approved procedures	2 per lift	In-place	—	Before placing next layer
Unclassified borrow (704.06)	Measured and tested for conformance (106.04)	Moisture-density	—	AASHTO T 99, method C(1)	1 per soil type	Source of material	Yes	Before using in work
		Classification	—	AASHTO M 145	“	“	“	“
		Compaction	—	AASHTO T 310 or other approved procedures	2 per lift	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Section 210. — Reserved

Section 211. — ROADWAY OBLITERATION

Description

211.01 This work consists of obliterating or closing roadways and other areas outside the roadway prism.

Roadway obliteration methods are designated as follows:

(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 all ruts and low spots that could hold water.

Construction Requirements

211.02 Conform to the following when obliterating or closing roadways:

(a) Rigid material.

(1) Nonasphalt material. Break concrete pavements, curbs, gutters, sidewalks, and other nonasphalt rigid material into pieces with maximum dimension of 12 inches when burying according to Subsection 203.05(c). As an alternative to breaking and burying, remove the rigid material from the project and dispose of it according to Subsection 203.05(a).

(2) Asphalt material. Dispose of asphalt material in a manner consistent with State and local regulations. Asphalt material may be considered hazardous waste. Furnish copies of the disposal permits. Where no regulations exist, dispose of the material as described in (1) above.

(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 soil.

(2) Asphalt contaminated material. Dispose of asphalt contaminated material according to Subsection 211.02(a)(2).

211.03 Waterbars and Barriers. Construct barriers to prevent vehicle access and waterbars as shown in the plans.

211.04 Acceptance. Roadway obliteration will be evaluated under Subsection 106.02.

Measurement

211.05 Measure the Section 211 items listed in the bid schedule according to Subsection 109.02.

Payment

211.06 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 GRADING

Description

212.01 This work consists of constructing roadbeds within the specified alignment and grade tolerances.

Construction Requirements

212.02 Roadway Preparation. Clear the area of vegetation and obstructions according to Sections 201 and 203.

212.03 Roadway Excavation and Embankment. Construct the roadbeds according to the applicable requirements of Section 204 except as modified herein.

Adjust the moisture content of embankment material to a moisture content suitable for compaction. Place embankment material in 12-inch layers and compact each layer according to Subsection 204.11(a). Where compacting with rollers is not practical, use approved mechanical or vibratory compaction equipment.

Construct approach connections to all existing roads, parking areas, and trails. Construct all new approaches.

212.04 Grading Tolerance. Do not encroach on stream channels, impact wetlands, or extend beyond right-of-way or easement limits. Do not make alignment or profile grade adjustments that adversely affect drainage. Construct the roadbed within the following grading tolerances:

> **(a) 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 permitted.
>
> **(b) Profile grade.** Profile grade may be shifted a maximum of 5 feet up or down 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.

212.05 Acceptance. Linear grading will be evaluated under Subsections 106.02 and 106.04.

Clearing and removal of obstructions will be evaluated under Sections 201 and 203.

Measurement

212.06 Measure the Section 212 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Do not measure changes in the clearing and grubbing quantity caused by alignment adjustments under Subsection 212.04.

Payment

212.07 The accepted quantities will be paid at the contract price per unit of measurement for the Section 212 pay item 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 lime, lime/fly ash, or hydraulic cement into the upper layer of a subgrade.

Material

213.02 Conform to the following Subsections:

Blotter	703.13
Chemical admixtures (retarder)	711.03
Emulsified asphalt	702.03
Fly ash	725.04
Hydraulic cement	701.01
Lime	725.03
Water	725.01

Construction Requirements

213.03 Proportioning. Submit a subgrade stabilization mix design 30 days before production. Provide minimum compressive strengths in Table 213-1.

Table 213-1
Subgrade Stabilization Strengths

Stabilization Mixture	Test Procedure	Minimum Compressive Strength
Lime/Soil	ASTM D 5102	100 pounds / square inch (1)
Lime/Fly ash/Soil	ASTM C 593	400 pounds / square inch (2)
Cement/Soil	ASTM D 1633	400 pounds / square inch (2)

(1) 28-day cure.
(2) 7-day cure followed by vacuum saturation.

Include the following with the mix design, as applicable:

(a) Source of each component material;

(b) Results of the applicable tests;

(c) 200-pound sample of the subgrade soil;

(d) 50-pound sample of the fly ash;

(e) 25-pound sample of the lime;

(f) 25-pound sample of the cement; and

(g) 5-pound sample of the retarder or other admixtures proposed.

Begin production only after the mix design is approved. Furnish a new mix design if there is a change in a material source.

213.04 General. Store chemical additives and admixtures in closed, weatherproof containers. Prepare the subgrade according to Section 303. Scarify and pulverize the subgrade to a depth of 6 inches. Size and shape the subgrade material to a windrow or blanket that is suitable for mixing. Determine the optimum moisture content and maximum density according to AASHTO T 99, method C.

213.05 Application. Apply additives when the subgrade material is at least 3 percent below optimum moisture content and at least 40 ºF. Do not apply when excessive additive is lost to washing or blowing or when the air temperature is expected to fall below 40 ºF within 48 hours.

Apply additives at the required rates by one of the following methods:

(a) Dry method. Uniformly apply the additives by an approved spreader. A motor grader is not an approved spreader. Apply water using approved methods to obtain the proper moisture content for mixing and compaction.

(b) Slurry method. Mix additives with water and apply as a thin water suspension or slurry using either trucks with approved distributors or rotary mixers. Equip the distributor truck or rotary mixer tank with an agitator to keep the additives suspended in water. Make successive passes over the material to obtain the moisture and additive content for mixing and compacting.

213.06 Mixing. Keep all traffic, except mixing equipment, off the spread material. Mix the material to obtain a homogeneous friable mixture.

(a) Lime and lime/fly ash mixtures. Add water and thoroughly mix to adjust the moisture content of the mixture to the optimum moisture content plus necessary hydration moisture. Hydration moisture is 1½ percent for each percent of additive in the mixture. Complete the mixing within 6 hours of additive application. Cure the mixture for 2 to 4 days by keeping it moist.

After curing, remix the mixture until 95 percent of all the mixture, except rock, passes a 1¾-inch sieve and at least 50 percent of the mixture passes a No. 4 sieve when tested according to AASHTO T 27, in a nondried condition. Retarders may be added.

(b) Cement mixtures. Add water and thoroughly mix to adjust the moisture content of the mixture to 2 percent above the optimum moisture content. Complete the mixing within 2 hours of cement application.

Adjust the moisture content of the mixture to within 2 percent of the optimum moisture content.

213.07 Compacting and Finishing. Immediately after mixing, spread and compact the mixture to at least 95 percent of the maximum density. Determine the inplace density and moisture content according to AASHTO T 310 or other approved test procedures. If the time between compacting adjacent partial widths exceeds 30 minutes, or when tying into the previous work, provide a construction joint according to Subsection 302.07. Finish the subgrade so it is smooth and suitable for placing a subsequent course.

213.08 Curing. Do not allow traffic on the stabilized subgrade. Keep the subgrade continuously moist 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 7 days after compacting and finishing the subgrade.

Placement of the next course may be deferred up to 21 days by sealing the surface with rapid setting emulsified asphalt. Keep the surface continuously moist for at least 7 days after compacting and finishing. After the 7 days, apply undiluted CRS-2 or RS-2 emulsified asphalt at a rate of ¼ gallon per square yard according to Section 409. Provide a continuous film over the surface. If the surface is opened to public traffic, furnish and apply blotter according to Section 411.

If the subgrade looses stability, density, or finish before placement of the next course, reprocess or recompact the subgrade as necessary to restore the strength of the damaged material to that specified in the mix design. Reapply the emulsified asphalt seal where the continuous film is damaged.

213.09 Acceptance. See Table 213-2 for sampling and testing requirements.

Material for blotter, chemical admixtures (retarder), fly ash, lime, hydraulic cement, and water will be evaluated under Subsections 106.02 and 106.03.

Emulsified asphalt will be evaluated under Subsections 106.03 and 702.09.

Subgrade stabilization work will be evaluated under Subsections 106.02 and 106.04.

Reconditioning of subgrade will be evaluated under Section 303.

Emulsified asphalt seal will be evaluated under Section 409.

Measurement

213.10 Measure the Section 213 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure the width horizontally to include the top of subgrade width and allowable curve widening. Measure length horizontally along the centerline of the roadway.

Measure emulsified asphalt under Section 409.

Measure blotter under Section 411.

Payment

213.11 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Remix material	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per 6000 yd^2	Processed material	Yes	Before using in work
		Moisture-density	—	AASHTO T 99, method C(1)	"	"	"	"
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 2500 yd^2, but not less than 1 per layer	In-place	—	Before placing next layer
		Strength	—	ASTM D 5102, C 593, & D 1633	1 per mix design	After proportioning	"	Before producing

(1) Minium of 5 points per proctor.

DIVISION 250

SLOPE REINFORCEMENT AND RETAINING WALLS

Section 251. — RIPRAP

Description

251.01 This work consists of furnishing and placing riprap for bank protection, slope protection, drainage structures, and erosion control.

Riprap classes are designated as shown in Table 705-1.

Material

251.02 Conform to the following Subsections:

Geotextile type IV	714.01
Cement grout	725.22(e)
Riprap rock	705.02

Construction Requirements

251.03 General. Perform the work under Section 209. Dress the slope to produce a smooth surface. If earthwork geotextile is required, place according to Section 207.

251.04 Placed Riprap. Placed riprap is rock placed on a prepared surface to form a well-graded mass.

Place riprap to its full thickness in one operation to avoid displacing the underlying material. 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. Keyed riprap is rock placed 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. Repeated impacts should be made 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. Grouted riprap is rock placed or keyed on a prepared surface with the voids filled with grout.

Place rock for grouted riprap according to Subsections 251.04 or 251.05. Thoroughly moisten the rocks and wash excess fines from the riprap or to the underside of the riprap. Place grout only when the air temperature is no less than 35 ºF within the near-surface voids of the riprap. Place the grout in a manner to prevent segregation. Begin placing grout at the lowest elevation of the riprap. Fill all 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 a minimum of 7 days after grouting.

251.07 Acceptance. See Table 251-1 for sampling and testing requirements.

Rock for riprap will be evaluated under Subsection 106.02 and 106.03.

Rock placement for riprap will be evaluated under Subsections 106.02 and 106.04.

Structure excavation and backfill will be evaluated under Section 209.

Geotextile will be evaluated under Section 207.

Material for grout will be evaluated under Subsections 106.02 and 106.03. Grout will be evaluated under Subsections 106.02 and 106.04. Grout placement will be evaluated under Subsection 106.02.

Measurement

251.08 Measure the Section 251 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure riprap by the cubic yard in place.

Payment

251.09 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Riprap (705.02)	Measured and tested for conformance (106.04)	Apparent specific gravity & absorption	—	AASHTO T 85	1 per material type	Source of material	Yes	Before using in work
		Coarse durability index	—	AASHTO T 210	“	“	“	“
		Sodium sulfate soundness	—	AASHTO T 104	“	“	“	“
		LA abrasion	—	AASHTO T 96	“	“	“	“
Mortar	Measured and tested for conformance (106.04)	Making test specimens Compressive strength	—	AASHTO T 23 & T 22	1 per mix design	—	Yes, when requested	Before using in work

Section 252. — SPECIAL ROCK EMBANKMENT AND ROCK BUTTRESS

Description

252.01 Special rock embankment work consists of furnishing and placing hand-placed or mechanically-placed rock in fill sections. Rock buttress work consists of furnishing and placing hand-placed or mechanically-placed rock in cut sections.

Special rock embankments and rock buttresses are designated as hand-placed or mechanically-placed.

Material

252.02 Conform to the following Subsections:

Rock for buttresses	705.05
Rock for special rock embankment	705.04

Construction Requirements

252.03 Placing Rock. Perform the work under Section 204 or 209 as required.

Place the rock in a stable orientation with minimal voids. Offset the rock to produce a random pattern. Use spalls smaller than the minimum rock size to chock the larger rock solidly in position and to fill voids between the large rock.

Construct the exposed face of the rock mass reasonably uniform with no projections beyond the line of the slope that are more than 12 inches for mechanically-placed rock or 6 inches for hand-placed rock.

252.04 Acceptance. Rock for special rock embankment and rock buttress will be evaluated under Subsection 106.02.

Rock placement for special rock embankment and rock buttress will be evaluated under Subsections 106.02 and 106.04.

Structure excavation and backfill will be evaluated under Section 209.

Measurement

252.05 Measure the Section 252 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure special rock embankment and rock buttress by the cubic yard in place.

Payment

252.06 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.

Section 253. — GABIONS AND REVET MATTRESSES

Description

253.01 This work consists of constructing gabion structures and revet mattresses.

Material

253.02 Conform to the following Subsections:

Backfill material	704.03
Gabion and revet mattress material	720.02
Gabion and revet mattress rock	705.01
Geotextile type IV	714.01
Structural backfill	704.04

Construction Requirements

253.03 General. Survey according to Section 152 and verify the limits of the wall installation. Prepare and submit installation drawings according to Subsection 104.03. Perform the work under Section 209.

253.04 Basket Assembly. 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. Place the empty gabion baskets on the foundation and interconnect the adjacent baskets along the top and vertical edges using permanent fasteners.

Where lacing wire is used, wrap the wire with alternating single and double loops every other mesh opening and not 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 not more than 6 inches apart.

In the same manner, interconnect each vertical layer of baskets to the underlying layer of baskets along the front, back, and sides. Stagger the vertical joints between baskets of adjacent rows and layers by at least one cell length.

253.06 Cell Filling. Remove all kinks and folds in the wire mesh, and properly align all 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 internal connecting wires in each unrestrained exterior basket cell greater than 1 foot in height. This includes interior basket cells left temporarily unrestrained. Place internal connecting wires concurrently with rock placement.

Fill the cells in any row or layer so that no cell is filled more than 1 foot above an adjacent cell. Repeat this process until the basket is full and the lid bears on the final rock layer.

Secure the lid to the sides, ends, and diaphragms according to Subsection 253.05. Make all exposed basket surfaces smooth and neat with no sharp rock edges projecting through the wire mesh.

253.07 Backfilling. Place a geotextile over the back face of the gabion structure. Concurrently with the cell filling operation, backfill the area behind the gabion structure with structural backfill according to Subsection 209.10. Compact each layer according to Subsection 209.11 except use an acceptable lightweight mechanical or vibratory compactor within 3 feet of the gabion structure.

253.08 Revet Mattresses. Place a geotextile according to Section 207. Construct revet mattresses according to Subsections 253.04 through 253.06. Anchor the mattresses in place. Place geotextile against the vertical edges of the mattress and backfill against the geotextile using backfill material or other approved material. Overfill revet mattresses by 1 to 2 inches.

253.09 Acceptance. See Table 209-1 for sampling and testing requirements.

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.

Survey work will be evaluated under Section 152.

Geotextile will be evaluated under Subsection 207.

Structure excavation, structural backfill, and backfill material will be evaluated under Section 209.

Measurement

253.10 Measure the Section 253 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure gabions by the square yard of front wall face or by the cubic yard in the structures.

Measure foundation fill under Section 208.

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. — CRIB WALLS

Description

254.01 This work consists of constructing concrete, metal, or timber crib retaining walls.

Material

254.02 Conform to the following Section and Subsections:

Bed course	704.09
Concrete	601
Crib wall backfill	704.12
Hardware for timber structures	716.02
Metal bin type crib walls	720.03
Precast concrete units	725.11(c)
Reinforcing steel	709.01
Structural backfill	704.04
Treated structural timber and lumber	716.03

Construction Requirements

254.03 General. Survey according to Section 152 and verify the limits of the wall installation. Prepare and submit installation drawings according to Subsection 104.03. Perform the work under Section 209. When the wall is set on a rocky foundation, place 8 inches of bed course under the wall base elements.

254.04 Erection. Furnish all necessary bolts, nuts, and hardware for complete assembly of the units into a continuous wall of connected units. Erect the crib wall according to the fabricator's or manufacturer's instructions. On curves, obtain the proper curvature for the face by using shorter stringers in the front or rear panels. Construct the wall to within 1 inch in 10 feet from the lines and elevations shown on the plans.

(a) Concrete crib wall. Remove and replace all concrete members that are cracked or damaged.

(b) Metal crib wall. Torque bolts for metal crib walls to at least 25 foot-pounds.

(c) Timber crib wall. Construct timber cribs according to Section 557.

254.05 Backfilling. Backfill within the cribs with crib wall backfill according to Subsection 209.10. Backfill behind the cribs with structural backfill according to Subsection 209.10. Maintain an equal level of backfill within and behind the cribs during the backfilling process. Compact each layer according to Subsection 209.11 except use an acceptable lightweight mechanical or vibratory compactor within 3 feet of the crib wall face.

254.06 Acceptance. Material for crib walls will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each shipment for the following:

(a) Metal bin type crib walls;

(b) Precast concrete units;

(c) Reinforcement steel; and

(d) Treated structural timber and lumber.

Concrete, metal, or timber crib retaining wall construction will be evaluated under Subsections 106.02 and 106.04.

Survey work will be evaluated under Section 152.

Structure excavation, crib wall backfill, structural backfill, and bed course material will be evaluated under Section 209.

Concrete crib walls will be evaluated under Section 601.

Timber crib walls will be evaluated under Section 557.

Measurement

254.07 Measure the Section 254 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure crib walls by the square foot of front wall face.

Measure crib wall backfill by the cubic yard in place.

Measure foundation fill under Section 208.

Payment

254.08 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-STABLILIZED EARTH WALLS

Description

255.01 This work consists of constructing mechanically-stabilized earth walls.

Material

255.02 Conform to the following Section and Subsections:

Concrete leveling pad	601
Geotextile type IV	714.01
Mechanically-stabilized earth wall material	720.01
Select granular backfill	704.10
Structural backfill	704.04

Construction Requirements

255.03 General. Survey according to Section 152, and verify the limits of the wall installation. Prepare and submit installation drawings according to Subsection 104.03. Perform the work under Section 209. Grade the foundation for a width equal to the length of reinforcing elements plus 18 inches. Where the wall is set on a rocky foundation, place 6 inches of select granular backfill under the reinforcing mesh or strips.

For concrete-faced walls, provide a precast reinforced or a nonreinforced cast-in-place concrete leveling pad. Cure cast-in-place leveling pads a minimum of 12 hours before placing wall panels.

255.04 Wall Erection. Erect the wall according to the drawings and the manufacturer's recommendations. When requested, have an experienced field representative from the wall system manufacturer available during erection.

(a) Concrete-faced walls. Erect panels by means of lifting devices connected to the upper edge of the panel. Align precast facing panels within 3/4 inch vertically and horizontally when measured with a 10-foot straightedge.

Make the joint openings 3/4±1/4 inch wide. Install joint material according to the drawings. Cover all joints on the backside of the panels with a 12-inch wide strip of geotextile. Overlap geotextile splices a minimum of 4 inches.

Hold the panels in position with temporary wedges or bracing during backfilling operations. Erect the wall so the overall vertical tolerance (top to bottom) does not exceed 1/2 inch per 10 feet of wall height.

(b) Wire-faced walls. Place backing mats and 1/4-inch hardware cloth in successive horizontal lifts as backfill placement proceeds. Connect, tighten, and anchor soil reinforcement elements to the wall facing units before placing backfill. Do not exceed an individual lift vertical tolerance and an overall wall (top to bottom) vertical tolerance of 1 inch per 10 feet of wall height. Place reinforcement elements within 1 inch vertically above the corresponding connection elevation at the wall face. Do not place reinforcing elements below the corresponding connection elevations. Do not deviate from the designed batter of the wall by more than 1 inch per 10 feet of wall height. Do not deviate more than 2 inches at any point in the wall from a 10-foot straightedge placed horizontally on the theoretical plane of the design face.

(c) Gabion-faced walls. Place the first lift of backfill before filling the gabion baskets. 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. Pull and anchor the reinforcement mesh taut before placing additional backfill.

255.05 Backfilling. Backfill the stabilized volume with select granular backfill according to Subsection 209.10. Ensure that no voids exist below the reinforcing mesh or strips. Compact each layer according to Subsection 209.11, except use an acceptable lightweight mechanical or vibratory compactor within 3 feet of the wall face. Where the stabilized volume 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 reinforcing mesh or strips. Correct all damaged, misaligned, or distorted wall elements.

Backfill and compact behind the stabilized volume with structural backfill according to Subsection 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. Material for mechanically-stabilized earth walls listed under Subsection 720.01 will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each shipment of concrete face panels.

Construction of mechanically-stabilized earth wall and services will be evaluated under Subsections 106.02 and 106.04.

Survey work will be evaluated under Section 152.

Geotextile will be evaluated under Section 207.

Structure excavation, select granular backfill, and structural backfill will be evaluated under Section 209.

Gabions will be evaluated under Section 253.

Concrete leveling pad will be evaluated under Section 601.

Measurement

255.07 Measure the Section 255 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure mechanically-stabilized earth walls by the square foot of front wall face.

Measure select granular backfill within the stabilized volume by the cubic yard in place.

Measure foundation fill under Section 208.

Payment

255.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 255 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 255-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Backfill (704)	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type	Source of material	Yes	Before using in work
		Gradation	—	AASHTO T 27 & T 11	“	“	“	“
		Moisture-density	—	AASHTO T 180, method D(1) or T 99, method C(1)	“	“	“	“
		Compaction	—	AASHTO T 310 or other approved procedures	2 per lift	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Section 256. — PERMANENT GROUND ANCHORS

Description

256.01 This work consists of constructing permanent ground anchors.

Material

256.02 Conform to the following Subsection:

Ground anchors	722.02
Grout	722.02(e)

Construction Requirements

256.03 Qualifications. The Contractor or subcontractor performing the ground anchor work shall have completed at least 5 permanent ground anchor projects within the last 3 years. Submit a brief description of each project including the owning agency's name and current telephone number.

Provide a professional engineer with at least 3 years experience in the design and construction of permanent ground anchors. Provide on-site supervisors and drill operators with at least 1 year experience installing permanent ground anchors. At least 30 days before starting ground anchor work, identify the professional engineer, on-site supervisors, and drill operators assigned to the project and submit a summary of each individual's experience.

256.04 Drawings. At least 30 days before starting ground anchor work, submit drawings according to Subsection 104.03. Include the following:

(a) A ground anchor schedule giving the following information:

(1) Ground anchor number;

(2) Ground anchor design load;

(3) Type and size of tendon;

(4) Minimum total anchor length;

(5) Minimum bond length;

(6) Minimum tendon bond length; and

(7) Minimum unbonded length.

(b) Include the following details in the ground anchor system drawings:

(1) Spacers and their location;

(2) Centralizers and their location;

(3) Unbonded length corrosion protection system;

(4) Bond length corrosion protection system;

(5) Transition between the unbonded length and the bond length corrosion protection systems;

(6) Anchorage and trumpet; and

(7) Anchorage corrosion protection system.

256.05 Tendon Fabrication.

(a) General. Fabricate the tendons in either the shop or field as indicated on the drawings. Size the tendon so:

(1) The design load does not exceed 60 percent of the minimum required ultimate tensile strength of the tendon; and

(2) The maximum test load does not exceed 80 percent of the minimum specified ultimate tensile strength of the tendon.

(b) Bond length. Determine the bond length necessary to develop the design load indicated on the drawings. Use a minimum tendon bond length of 10 feet in rock and 15 feet in soil. 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 by coating it with fusion-bonded epoxy. 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 a minimum 1/8-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 a minimum of 1/2 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 so their center-to-center spacing does not exceed 10 feet.

Locate the upper centralizer a maximum of 5 feet from the top of the tendon bond length. Locate the lower centralizer a maximum of 12 inches from the bottom of the tendon bond length.

Centralizers are not required on pressure-injected tendons if the ground anchor is installed in coarse-grained soils using grouting pressures greater than 150 pounds per square inch.

Centralizers are not required on hollow-stem-augered tendons if the ground anchor is grouted through the auger and the hole is maintained full of a stiff grout during extraction of the auger. A grout is considered *"stiff"* if its slump is less than 9 inches.

(d) Unbonded length. Provide minimum unbonded length of 15 feet.

(1) If the entire drill hole is grouted in one operation, provide corrosion protection of the unbonded length with a sheath completely filled with corrosion-inhibiting grease or grout, or a heat-shrinkable tube internally coated with an elastic adhesive.

If grease is used under the sheath, completely coat the unbounded 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 bondbreaker 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 a restressable anchorage compatible with the post-tensioning system provided.

If multi-element tendons are used, properly seat the wedges as recommended for the post-tensioning system provided.

(e) Bearing plates. Size the bearing plates so:

(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 does not exceed that recommended in section 3.1.7 of the PTI, *Guide Specification for Post-Tensioning Materials.*

Weld trumpet to bearing plate. Make the inside diameter of the trumpet equal to or larger than the hole in the bearing plate. Make the trumpet long enough to accommodate movements during stressing and testing. For multi-element tendons with encapsulation over the unbonded length, make the trumpet long enough to enable the tendon to make a transition from the diameter of the tendon in the unbonded length to the diameter of the tendon at the anchorhead without damaging the encapsulation. Fill the trumpet of restressable ground anchors with corrosion-inhibiting grease. Provide a permanent Buna-N synthetic rubber seal or an approved equal between the trumpet and the unbonded length corrosion protection.

Fill the trumpets of non-restressable ground anchors with grout. Provide a 12-inch minimum tightly-fitting temporary seal between the trumpet and the unbonded length corrosion protection.

256.06 Storing and Handling. Handle and store tendons in a manner to avoid damage or corrosion. Replace tendons exhibiting abrasions, cuts, welds, weld splatter, corrosion or pitting. Repair or replace any tendons exhibiting damage to encapsulation or sheathing. Degrease the bond length of tendons, and remove solvent residue before installation.

256.07 Installation. 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.

Insert the tendon in the drill hole to the required depth without driving or forcing. Where the tendon cannot be completely inserted, remove the tendon, and clean or redrill the hole to permit insertion.

Use a positive displacement pump to grout tendons into drill holes using either a neat cement grout or a sand/cement grout. Use a grout pump equipped with a pressure gauge capable of measuring pressures of at least 150 pounds per square inch or twice the actual grout pressure, whichever is greater. Use well-mixed grout that is free of lumps or other indications of prior cement hydration. Continuously agitate the grout during placement. Place the grout 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.

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 it shall not be placed 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.

If the ground anchor is installed in a fine-grained soil using drill holes larger than 6 inches in diameter, place the grout above the top of the bond length after the ground anchor has been tested and stressed. The entire drill hole may be grouted at one time if it can be demonstrated that the ground anchor does not derive a significant portion of its load-carrying capacity from the soil above the bond length.

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.

After grouting is complete, fill the grout tube with grout if it will remain in the hole. Wait a minimum of 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 unbonded length of the tendon as necessary so that it does not contact the bearing plate of the anchorhead during testing and stressing.

Place the bearing plate and anchorhead so the axis of the tendon is within 3 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 fusion-bonded epoxy encapsulations are used, electronically isolate the bearing plate, anchorhead, and trumpet from the surrounding concrete, soldier pile, or any metallic element embedded in the structure.

Place trumpet grease any time during construction. Place trumpet grout after the ground anchor has been tested and stressed.

Completely cover all anchorages permanently exposed to the atmosphere with a corrosion-inhibiting grease or grout.

256.08 Testing and Stressing. Test each ground anchor using a maximum test load not to exceed 80 percent of the minimum ultimate tensile strength of the tendon. Simultaneously apply the test load to the entire tendon and all elements of multi-element tendons.

(a) Testing equipment. The testing equipment shall consist of:

(1) A dial gauge or vernier scale capable of measuring to 0.001 inch. Use a movement-measuring device having a minimum travel equal to the theoretical elastic elongation of the total anchor length at the maximum test load. Use a device with sufficient travel so the anchor movement is measured without resetting the device.

(2) A hydraulic jack and pump. Use a jack and a calibrated pressure gauge to measure the applied load. Have the jack and pressure gauge calibrated as a unit by an independent firm within 45 days of the start of ground anchor work. Use a pressure gauge graduated in 100-pound per square inch increments or less. Use a jack having a minimum ram travel equal to the theoretical elastic elongation of the total anchor length at the maximum test load.

(3) A calibrated reference gauge. Have the reference gauge calibrated with the test jack and pressure gauge. Keep it at the project site.

(b) Performance tests. Place stressing equipment over the ground anchor tendon so that the jack, bearing plates, load cells, and stressing anchorage are axially aligned with the tendon and the tendon is centered within the equipment.

Performance test 5 percent of the ground anchors or a minimum of 3 anchors, whichever is greater, at each separate structure. The CO will select the ground anchors to be performance tested.

Perform the performance test as indicated in Table 256-1.

Raise the load from one increment to another immediately after recording the ground anchor movement. Measure and record the ground anchor movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load and at each load increment. Monitor the load with a pressure gauge. Place the reference pressure gauge in series with the pressure gauge during each performance test. 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. At load increments other than the maximum test load, hold the load just long enough to obtain the movement reading.

Table 256-1
Performance Test Load Sequence

Test Sequence	Test Load Increment							
	A	0.25D	0.50D	0.75D	1.00D	1.20D	1.33D	Reduce to Lock-Off Load
1	•	•						
2	•	•	•					
3	•	•	•	•				
4	•	•	•	•	•			
5	•	•	•	•	•	•		
6	•	•	•	•	•	•	•	•

Note: A = Alignment load; D = Design load.

Hold the maximum test load for a minimum of 10 minutes. Repump the jack as necessary in order to maintain a constant load. Begin the load-hold period as soon as the maximum test load is applied.

Measure and record the ground anchor movement at 1, 2, 3, 4, 5, 6, and 10 minutes. If the ground anchor movement between 1 and 10 minutes exceeds 0.04 inches, continue holding the maximum test load and record ground anchor movement at 15, 20, 25, 30, 45, and 60 minutes.

Plot the ground anchor movement versus the maximum load for each test sequence in Table 256-1, and plot the residual movement of the tendon at each alignment load versus the highest previously applied load.

(c) Proof tests. Proof test all ground anchors that are not performance tested. Perform the proof test as indicated in Table 256-2.

Raise the load from one increment to another immediately after recording the ground anchor movement. Measure and record the ground anchor movement to the nearest 0.001 inch with respect to an independent fixed reference point at the alignment load, and at each load increment. Monitor the load with a pressure gauge.

Hold the maximum test load for a minimum of 10 minutes. Repump the jack as necessary in order to maintain a constant load. Begin the load-hold period as soon as the maximum test load is applied.

Measure and record the ground anchor movement at 1, 2, 3, 4, 5, 6, and 10 minutes. If the anchor movement between 1 and 10 minutes exceeds 0.04 inches, continue holding the maximum test load and record anchor movements at 15, 20, 25, 30, 45, and 60 minutes.

Table 256-2
Proof Test Load Sequence

Test Load Increment							
A	**0.25D**	**0.50D**	**0.75D**	**1.00D**	**1.20D**	**1.33D**	**Reduce to Lock-Off Load**
•	•	•	•	•	•	•	•

Note: A = Alignment load; D = Design load.

Plot the ground anchor movement versus load for each load increment in Table 256-2.

(d) Lock off. Upon completion of performance and proof tests, reduce the load to the specified lock-off load 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 Acceptance. See Table 256-3 for sampling and testing requirements.

Material for ground anchors will be evaluated under Subsections 106.02 and 106.03.

Construction of ground anchors and services will be evaluated under Subsections 106.02 and 106.04.

Grouting will be evaluated under Subsection 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 inches 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, the ground anchor carries the maximum test load with a creep rate that does not exceed 0.08 inches 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.

Replace all ground anchors with unacceptable performance or proof test results. Do not retest failed ground anchors.

Measurement

256.10 Measure the Section 256 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure performance tests that indicate acceptable installations.

Payment

256.11 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality (fine) (703.01)	Measured and tested for conformance (106.04)	Quality	—	AASHTO M 6	1 per material type	Source of material	Yes	Before producing
Grout mix design (722.02(e))	Measured and tested for conformance (106.04)	Flow	—	ASTM C 939	1 per mix design	Source of material	Yes, when requested	Before producing
		7-day compressive strength	—	AASHTO T 106	“	“	“	“

Section 257. — ALTERNATE RETAINING WALLS

Description

257.01 This work consists of constructing various types of retaining walls at the Contractor's option. The alternate wall types are gabions, crib walls, mechanically-stabilized earth walls, permanent ground anchor walls, and reinforced concrete retaining walls.

Material

257.02 Conform to the following Sections:

Crib walls	254
Driven piles	551
Gabions	253
Mechanically-stabilized earth walls	255
Permanent ground anchors	256
Reinforced concrete retaining walls	258
Reinforcing steel	554
Structural concrete	552

Construction Requirements

257.03 General. The designer/supplier furnishing the proposed wall is responsible for the stability of the wall. Do not qualify the responsibility for the design or restrict the use of the drawings or calculations for the proposed alternate. Indemnify the Government from all claims for infringement of proprietary rights by others without the consent of the patent holders or licensees.

257.04 Submittal. Submit a proposal using any of the wall types listed. Submit wall type proposals on a site-by-site basis. Different types may be used at individual sites on the project.

Survey according to Section 152, and verify the limits of the wall installation. Provide drawings of the proposed wall according to Subsection 104.03 within 120 days of the notice to proceed and at least 90 days before starting wall construction.

All drawings shall be signed by a professional engineer.

Include all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct the wall. Submit design calculations on sheets about 8½ by 11 inches in size with the project number, wall location, designation, date of preparation, initials of designer and checker, and page number at the top of the page.

Provide an index page with the design calculations. The drawings must include, but not be limited to, the following items:

(a) Plan and elevation drawings for each wall containing the following:

(1) A plan view of the wall identifying:

(a) Offset from the construction centerline to the face of the wall at its base at all changes in horizontal alignment;

(b) Limit of widest module, mesh, strip, or anchor; and

(c) Centerline of any drainage structure or drainage pipe behind, passing through, or passing under the wall.

(2) An elevation view of the wall identifying:

(a) Elevation at the top of the wall, at all horizontal and vertical break points, and at least every 50 feet along the wall;

(b) Elevations at the wall base, the top of leveling pads and footings, or the bottom of soldier piles;

(c) Wall batter;

(d) Distance along the face of the wall to all steps in the wall base, footings, leveling pads, or lagging;

(e) Type of panel or depth of module or lagging;

(f) Length and type of mesh, strips, or anchors;

(g) Distance along the face of the wall to where changes in length of the mesh, strips, or anchors occur; and

(h) Original and final ground line.

(3) General notes for constructing the wall.

(4) Horizontal and vertical curve data affecting the wall. Match lines or other details to relate wall stationing to centerline stationing.

(5) A listing of the summary of quantities on the elevation drawing of each wall.

(b) Dimensions and schedules of all reinforcing steel including reinforcing bar bending details, dowels, and studs for attaching the facing.

(c) Details and dimensions for foundations and leveling pads including steps in the footings or leveling pads.

(d) Details and dimensions for all:

(1) Panels, modules, soldier piles, and lagging necessary to construct the element;

(2) Reinforcing steel in the element;

(3) Location of mesh, strip attachment, or anchor devices embedded in the panels; and

(4) Anchors and soldier piling including the spacing and size of piles and the spacing and angle of anchors.

(e) Details for constructing walls around drainage facilities.

(f) Details for terminating walls and adjacent slope construction.

(g) Architectural treatment details.

(h) Design notes including an explanation of any symbols and computer programs used in the design of the walls. Specify the factors of safety for sliding, pullout, and overturning. Specify the bearing pressure beneath the wall footing, stabilized earth mass, or soldier piles.

(i) Verification of design criteria for the site specific wall locations with test procedures, results, and interpretations. Include results from creep, durability, construction induced damage, and junction strength tests.

(j) Other design calculations.

Process all submissions through the Contractor unless the Contractor gives written permission for the wall designer/supplier and the CO to communicate directly.

Submit 3 sets of the wall drawings with the initial submission. One set will be returned with any indicated corrections. If revisions are necessary, make the necessary corrections and resubmit 3 revised sets.

When the drawings are accepted, furnish 5 sets and a mylar sepia set of the drawings.

257.05 Construction. Construct the wall according to the accepted drawings and the following Sections, as applicable:

(a) Gabions. Section 253.

(b) Crib walls. Section 254.

(c) Mechanically-stabilized earth walls. Section 255.

(d) Permanent ground anchor walls. Sections 256, 551, and 552.

(e) Reinforced concrete retaining walls. Section 258.

Revise the drawings when plan dimensions are revised due to field conditions or for other reasons.

257.06 Acceptance. Material for alternate retaining walls will be evaluated under Subsection 106.02, 106.03, or 106.04 according to the applicable sections listed in Subsection 257.05.

Construction of alternate retaining walls and services will be evaluated under Subsections 106.02 and 106.04 according to the applicable sections listed in Subsection 257.05.

Structure excavation and backfill will be evaluated under Section 209.

Measurement

257.07 Measure the Section 257 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure foundation fill under Section 208.

Payment

257.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 257 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

When plan dimensions are changed by the CO during construction to account for field conditions, the lump sum price of the wall will be adjusted by applying a calculated per square foot cost adjustment factor to the added or decreased wall front face area.

The adjustment factor will be determined by dividing the lump sum price bid for each wall by its estimated area.

The alternate retaining wall lump sum will be paid based on the progress of the work under this Section.

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 Sections and Subsections:

Concrete	552
Forms and falsework	562
Joint fillers and sealants	712.01
Reinforcing steel	709.01
Structural backfill	704.04
Tie bars, dowel bars, and hook bolts	709.01

Construction Requirements

258.03 General. Survey according to Section 152, and verify the limits of the wall installation. Prepare and submit forms and falsework drawings according to Section 562. Perform the work under Section 209.

258.04 Reinforcing Steel. Submit all order lists and bending diagrams according to Subsections 104.03 and 554.03. Fabricate reinforcing steel according to Subsection 554.05. Ship and protect material according to Subsections 554.04 and 554.06. Place, fasten, and splice reinforcing steel according to Subsections 554.08 and 554.09.

258.05 Structural Concrete. Design concrete mixture according to Subsection 552.03. Store, handle, batch, and mix material and deliver concrete according to Subsections 552.04 through 552.08. Provide quality control according to Section 153 and Subsection 552.09. Construct wall according to Subsections 552.10 through 552.16.

258.06 Backfilling. Backfill the area behind the wall with structural backfill according to Subsection 209.10. Compact each layer according to Subsection 209.11 except use an approved lightweight mechanical or vibratory compactor within 3 feet of the wall.

258.07 Acceptance. Reinforced concrete retaining wall material, construction, and services will be evaluated as follows:

Survey work will be evaluated under Section 152.

Forms and falsework drawings will be evaluated under Section 562.

Structure excavation and backfill will be evaluated under Section 209.

Concrete will be evaluated under Section 552.

Reinforcing steel will be evaluated under Section 554.

Material for joint fillers, sealants, tie bars, dowel bars, and hook bolts will be evaluated under Subsections 106.02 and 106.03.

Measurement

258.08 Measure the Section 258 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure by the cubic yard of concrete in the structure including footings.

Measure the square foot area by the length of the front wall face and the height excluding footings.

Measure foundation fill under Section 208.

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.

The accepted quantities of reinforced concrete retaining wall will be paid for at the contract unit bid price multiplied by an adjusted pay factor (PF_a) determined as follows:

$$PF_a = 1 - 0.5\,(1 - PF)$$

where:

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.

Material

259.02 Conform to the following Section and Subsections:

Bolts and nuts	717.01(d)
Centralizers	722.02(f)
Geocomposite sheet drain	714.02(b)
Grout	722.02(e)
Shotcrete	566
Soil nails	722.04
Structural backfill	704.04
Structural steel (bearing plates)	717.01(a)
Welded stud sheer connectors	717.05

Construction Requirements

259.03 Qualifications. The Contractor or subcontractor must demonstrate satisfactory completion of at least 5 permanent soil nail-retaining wall projects during the past 3 years, totaling at least 10,000 square feet of wall face area and at least 500 permanent soil nails. Submit a brief description of each project including the owning agency's name, contact person, and current telephone number.

Provide a professional engineer with experience in constructing at least 3 soil nail-retaining walls over the past 5 years. Provide on-site supervisors and drill operators with experience installing permanent soil nails on at least 3 projects over the past 5 years. At least 30 days before starting soil nail work, identify the engineer, on-site supervisors, and drill operators assigned to the project and submit a summary of each individual's experience.

259.04 General. Survey according to Section 152 and verify the limits of the wall installation.

259.05 Construction Plan. At least 30 days before starting soil nail-retaining wall work, submit the following according to Subsection 104.03:

(a) Start date and proposed retaining wall construction sequence. Include the proposed method of excavating to ensure wall and slope stability.

(b) Drilling methods and equipment. Include drill hole diameter to achieve the specified pullout resistance values and any variation of drill hole diameter or specific pullout resistance along the wall alignment.

(c) Nail grout mix design, placement procedures, and equipment. Include test results conducted according to AASHTO T 106 and supplied by a qualified testing lab verifying grout 3-day and 28-day compressive strengths. Previous test results for the same grout mix completed within one year of grouting are acceptable.

(d) Soil nail testing methods and equipment setup.

(e) Identification number and calibration test results for each test jack, pressure gauge, and load cell. Calibrate the test jack and pressure gauge as one unit. Submit results from calibration tests conducted by an independent testing laboratory within the previous 90 days.

(f) Ultimate strength of proposed soil nail tendons.

259.06 Excavation. Complete any clearing and excavation above the wall area according to Sections 201 and 204 before commencing wall excavation. Do not perform any of the wall excavation before beginning the wall construction. A work bench for the drilling equipment may be provided by placing material excavated from elsewhere on the project in front of the soil nail wall area.

Perform excavation for the wall in lifts concurrent with soil nail installation and shotcrete placement. Do not allow the exposed unsupported final excavation face cut height to exceed the vertical nail spacing plus the required reinforcing lap or the short-term stand-up height of the ground, whichever is less. Complete excavation to the final wall excavation line and application of the shotcrete in the same work shift. 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. A stabilizing berm of soil may be left in place to contain the lift face during nail installation.

Do not excavate to the next lower lift until nail installation, reinforced shotcrete placement, attachment of bearing plates and nuts, and nail testing have been completed and accepted in 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.

259.07 Nail Installation.

(a) Storing and handling. Store and handle soil nail tendons in a manner that avoids damage or corrosion. Replace tendons exhibiting abrasions, cuts, weld splatter, corrosion, or pitting. Repair or replace any tendons exhibiting damage to the encapsulation or epoxy coating.

(b) Fabrication. Provide tendons threaded a minimum of 6 inches to allow proper attachment of bearing plate and nut. Threading may be continuous spiral deformed ribbing provided by the bar deformations or may be cut into the reinforcing bar. Use the next larger bar size if threads are cut into the reinforcing bar. When appropriate, repair damage to the epoxy coating with a minimum 12 mil-thick coating.

Provide centralizers sized to position the tendon within 1 inch of the center of the drill hole. Position centralizers a maximum of 10 feet apart and within 24 inches from the top and bottom of the tendon. Use centralizers that do not impede the free flow of grout into the drill hole.

(c) Drilling. Drill holes for the soil nails at the locations and to the orientation shown on the plans. Select drilling equipment and methods suitable for the ground conditions. Do not use water, drilling mud, or other fluids for drilling or removing cuttings. If unstable ground is encountered, use cased drilling methods to support the circumference of the drill holes. Self-drilling tendons are not acceptable.

(d) Grouting. Insert the nail tendon into the hole and grout the drill hole within 2 hours of completing drilling. Inject the grout at the lowest point of each drill hole through a grout tube, casing, hollow-stem auger, or drill rods. Completely fill the drill hole in one continuous operation. To prevent voids, keep the outlet end of the grout conduit below the surface of the grout as the conduit is withdrawn. Cold joints in the grout column are only allowed at the top of the test bond length of proof-tested production nails.

Maintain the temporary unbonded length of proof test nails open for subsequent grouting. If the unbonded test length of production proof test nails cannot be satisfactorily grouted subsequent to testing, install a new nail in its place.

259.08 Nail Testing. Perform both verification and proof testing of designated test nails. Do not test any nail until the nail grout and shotcrete facing have cured for at least 72 hours and attained the specified 3-day compressive strength.

(a) Testing equipment. Furnish two dial gauges, dial gauge support, jack and pressure gauge, electronic load cell, and a reaction frame. The load cell is required for verification tests only.

Use pressure gauges graduated in no greater than 100-pound per square inch increments. Measure the nail head movement with a minimum of two dial gauges capable of measuring to 0.001 inch.

(b) Verification test. Perform verification tests on sacrificial test nails at locations shown on the plans. Perform verification tests before installation of production nails to verify drilling and installation methods, nail pullout resistance, and design assumptions.

Provide verification test nails with both bonded and unbonded lengths. The minimum unbonded length is 3 feet and the minimum bonded length is 10 feet. Determine the maximum bonded length based on the verification nail bar grade and size to avoid exceeding the allowable bar structural load during testing. Provide larger bar sizes if required to safely accommodate the 10-foot minimum test bond length and testing to twice the allowable pullout resistance.

Use the following formula to determine the maximum bonded length:

$$L_{BV\max} = \frac{Cf_y A_s}{2Q_d}$$

where:

L_{BVmax}	=	Maximum verification test nail bonded length (feet)
C	=	0.9 for grades 60 and 75 bars and 0.8 for grade 150 bars
f_y	=	Bar yield or ultimate stress (pounds per square inch)
A_s	=	Bar steel area (suare inches)
Q_d	=	Allowable pullout resistance (pounds per foot)

Determine the design test load by the following equation:

$$DTL = L_{BV} \times Q_d$$

where:

DTL	=	Design test load (pounds)
L_{BV}	=	As-built bonded test length (feet)
Q_d	=	Allowable pullout resistance (pounds per foot)

Perform tests by incrementally loading the verification test nails as indicated in Table 259-1. Measure and record soil nail movement at each load increment.

The alignment load is the minimum load required to align the testing apparatus and should not exceed 5 percent of the design test load. Set dial gauges to “zero” after applying the alignment load. Following application of the maximum load, reduce the load to the alignment load and record the permanent set.

Hold each load increment for at least 10 minutes. Monitor the verification test nail for creep at the 1.50 DTL load increment by measuring and recording nail movement at 1, 2, 3, 5, 6, 10, 20, 30, 50, and 60 minutes. Maintain the load during the creep test within 2 percent of the intended load by use of the load cell.

Table 259-1
Verification Test Load Schedule

Test Load Increment	Hold Time (minutes)
AL (0.05DTL max.)	1
0.25DTL	10
0.50DTL	10
0.75DTL	10
1.00DTL	10
1.25DTL	10
1.50DTL (creep test)	60
1.75DTL	10
2.00DTL (maximum load)	10
AL	1

Note: AL = Alignment load; DTL = Design test load.

(c) Proof testing of production nails. Perform proof tests on production nails at locations selected by the CO. Perform successful proof testing on 5 percent of the production nails in each nail row or a minimum of 1 per row.

Provide production proof test nails with both bonded and temporary unbonded lengths. The minimum temporary unbonded length is 3 feet. Determine the maximum bonded length based on the production nail bar grade and size to avoid exceeding the allowable bar structural load during testing. Provide a test nail bonded length of 10 feet or L_{BPmax}, whichever is less.

Use the following formula to determine the maximum bonded length:

$$L_{BP\max} = \frac{Cf_y A_s}{1.5Q_d}$$

where:

L_{BPmax} = Maximum proof test nail bonded length (m)

C = 0.9 for grade 60 and 75 bars and 0.8 for grade 150 bars

f_y = Bar yield or ultimate stress (pounds per square inch)

A_s = Bar steel area (square inches)

Q_d = Allowable pullout resistance (pounds per foot)

Determine the design test load by the following equation:

$$DTL = L_{BP} \times Q_d$$

where:

DTL = Design test load (pounds)

L_{BP} = As-built bonded test length (feet)

Q_d = Allowable pullout resistance (pounds per foot)

Perform proof tests by incrementally loading the proof test nail to 150 percent of the design load as indicated in Table 259-2. Measure and record soil nail movement at each load increment.

Table 259-2
Proof Test Load Schedule

Test Load Increment	Hold Time (minutes)
AL (0.05DTL max.)	Until stable
0.25DTL	Until stable
0.50DTL	Until stable
0.75DTL	Until stable
1.00DTL	Until stable
1.25DTL	Until stable
1.50DTL (maximum load)	See below

Note: AL = Alignment load; DTL = Design test load.

The alignment load should be the minimum load required to align the testing apparatus and should not exceed 5 percent of the design test load. Set dial gauges to "zero" after the alignment load has been applied.

Perform either 10-minute or 60-minute creep tests at the maximum load. Start the creep period after the maximum test load is applied. Measure and record nail movement at 1, 2, 3, 5, 6, and 10 minutes. When the nail movement between 1 minute and 10 minutes exceeds 0.04 inches, maintain the maximum test load an additional 50 minutes, recording movement at 20, 30, 50, and 60 minutes. Maintain all load increments within 5 percent of the intended load.

259.09 Wall Drainage Network. Install drain strips, PVC connector pipes, wall footing drains, and weepholes as shown on the plans. Exclusive of the wall footing drains, install all elements of the drainage network, as appropriate, before shotcreting each lift.

Install geocomposite sheet drain strips centered between nail columns with the geotextile side against the ground. Add additional drain strips at locations where seepage is obvious. Secure strips to the excavated face to prevent shotcrete from contaminating the ground side of the geotextile. Construct drain strip splices with a 12-inch overlap so that the drain is vertically continuous and the splice does not impede the flow of water. Install a drain plate and connector pipe at the base of each strip.

Place PVC pipe sections, as required, to act as weepholes through the construction shotcrete face.

Install footing drains at the bottom of the wall according to Section 605.

259.10 Wall Construction. Place steel welded wire mesh and reinforcing steel according to Section 554.

Construct shotcrete facing according to Section 566. Completely fill the top ungrouted zone of any nail drill holes or other voids with shotcrete.

Attach a bearing plate and nut to each nail head. While the shotcrete is still plastic, uniformly seat the plate by tightening the nut with a hand wrench. 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.

Construction tolerances for wall elements are shown in Table 259-3.

Table 259-3
Wall Element Construction Tolerances

Wall Element	Tolerance
Horizontal location of headed studs, from plan location	3/8 inch
Location of headed studs on bearing plate, from plan location	1/4 inch
Nail head bearing plate, deviation from parallel to wall face	10 degrees

259.11 Permanent Wall Facing. Construct the permanent wall facing according to the applicable Subsection below. When applicable, finish surfaces with simulated stone masonry according to Section 613.

(a) Shotcrete-faced walls. Construct shotcrete facing according to Section 566. Construction tolerances for the permanent shotcrete facing are shown in Table 259-4.

(b) Concrete-faced walls. Construct according to Section 258.

Table 259-4
Permanent Shotcrete Facing Construction Tolerances

Facing Finish	Tolerance
Complete thickness of shotcrete, from plan dimension: Troweled or screeded finish Shot finish	 5/8 inch 1⅛ inches
Planeness of finish face, surface gap under a 10-foot straightedge: Troweled or screeded finish Shot finish	 5/8 inch 1⅛ inches

259.12 Backfilling Behind Wall Facing Upper Cantilever Section. Where the wall facing has an upper cantilever section, backfill with structural backfill according to Subsection 209.10. Compact backfill according to Subsection 209.11 within 3 feet behind this wall facing section using light mechanical tampers.

259.13 Acceptance. Soil nail retaining wall material, construction, and services will be evaluated as follows:

Survey work will be evaluated under Section 152.

Material for the soil nails will be evaluated under Subsections 106.03 and 106.04.

Construction of soil nails and services will be evaluated under Subsections 106.02 and 106.04.

Installed soil nails will be evaluated based on the criteria in Table 259-5.

Table 259-5
Nail Acceptance Criteria

Type of Nail Test	Total Creep Movement	Total Movement at Maximum Load(2)	Pullout Failure?(3)
Verification	< 0.080 inches between 6 and 60 minutes(1)	>80%	No
Proof	< 0.040 inches between 1 and 10 minutes, or < 0.080 inches between 6 and 60 minutes(1)	>80%	No

(1) And the creep rate is linear or decreasing throughout the creep test load hold period.
(2) Percent of the theoretical elastic elongation of the test nail unbonded length.
(3) Pullout failure is defined as the inability to further increase the test load while there is continued pullout movement of the test nail. Record the pullout failure load as part of the test data.

If a verification test fails, propose alternate installation methods before installing additional verification test nails and install a replacement verification test nail.

If a proof test fails, replace some or all of the installed production nails between the failed proof test nail and the next proof test nail in the row, as directed. Alternatively, install additional proof test nails within this area to ensure that the acceptance criteria is being met within this area. Propose alternative methods before installing additional soil nails.

Measurement

259.14 Measure the Section 259 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure soil nail retaining walls by the square foot of front wall face.

Measure verification test nails by the each. Do not measure failed verification test nails or additional verification test nails installed to verify alternative nail installation methods proposed by the Contractor.

Measure production soil nails by the linear foot. Measure along bar centerline from the line of the wall excavation face to the tip of the nail.

Do not measure temporary stabilization berms.

Do not measure wall excavation.

Payment

259.15 The accepted quantities will be paid for at the contract unit 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 259-6
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Centralizers	Certification of compliance (106.03)	Quality & performance	—	Subsection 722.02(f)	Each shipment	Source	—	Before using in work
Soil nails	Certification of compliance (106.03)	Quality & performance	—	Subsection 722.04	Each shipment	Source	—	Before using in work
Epoxy coating	Certification of compliance (106.03)	Quality & performance	—	Subsection 722.04(c)	Each shipment	Source	—	Before using in work
Geocomposite sheet drain	Certification of compliance (106.03)	Quality & performance	—	Subsection 714.02(b)	Each shipment	Source	—	Before using in work
Grout mix design	Certification of compliance (106.03)	Quality & strength	—	Subsection 259.05	1 per source of material	—	—	30 days before beginning soil nail work

**Table 259-6 (continued)
Sampling and Testing Requirements**

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Nail grout	Measured and tested for conformance (106.04)	Compressive strength	—	Subsection 722.02(e) AASHTO T 106	1 per mix design	Mixer	—	30 days before beginning soil nail work
Verification test nail	Measured and tested for conformance (106.04)	Performance	—	Subsection 259.08(b) Table 259-5	Each verification nail	Installation	—	—
Proof test nail	Measured and tested for conformance (106.04)	Performance	—	Subsection 259.08(c) Table 259-5	Each proof nail	Installation	—	—
Wall elements	Measured and tested for conformance (106.04)	Installation	—	Table 259-3	—	Installation	—	—
Permanent shotcrete facing	Measured and tested for conformance (106.04)	Placement	—	Table 259-4	—	Installation	—	—

Section 260. — ROCK BOLTS

Description

260.01 This work consists of furnishing and installing tensioned rock bolts.

Material

260.02 Conform to the following Subsections:

Grout	722.02(e)
Rock Bolts	722.03

Construction Requirements

260.03 Submittal. At least 14 days before the installation of rock bolts, submit the following information:

(a) Evidence that the foreman has a minimum of 1500 hours and the drill operator has a minimum of 1000 hours of satisfactory work in similar installation of post-tensioned rock bolts.

(b) Construction sequence and schedule.

(c) Drilling methods and type of equipment.

(d) Proposed rock bolt, couplers, bearing plate, anchor unit, flat washer, and beveled washer specifications including manufacturer's data sheets and specifications for any additional hardware items.

(e) If using cartridged polyester-resin adhesives, include manufacturer's data sheets and placement procedures.

(f) Proposed grout mix design.

(g) Calibration data for each torque wrench to be used. Submit results of calibration test performed by an independent testing laboratory within the last 60 days.

Allow 7 days for acceptance or rejection. Do not begin work until submittals have been approved.

260.04 Rock Bolt. Size the bolt so the design load does not exceed 60 percent of the minimum guaranteed ultimate tensile strength of the bolt. Select and fabricate bolts to carry the specified loads.

Couple only grouted bolts. Couple sections together when standard, commercially-available lengths are exceeded. Provide a center stop for connecting sections so that an equal length of thread connects each section. Provide couplings that equal the manufacturer's guaranteed ultimate strength for the rock bolt. Do not fabricate couplings in a manner that interferes with the flow of grout.

260.05 Handling and Storage. Protect bolts from dirt, mud, water, and other harmful substances to avoid damage and corrosion. Do not use rock bolts that are heavily corroded, pitted, damaged due to welding, or show signs of abrasions, cuts, or nicks.

260.06 Installation. Drill holes at the locations and orientations shown in the plans or as directed by the CO and to the diameter specified by the bolt manufacturer. Clean holes of all drill cuttings, sludge, and debris before the rock bolt is inserted or grout is injected into the hole. Insert bolt into the hole. Attach the bearing plate, washer, and nut to the bolt with the threaded outer end of the bolt projecting beyond the nut at least 2 inches.

For grout-anchored bolts, inject sufficient grout into the drill hole to fill the bond zone around the bolt. Apply tension to bolt after the time specified in Table 260-1.

Table 260-1
Grout Curing Time

Cement Type	Curing Time (Days)
I	5
II	5
III	3

For bolts anchored with polyester resin, use fast-setting polyester resin cartridges in the bond zone and slow-setting polyester resin cartridges in the no load zone with gel times consistent with rapid installation. Select cartridge diameters in accordance with the manufacturer's recommendations to ensure complete encapsulation of the rock bolt and satisfactory in-hole mixing. Break and mix resin cartridges by spinning the bolt as it is inserted into the drill hole according to the manufacturer's instructions.

For mechanically-anchored, hollow-stem rock bolts, tension the bolt before grouting. After grouting, inject grout through the hollow core of the bolt or through a grout tube until the space between the bolt and drill hole wall is filled and grout is forced out of the de-airing tube at the face of the hole.

260.07 Tensioning. Apply tension to the bolt with a calibrated torque wrench to 125 percent of the design load. After tensioning, lock bolt off at the specified design load.

Tension polyester resin-anchored bolts immediately after the fast-set resin in the bond zone has set up and before the slow-set resin in the unbonded zone has set up.

Tension grouted bolts after the bonded length has been grouted and the grout has set up but before the unbonded length is grouted.

Tension mechanically-anchored rock bolts immediately after insertion into the drill hole according to the manufacturer's recommendations.

Allow the bolt to remain in place if:

(a) The bolt can be tensioned to 125 percent of the design load and the load can be held for 10 minutes.

(b) The design load is maintained after final grouting has been accomplished.

Replace any bolt that does not meet (a) or (b) in a manner and in a location approved by the CO.

260.08 Acceptance. Material for rock bolts will be evaluated under Subsection 106.02 and 106.03.

Installation of rock bolts will be evaluated under Subsections 106.02 and 106.04.

Measurement

260.09 Measure the Section 260 items listed in the bid schedule according to Subsection 109.02.

Payment

260.10 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.

Section 261. — ROCK DOWELS

Description

261.01 This work consists of furnishing and installing rock dowels.

Material

261.02 Materials. Conform to the following Sections and Subsections:

Concrete	601
Grout	722.02(e)
Reinforcing steel	709.01(b)
Shotcrete	566

Supply reinforcing steel for dowels in the form of deformed or threaded bar.

Construction Requirements

261.03 General. Install dowels at the locations and to the depths shown on the plans or directed by the CO.

261.04 Drilling. Drill holes for dowels perpendicular to the supporting rock surface and as close as possible to the rock that is to be supported. Drill holes for rock dowels a minimum of 1 inch larger than the dowel diameter.

261.05 Installation. Partially fill the dowel hole with grout. Place and center the dowel in the drill hole. Inject sufficient grout to fill the remainder of the hole. Encase the length of dowel protruding from the hole with a sufficient amount of shotcrete or hand-packed concrete to completely encapsulate the dowel and fill the space between the dowel and the surface of the rock to be supported. Construct forms as necessary to contain the shotcrete or concrete until it has hardened.

261.06 Acceptance. Material for dowels will be evaluated under Subsections 106.02 and 106.03.

Installation of rock dowels will be evaluated under Subsections 106.02 and 106.04.

Measurement

261.07 Measure the Section 261 items listed in the bid schedule according to Subsection 109.02.

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.

DIVISION 300

AGGREGATE COURSES

Section 301. — UNTREATED AGGREGATE COURSES

Description

301.01 This work consists of constructing one or more courses of aggregate on a prepared surface.

Subbase and base aggregate grading is designated as shown in Table 703-2.

Material

301.02 Conform to the following Subsections:

Aggregate	703.05
Water	725.01

Construction Requirements

301.03 General. Prepare the surface on which the aggregate course is placed according to Section 204 or 303 as applicable.

After a representative quantity of aggregate is produced, submit proposed target values for the appropriate sieve sizes along with a representative 300-pound sample at least 14 days before incorporating the aggregate into the work.

Set target values within the gradation ranges shown in Table 703-2 or 703-3 for the required grading.

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 layer.

Do not place the mixture in a layer exceeding 6 inches in compacted thickness. When more than one layer is necessary, compact each layer according to Subsection 301.05 before placing the next layer. 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 each layer full width. Roll from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and all places not accessible to the roller, compact the material with approved tampers or compactors.

Compact each layer to at least 95 percent of maximum density. Determine the inplace 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 grade finishing stakes are not required, shape the surface to the required template and check the surface with a 10-foot straightedge. Defective areas are surface deviations in excess of 1/2 inch in 10 feet between any two contacts of the straightedge with the surface.

Correct all 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 any combination thereof until placement of the next course. Correct all defects according to Subsection 301.06.

301.08 Acceptance. See Table 301-1 for sampling and testing requirements and the acceptance quality characteristic category.

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 703-2 and 703-3, except as follows:

(1) If the calculated mean value for any tested sieve exceeds the maximum gradation value shown in Table 703-2 or 703-3, the upper specification is equal to the maximum gradation value plus the allowable deviation, and the lower specification is equal to the maximum gradation value minus the allowable deviation.

(2) If the calculated mean value for any tested sieve is less than the minimum gradation value shown in Table 703-2 or 703-3, the upper specification is equal to the minimum gradation value plus the allowable deviation and the lower specification is equal to the minimum gradation value minus the allowable deviation.

(b) Plasticity index. The upper and lower specification limits for surface courses are shown in Table 703-3.

Construction of untreated aggregate courses will be evaluated under Subsections 106.02 and 106.04.

Preparation of the surface on which the aggregate course is placed will be evaluated under Section 204 or 303 as applicable.

Measurement

301.09 Measure the Section 301 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure aggregate by the cubic yard in the hauling vehicle.

Measure square yard width horizontally to include the top of aggregate width including designed widenings. Measure the square yard length horizontally along the centerline of the roadway.

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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality 703.05(a)	Measured and tested for conformance (106.04& 105)	LA abrasion (coarse)	—	AASHTO T 96	1 per type & source of material	Source of material	Yes, when requested	Before using in work
		Sodium sulfate soundness loss (coarse & fine)	—	AASHTO T 104	“	“	“	“
		Durability index (coarse & fine)	—	AASHTO T 210	“	“	“	“
		Fractured faces	—	ASTM D 5821	“	“	“	“
Subbase courses grading A & B	Statistical (106.05)	Gradation		AASHTO T 27 & T 11	1 per 1000 tons	From windrow or road bed after processing	Yes	4 hours
		No. 4	I					
		No. 200	I					
		Other specified sieves	II					

Table 301-1 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
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
		3/8 inch	I					
		No. 4	I					
		No. 200	I					
		Other specified sieves	II					
Subbase & base course grading A, B, C, D & E	Measured and tested for conformance (106.04)	Liquid limit	—	AASHTO T 89	1 per 1000 tons	From windrow or roadbed after processing	Yes	4 hours
		Moisture-density (max. density)	—	AASHTO T 180, method D (1)	1 per type & source of material	Material source before using	Yes	
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Table 301-1 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
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					
		Liquid limit	II	AASHTO T 89	"	"	"	"
		Plasticity index	I	AASHTO T 90	"	"	"	"
	Measured and tested for conformance (106.04)	Moisture-density (max. density)	—	AASHTO T 180, method D [1]	1 per type & source of material	Source of material	Yes	Before using in work
		Density	—	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place	—	Before placing next layer
		Fractured faces	—	ASTM D5821	1 per 1000 tons	From windrow on roadbed after processing	Yes	Before using in work

(1) Minimum of 5 points per proctor.

Section 302. — TREATED AGGREGATE COURSES

Description

302.01 This work consists of constructing one or more courses of an aggregate and cement mixture or an aggregate, fly ash, lime, and cement (AFLC) mixture on a prepared roadbed.

Treated aggregate courses are designated as cement or AFLC.

Aggregate grading is designated as shown in Table 703-2.

Material

302.02 Conform to the following Subsections:

Aggregate	703.05
Blotter	703.13
Chemical admixture (set-retarding)	711.03
Emulsified asphalt	702.03
Fly ash	725.04
Hydraulic cement	701.01
Lime	725.03
Water	725.01

Construction Requirements

302.03 Proportioning. Submit a treated aggregate course mix design 30 days before production.

Provide a minimum average compressive strength of 500 pounds per square inch with no single test lower than 400 pounds per square inch. Mold, cure, and test samples of the AFLC mixture according to ASTM C 593, parts 10 and 11 except revise the curing period from 7 to 28 days at 100±3 ºF.

For aggregate and cement mixtures, meet the design parameters in Table 302-1.

Table 302-1
Range of Aggregate/Cement
Mix Design Parameters

Material	Percent(1)
Aggregate	90 - 96
Hydraulic cement	4 - 10

(1) By mass of total dry mix.

For AFLC mixtures, meet the design parameters in Table 302-2.

Table 302-2
Range of AFLC Mix Design Parameters

Material	Percent(1)
Aggregate	75 - 92
Fly ash	6 - 20
Lime and hydraulic cement	2 - 5

(1) By mass of total dry mix.

Include the following with the mix design, as applicable:

(a) Source of each component material;

(b) Results of the applicable tests;

(c) Target values for each aggregate sieve size specified as applicable;

(d) 200-pound sample of aggregate;

(e) 50-pound sample of fly ash;

(f) 25-pound sample of lime;

(g) 25-pound sample of hydraulic cement; and

(h) 5-pound sample of the retarder or other admixtures.

Begin production only after the mix design is approved. Furnish a new mix design if there is a change in a material source.

302.04 General. Store chemical additives and admixtures in closed, weatherproof containers. Prepare the surface on which the treated aggregate course is placed according to Section 204 or 303 as applicable. Determine the optimum moisture content according to AASHTO T 180, method D.

302.05 Mixing. Do not begin mixing operations when the atmospheric temperature is expected to fall below 40 ºF within 48 hours. Do not place a treated aggregate course when the underlying surface is frozen, muddy, or when it is raining or snowing.

Mix the components with suitable equipment until a uniform mixture is obtained. During mixing, add sufficient water to obtain the optimum moisture content for compaction plus 2 percent.

Equip the mixer with batching or metering devices for proportioning the components either by mass or volume. Maintain the accuracy of the amounts of aggregate, chemical additives, and water (based on total dry mass) within the following tolerances:

Aggregate	±2.0% by mass
Fly ash	±1.5% by mass
Lime or cement	±0.5% by mass
Retarder or other additive	±2.0% by mass
Water	±2.0% by mass

A retarder may be used to slow initial set for a maximum of 2 hours. Dissolve retarder in water, and uniformly add the solution to the mixture.

When a central plant is used, transport the mixture in vehicles that maintain moisture content and prevent segregation and loss of the fine material.

302.06 Placing, Compacting, and Finishing. Place, compact, and finish the treated aggregate course according to Subsections 301.04, 301.05, and 301.06. Maintain the moisture content (±2 percent of optimum) during placing and finishing.

Do not leave any treated aggregate that has not been compacted undisturbed for more than 30 minutes. Complete the compaction and finishing within 1 hour (longer with a retarder) from the time water is added to the mixture. Make the compacted surface smooth, dense, and free of compaction planes, ridges, or loose material.

If the time between placing adjacent partial widths exceeds 30 minutes, provide a construction joint.

302.07 Construction Joints. For lime and fly ash mixtures, tie each day's operation into the completed work of the previous day by remixing approximately 2 feet of the completed course before processing additional sections. Add 50 percent of the original amount of lime or fly ash to the remixed material.

For cement mixtures or when a lime or fly ash mixture remains undisturbed for more than 24 hours, make a transverse construction joint by cutting back into the completed work to form an approximately vertical face.

302.08 Curing. Do not allow traffic on the treated aggregate course. Keep the completed layer or course continuously moist until the next layer or course is placed. Apply water under pressure through a spray bar equipped with nozzles producing a fine, uniform spray. Place and compact the next layer or course within 7 days after compacting and finishing the treated aggregate course.

Placement of the next course may be deferred up to 21 days by sealing the surface with rapid setting emulsified asphalt. Do not seal intermediate layers of a course. Keep surface continuously moist for at least 7 days after compacting and finishing. After the 7 days, apply undiluted CRS-2 or RS-2 emulsified asphalt at a rate of 0.25 gallons per square yard according to Section 409. Provide a continuous film over the surface. If the surface is opened to public traffic, furnish and apply blotter according to Section 411.

If the treated aggregate course looses stability, density, or finish before placement of the next course or acceptance of the work, reprocess, recompact, and add additives as necessary to restore the strength of the damaged material. Reapply the emulsified asphalt seal where the continuous film is damaged.

302.09 Acceptance. See Table 302-3 for sampling and testing requirements and the acceptance quality characteristic category.

Fly ash, lime, cement, and chemical admixtures will be evaluated under Subsections 106.02 and 106.03. Emulsified asphalt will be evaluated under Subsections 106.03 and 702.09.

(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 703-2 and 703-3, except as follows:

(1) If the calculated mean value for any tested sieve exceeds the maximum gradation value shown in Table 703-2 or 703-3, the upper specification is equal to the maximum gradation value plus the allowable deviation, and the lower specification is equal to the maximum gradation value minus the allowable deviation.

(2) If the calculated mean value for any tested sieve is less than the minimum gradation value shown in Table 703-2 or 703-3, the upper specification is equal to the minimum gradation value plus the allowable deviation and the lower specification is equal to the minimum gradation value minus the allowable deviation.

Construction of treated aggregate courses will be evaluated under Subsections 106.02 and 106.04.

Preparation of the surface on which the treated aggregate course is placed will be evaluated under Section 204 or 303 as applicable.

Emulsified asphalt seal will be evaluated under Section 409.

Blotter will be evaluated under Section 411.

Measurement

302.10 Measure the Section 302 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure the square yard width horizontally to include the top of aggregate width including designed widenings. Measure the square yard length horizontally along the centerline of the roadway.

Measure emulsified asphalt under Section 409.

Measure blotter under Section 411.

Payment

302.11 The accepted quantities will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 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 302-3
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate (703.05)	Statisical (106.05)	Gradation [1]		AASHTO T 27 & T 11	1 per 1000 tons	From windrow or roadbed after processing	Yes, when requested	4 hours
		3/8 inch	I					
		No. 4	I					
		No. 200	I					
		Other specified sieves	II					
		Liquid limit	—	AASHTO 89	1 per 3000 tons	"	"	
Mixture (302)	Measured and tested for conformance (106.04)	Moisture-density	—	AASHTO T 180, method D [1]	1 per aggregate grading produced	Processed material before incorporating in work	Yes, when requested	Before using in work
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Section 303. — ROAD RECONDITIONING

Description

303.01 This work consists of reconditioning ditches, shoulders, roadbeds, and aggregate surfaces.

Material

303.02 Conform to the following Subsection:

Water	725.01

Construction Requirements

303.03 Ditch Reconditioning. Remove all slide material, sediment, vegetation, and other debris from the existing ditches and culvert inlets and outlets. Reshape ditches and culvert inlets and outlets to achieve positive drainage and a uniform ditch width, depth, and grade. Dispose of waste according to Subsection 204.14.

303.04 Shoulder Reconditioning. Repair soft and unstable areas according to Subsection 204.07. Remove all slide material, vegetation, and other debris from existing shoulders including shoulders of parking areas, turnouts, and other widened areas. Reshape shoulders and dispose of waste according to Subsection 204.14.

303.05 Roadbed Reconditioning. Repair soft and unstable areas according to Subsection 204.07. Remove all organic, deleterious, or oversize material larger than 6 inches from the top 6 inches of subgrade. Dispose of waste according to Subsection 204.14. Scarify to a 6-inch depth, remove surface irregularities, and shape to provide a uniform surface. Finish earth surfaces to within 0.05 feet and rock surfaces to within 0.10 feet of the required line, cross-section, and grade. Compact according to Subsection 204.11.

303.06 Aggregate Surface Reconditioning. Repair soft and unstable areas to the full depth of the aggregate surface and according to Subsection 204.07. Scarify to the depth of the aggregate surface or to a depth of 8 inches, whichever is less, and remove surface irregularities. Reshape, finish, and compact the entire aggregate surface according to Section 308.

303.07 Roadway Reconditioning. Perform all the applicable work described in Subsections 303.03 through 303.06.

303.08 Pulverizing. Scarify the surface to the designated depth and width. Pulverize all material to a size one and one half times the maximum sized aggregate or to 1½ inches, whichever is greater. Mix, spread, compact, and finish the material according to Section 301.

303.09 Acceptance. See Table 303-1 for sampling and testing requirements. Road reconditioning work will be evaluated under Subsections 106.02 and 106.04.

Measurement

303.10 Measure the Section 303 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure ditch reconditioning and shoulder reconditioning by the station or foot horizontally along the centerline of the roadway for each side of the roadway.

Measure roadbed reconditioning, aggregate surface reconditioning, roadway reconditioning, and pulverizing by the station or by the square yard. Measure the square yard area on a horizontal plane. Do not measure isolated areas less than 20 square yards.

Measure waste under Section 204.

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 and Testing and Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Existing roadbed	Measured and tested for conformance (106.04)	Classification	—	AASHTO M 145	1 per soil type	Roadbed	Yes, when requested	Before using in work
		Moisture-density	—	AASHTO T 180, method D (1)	1 for each mixture or change in material	Processed material before incorporating in work	—	Before using in work
		In-place density & moisture content	—	AASHTO T 310 or other approved procedures	1 per 3000 yd^2	Compacted material	—	End of shift

(1) Minimum 5 points per proctor.

Section 304. — AGGREGATE STABILIZATION

Description

304.01 This work consists of constructing a stabilized aggregate layer with either imported or in-place aggregate. The aggregate layer is stabilized by incorporating cement (aggregate cement) or fly ash plus lime, and cement (AFLC).

Aggregate stabilization is designated as imported aggregate course or in-place aggregate course.

Imported aggregate stabilization and in-place aggregate stabilization are designated as aggregate cement or AFLC.

Aggregate grading is designated as shown in Table 703-2.

Material

304.02 Conform to the following Subsections:

Aggregate	703.05
Blotter	703.13
Chemical admixtures (set-retarding)	711.03
Emulsified asphalt	702.03
Fly ash	725.04
Portland cement	701.01(a)
Lime	725.03
Water	725.01

Construction Requirements

304.03 Proportioning. Submit a mix design 30 days before production.

(a) Aggregate cement mixtures. Estimate the median cement content required for maximum density of the mixture and select cement contents by mass at 2 percentage points above and below the estimated median cement content.

At these 3 cement contents:

(1) Use a minimum of 4 points to determine the maximum density and optimum moisture content of the 3 mixtures according to AASHTO T 134.

(2) Determine the loss in mass of the 3 mixtures according to AASHTO T 135 and T 136.

(3) Determine the 7-day unconfined compressive strength of the 3 mixtures according to ASTM D 633, method A.

Design and use a mixture that meets the requirements of Table 304-1.

Table 304-1
Aggregate Cement Mix Design Parameters

Material or Property	Requirement
Aggregate	90 – 96 %(1)
Portland cement	4 – 10 %(1)
Loss in mass, AASHTO T 135 & T 136 (12 cycles) A-1, A-2-4, A-2-5, & A-3 A-2-6, A-2-7, A-4, & A-5 A-6 & A-7	 14% max. 10% max. 7% max.
7-day unconfined compressive strength, ASTM D-1633, method A	400 pounds per square inch min.

(1) By mass of total dry mix.

(b) AFLC mixtures. Determine the optimum fly ash plus lime and cement content according to ASTM C 593, Section 10 using several mixtures with varying fly ash plus lime and cement contents. The peak of the density fly ash plus lime and cement content curve is the optimum fly ash plus lime and cement content.

Determine the lime and cement fly ash ratio according to ASTM C 593, Sections 10 and 11 using a series of mixtures at the optimum fly ash plus lime and cement content and varying lime and cement fly ash ratio. Use a curing period from 7 to 28 days at 97 to 104 °F.

Design a mixture that meets the requirements of Table 304-2.

Use a mixture with a fly ash plus lime and cement content that exceeds the optimum fly ash plus lime and cement content by 0.5 percent.

Table 304-2
AFLC Mix Design Parameters

Material or Property	Requirement
Aggregate	75 – 92 %(1)
Fly ash	6 – 20 %(1)
Lime and portland cement	2 – 5 %(1)
Average compressive strength, ASTM C 593	500 psi min.
Single compressive strength, ASTM C 593	400 psi min.

(1) By mass of total dry mix.

(c) Job-mix formula.

(1) Submit the following for each job-mix formula:

(a) Source of each component;

(b) Results of applicable tests; and

(c) Target values for:

(1) Each aggregate sieve size specified as applicable; and

(2) Stabilizing agent.

(2) At the request of the CO, submit the following:

(a) 200-pound sample of aggregate;

(b) 50-pound sample of fly ash;

(c) 25-pound sample of lime;

(d) 25-pound sample of Portland cement; and

(e) 5-pound sample of retarder or other admixtures.

Furnish a new mix design if there is a change in a material source. Begin production only after the mix design is approved.

304.04 General. Store stabilizing agents and admixtures in closed, weatherproof containers. Do not construct the stabilized aggregate layer when the underlying surface is frozen, muddy, or when it is raining or snowing. Do not begin application or mixing operations when the atmospheric temperature is expected to fall below 40 ºF within 48 hours.

(a) Imported aggregate course. Prepare the underlying surface according to Section 204, Subsection 303.05, or Subsection 303.06, as applicable.

(b) In-place aggregate course. Recondition the aggregate according to Subsection 303.06. Shape the scarified aggregate into a windrow or blanket that is suitable for applying stabilizing agents.

304.05 Applying stabilizing agents.

(a) Imported aggregate course. Equip the mixer with batching or metering devices for proportioning the components either by mass or volume. Maintain the accuracy of the amounts of aggregate, chemical additives, and water (based on the total dry mass) within the following tolerances:

Aggregate	±2.0% by mass
Fly ash	±1.5% by mass
Lime and cement	±0.5% by mass
Retarder or other additive	±2.0% by mass
Water	±2.0% by mass

In aggregate cement mixtures, a retarder may be used to slow initial set for a maximum of 2 hours. Dissolve the retarder in water and then uniformly add it to the mixture.

(b) In-place aggregate course. Apply the moisture content of the aggregate to at least 3 percent below optimum. Do not apply stabilizing agents when conditions allow excessive loss to washing or blowing. Apply stabilizing agents at the required rates by one of the following methods:

(1) Dry method. Uniformly apply the stabilizing agents with an approved spreader. Apply water using approved methods to obtain the proper moisture content for mixing and compaction.

(2) Slurry method. Mix stabilizing agents with water and apply as a thin water suspension or slurry using either trucks with approved distributors or rotary mixers. Equip the distributor truck or rotary mixer tank with an agitator to keep the stabilizing agents suspended in water. Make successive passes over the material to obtain the moisture and stabilizing agents content for mixing and compacting.

304.06 Mixing. Mix the components with suitable equipment until all additives are distributed uniformly within the aggregate to create a homogeneous mixture. When a central plant is used, transport the mixture in vehicles that maintain moisture content and prevent segregation and loss of the fine material.

(a) Aggregate cement mixtures. Add water and thoroughly mix to adjust the moisture content of the mixture as determined from the mix design and approved by the CO. Complete the mixing within 2 hours of cement application.

(b) AFLC mixtures. Add water and thoroughly mix to adjust the moisture content of the mixture to optimum moisture content plus any necessary hydration moisture as determined from the mix design and approved by the CO. Complete the mixing within 6 hours of additive application. Cure the mixture for 2 to 4 days by keeping it moist.

304.07 Placing, Compacting, and Finishing. While placing and spreading the mixture, maintain the moisture content within 2 percent of optimum. Do not leave uncompacted aggregate cement mixtures undisturbed for more than 30 minutes, and complete their compaction and finishing within 1 hour from the time water is added. Additional time may be permitted if a retarder is used. Compact the mixture 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.

Finish the aggregate course according to Subsection 301.06 to produce a surface that is smooth, dense, and free of compaction planes, ridges, or loose material.

304.08 Construction Joints. For AFLC mixtures, tie each day's work into the completed work of the previous day by remixing approximately 2 feet of the completed course before processing additional sections. Add 50 percent of the original amount of lime or fly ash to the remixed material.

For aggregate cement mixtures or when an AFLC mixture remains undisturbed for more than 24 hours, make a transverse construction joint by cutting back into the completed work to form an approximately vertical face.

304.09 Curing. Do not allow traffic on the stabilized aggregate surface. Apply water under pressure through a spray bar equipped with nozzles producing a fine, uniform spray. Keep the surface continuously moist until the next layer is placed.

Place the next layer within 7 days of finishing the aggregate stabilization. This may be deferred up to 21 days by sealing the surface with rapid-setting emulsified asphalt or cutback asphalt. Apply undiluted CRS-2 emulsified asphalt or RS-2 cutback asphalt at a rate of 0.2 gallons per square yard according to Section 409. Provide a continuous film over the surface. Furnish and apply blotter according to Section 411.

If the stabilized aggregate looses stability, density, or finish, reprocess, re-compact, and add additives as necessary to restore the strength of the damaged material. Reapply the asphalt seal where the continuous film is damaged.

304.10 Acceptance. See Table 304-3 for sampling and testing requirements.

Material for blotter, chemical admixtures, fly ash, lime, hydraulic cement, and water will be evaluated under Subsections 106.02 and 106.03. Emulsified asphalt will be evaluated under Subsections 106.03 and 702.09.

New imported aggregate will be evaluated for gradation according to Subsection 301.08(a).

Stabilized imported and in-place aggregate courses will be evaluated under Subsections 106.02 and 106.04.

Reconditioning of the aggregate course for in-place aggregate will be evaluated under Section 303.

Preparation of the surface on which the treated imported aggregate course is placed will be evaluated under Sections 204 or 303.

Emulsified asphalt seal will be evaluated under Section 409.

Blotter will be evaluated under Section 411.

Measurement

304.11 Measure the Section 304 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure square yard width horizontally to include the top of aggregate width including designed widening. Measure the square yard length along the centerline of the roadway.

Measure emulsified asphalt under Section 409.

Measure blotter under Section 411.

Payment

304.12 The accepted quantities measured as provided in Subsection 109.02, 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 304-3
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate Cement Mixtures								
Proportioning (304.03)	Measured and tested for conformance (106.04)	Moisture-density	—	Cement: AASHTO T 134 (minimum of 4 points)	1 for each mixture or change in material	Processed material before incorporating in work	Yes, when requested	Before using in work
Aggregate, Fly Ash, Lime, and Cement (AFLC)								
Proportioning (304.03)	Measured and tested for conformance (106.04)	Moisture-density	—	AFLC ASTM C 593 Section 10 & 11 (minimum of 4 points)	1 for each mixture or change in material	Processed material before incorporating in work	Yes, when requested	Before using in work
Imported Aggregate								
Aggregate (703.05)	Statisical (106.05)	Gradation		AASHTO T 27 & T 11	1 per 1000 tons	Processed aggregate before stabilizing	Yes, when requested	4 hours
		3/8 inch	I					
		No. 4	I					
		No. 200	I					
		Other specified sieves	II					
	Measured and tested for conformance (106.04)	Liquid limit	—	AASHTO T 89	1 per 3000 tons	Processed aggregate before stabilizing	—	4 hours
Stabilized Aggregate								
Mixture (304)	Measured and 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	Compacted material	—	End of shift

Section 305. — AGGREGATE-TOPSOIL COURSE

Description

305.01 This work consists of furnishing and placing an aggregate, topsoil, and seed mixture on a prepared shoulder or other surface.

Material

305.02 Conform to the following Subsections:

Aggregate	703.14
Seed	713.04
Topsoil	713.01
Water	725.01

Construction Requirements

305.03 Preparing Surface. Complete the adjoining pavement before placing an aggregate-topsoil mixture on the shoulder. Scarify the area where the mixture is to be placed to a depth of 3 inches. Reduce all clods and sod to a maximum size of 4 inches.

305.04 Mixing, Placing, and Compacting. Furnish 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 layer. Shape the mixture to the line, grade, and cross-section. Remove all 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 so that it does not exhibit heaving, pumping, rutting, or shearing. After compaction, dry seed the surface again at a rate of 75 pounds per acre.

305.05 Acceptance. See Table 305-1 for sampling and testing requirements.

Aggregate for aggregate-topsoil will be evaluated under Subsections 106.02 and 106.04. 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

305.06 Measure the Section 305 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure aggregate-topsoil course by the cubic yard in the hauling vehicle.

Payment

305.07 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 305-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate – Topsoil	Measured and tested for conformance (106.04)	Moisture-Density	—	AASHTO T 99, method C [(1)]	1 per soil blend	Production output or stockpile	—	36 hours
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 4000 yd^2	In-place	—	24 hours

(1) Minimum of 5 points per proctor.

Section 306. — DUST PALLIATIVE

Description

306.01 This work consists of furnishing and applying one or more applications of a dust palliative on a prepared surface.

Material

306.02 Conform to the following Subsections:

Blotter	703.13
Calcium chloride	725.02
Calcium chloride flake	725.02
Emulsified asphalt	702.03
Lignosulfonate	725.20
Magnesium chloride	725.02
Water	725.01

Construction Requirements

306.03 General. Use distributor equipment conforming to Subsection 409.04 except heating capability is not required. Equip the distributor with a hose and nozzle for areas inaccessible to the distributor and for touch-up work. Do not apply a dust palliative when the weather is foggy or when rain is anticipated within 24 hours of application. Do not apply chloride brines, emulsified asphalt, or lignosulfonate when the ground is frozen.

Protect the surfaces of structures and trees from splatter or marring during application. Use multiple applications at a reduced rate if necessary to prevent runoff. Do not discharge dust palliative into streams.

306.04 Preparation and Application. Prepare the roadbed by blading and shaping to leave 1 to 2 inches of relatively loose material on the surface.

(a) Emulsified asphalt. When a slow setting emulsified asphalt is used, dilute it with water until the emulsion contains 20 to 30 percent residual asphalt. The CO will approve the exact proportion. Thoroughly blend the emulsified asphalt with the added water. Apply according to Subsection 409.08 when the ambient air temperature is 40 °F or above.

(b) Lignosulfonate, calcium chloride, or magnesium chloride. Water the loose material so it is visibly moist.

When lignosulfonate is used, dilute it with water until the mixture contains a minimum 48 percent concentration. When calcium chloride brine is used, provide a minimum 36 percent concentration. When magnesium chloride brine is used, provide a minimum 28 percent concentration. When calcium chloride flake is used, provide flakes with a minimum 77 percent purity.

Thoroughly mix the components. Apply when the ambient air temperature is 40 °C or above. Apply liquid concentrations at a rate of 0.25 to 0.50 gallons per square yard as approved. Apply the chloride flakes at the rate of 1.0 to 2.0 pounds per square yard as approved.

Process the dust palliative uniformly throughout the layer, moisten as necessary, and compact the surface.

306.05 Maintenance and Opening to Traffic. Do not permit traffic on the treated surface until the dust palliative has penetrated and cured enough to prevent excessive pickup under traffic. If it becomes necessary to permit traffic before that time, apply blotter as necessary.

306.06 Acceptance. Dust palliative material (emulsified asphalt, lignosulfonate, calcium chloride, calcium chloride flake, and magnesium chloride) 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, non-petroleum dust palliatives also provide the net volume and specific gravity at 60 ºF, percent solids by mass, and pH. For solid dust palliatives also provide the concentration of the product.

Application of dust palliative will be evaluated under Subsections 106.02 and 106.04.

Measurement

306.07 Measure the Section 306 items listed in the bid schedule according to Subsection 109.02.

Payment

306.08 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.

Section 307. — Reserved

Section 308. — MINOR CRUSHED AGGREGATE

Description

308.01 This work consists of furnishing and placing crushed aggregate for bedding, backfill, and roadway aggregate courses.

The roadway aggregate compaction method is designated as shown in Subsection 308.05(a).

Material

308.02 Conform to the following Subsections:

Crushed aggregate	703.06
Water	725.01

Construction Requirements

308.03 Preparing Surface.

(a) Roadway aggregate. Prepare the surface on which the aggregate course is placed according to Subsection 303.07.

(b) Bedding and backfill aggregate. Shape, compact, and finish the surface to the required lines, grade, elevation, and cross-section according to Section 209.

308.04 Placing Crushed Aggregate.

(a) Roadway aggregate. Mix the aggregate and adjust the moisture content to obtain a uniform mixture with a moisture content suitable for compaction. Spread and shape the mixture on the prepared surface in a uniform layer.

Do not place the mixture in a layer exceeding 6 inches in compacted thickness. When more than one layer is necessary, compact each layer according to Subsection 308.05(a) before placing the next layer.

(b) Bedding and backfill aggregate. Place and shape the mixture in layers that, when compacted, do not exceed 6 inches in depth.

308.05 Compacting and Finishing Crushed Aggregate.

(a) Roadway aggregate. Compact using the specified method. When no method is specified, use either method. Finish the surface according to Subsection 301.06.

(1) Method 1. Compact each layer according to Subsection 204.11. Roll from the sides to the center, parallel to the centerline of the road. Along curbs, headers, and walls, and all places not accessible to the roller, compact the material with approved tampers or compactors.

Compactive effort may be decreased if inplace densities show that less compactive effort is required under Method 2.

(2) Method 2. Compact each layer according to 301.05.

(b) Bedding and backfill aggregate. Compact each layer according to Subsection 209.11.

308.06 Acceptance. See Table 308-1 for sampling and testing requirements.

Crushed aggregate will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification including gradation and quality properties for each source.

Construction of roadway aggregate courses will be evaluated under Subsections 106.02 and 106.04. Method 2 compaction will be evaluated under Section 106.04.

Placement of bedding and backfill aggregate will be evaluated under Subsection 106.02 and Section 209.

Preparation of the surfaces on which crushed aggregate is placed will be evaluated under Section 303 and 209 as applicable.

Measurement

308.07 Measure the Section 308 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure crushed aggregate by the cubic yard in the hauling vehicle.

Measure square yard width horizontally to include the top of aggregate width including designed widenings. Measure the square yard length horizontally along the centerline of the roadway.

Payment

308.08 The accepted quantities will be paid at the contract price per unit of measurement for the Section 308 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 308-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Crushed aggregate	Measured and tested for conformance (106.04)	Moisture-density	—	AASHTO T 180, method D[1]	1 for each aggregate supplied	Production output or stockpile	—	Before using in work
		Compaction	—	AASHTO T 310 or other approved procedures	1 per 500 tons	In-place	—	Before placing next layer

(1) Minimum of 5 points per proctor.

Section 309. — EMULSIFIED ASPHALT-TREATED BASE COURSE

Description

309.01 This work consists of constructing an emulsified asphalt-treated base course on a prepared surface.

Base aggregate grading is designated as shown in Table 703-2.

Material

309.02 Conform to the following Subsections:

Base course aggregate	703.05
Emulsified asphalt	702.03
Water	725.01

Construction Requirements

309.03 General. Prepare the surface on which the treated aggregate base course is placed according to Section 204 or 303 as applicable.

After a representative quantity of aggregate is produced, submit proposed target values for the appropriate sieve sizes along with a representative 300-pound sample at least 14 days before incorporating the aggregate into the work.

Set target values within the gradation ranges shown in Table 703-2 for the required grading.

309.04 Mixing and Spreading. Use a stationary pugmill with weighing, volumetric, or other gauging equipment capable of accurately controlling 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 the 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) so that, at the time of compaction, the total liquid content is within 2 percent of the optimum moisture content. Mix until all particles are uniformly coated.

Immediately after mixing, spread the mixture on the prepared surface in a uniform layer. Shape the mixture to the line, grade, and cross-section. Route hauling equipment uniformly over the full width of the surface to minimize rutting or uneven compaction.

309.05 Compacting. Determine the maximum density of the mixture according to AASHTO T 180, method D.

Compact the full width. Roll from the sides to the center, parallel to the centerline of the road. Along curbs, headers, walls, and all places not accessible to the roller, compact the material with approved tampers or compactors.

Compact the mixture to at least 95 percent of maximum density. Determine the inplace density and moisture content according to AASHTO T 310 or other approved test procedures.

309.06 Surface Tolerance. Finish the surface according to Subsection 301.06.

309.07 Maintenance. Maintain the treated aggregate course to the correct line, grade, and cross-section by blading, watering, rolling, or any combination thereof until placement of the next course. Correct all defects according to Subsection 301.06.

309.08 Acceptance. See Table 309-1 for sampling and testing requirements.

Emulsified asphalt will be evaluated under Subsections 106.03 and 702.09.

Aggregate gradation will be evaluated under Subsection 106.05. The aggregate gradation upper and lower specification limits are the approved target values plus or minus the allowable deviations shown in Table 703-2. See Table 309-1 for the acceptance quality characteristic categories. All 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.

Preparation of the surface on which the treated aggregate base course is placed will be evaluated under Section 204 or 303 as applicable.

Measurement

309.09 Measure the Section 309 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure emulsified asphalt treated aggregate base by the cubic yard in the hauling vehicle.

Measure the square yard width horizontally to include the top of base width including designed widening. Measure the square yard length horizontally along the centerline of the roadway.

Payment

309.10 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 except the emulsified asphalt-treated aggregate base unit bid 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 309-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate quality	Measured and tested for conformance (106.04 & 105)	LA abrasion (coarse)	—	AASHTO T 96	1 for each source	Source of material	Yes, when requested	Before using in work
		Durability index (coarse & fine)	—	AASHTO T 210	“	“	“	“
		Sodium sulfate soundness	—	AASHTO T 104	“	“	“	“
Emulsified asphalt-treated aggregate base, grading C, D & E	Statistical (106.05)	Gradation		AASHTO T 30	1 per 1000 tons	In-place	Yes, when requested	4 hours
		3/8 inch	I	“				
		No. 4	I	“				
		No. 40	II	”				
		No. 200	—	“	“	“	“	“
		Fractured faces	I	ASTM D 5821	“	“	“	“
		Sand equivalent	—	AASHTO T 176, alternate method no. 2, reference method	“	Belt feed before adding emulsified asphalt	“	“
		SE/P_{200} index	I	Note 1		—	—	—
Emulsified asphalt-treated aggregate base, grading D	Measured and tested for conformance (106.04)	Compaction	—	AASHTO T 310 or other approved procedures	1 per 500 tons but not less than 1 per layer	In-place	—	Before placing next layer

(1) SE/P_{200} index (SEP) is a measure of a material's ability to perform based on the quality and quantity of fines present. The quality is represented by the sand equivalent (SE) and quantity is represented by the percent passing the No. 200 sieve (P_{200}). The SEP is computed as follows:
For an $SE \geq 29$, $SEP = SE/(P_{200} + 25)$ and for an $SE < 29$, $SEP = (SE + 4)/(SE + P_{200})$.
Where: SE = Plastic fines in graded aggregates and soils by using the sand equivalent test AASHTO T 176, alternate method no.2, referee method
P_{200} = Material finer than the No. 200 sieve in mineral aggregates by washing AASHTO T 11

DIVISION 400

ASPAHLT PAVEMENTS AND SURFACE TREATMENTS

Section 401. — SUPERPAVE HOT ASPHALT CONCRETE PAVEMENT

Description

401.01 This work consists of constructing one or more courses of Superpave hot asphalt concrete pavement.

Superpave hot asphalt concrete pavement nominal maximum size aggregate is designated as shown in Tables 401-1 and 703-12. Equivalent single axle loads (ESAL) or number of gyrations at design (N_{Design}) is designated as shown in Tables 401-1, 703-10, and 703-11. Pavement smoothness/roughness type is designated as shown in Subsection 401.16. Asphalt binder is designated as shown in AASHTO M 320.

Antistrip additive type is designated as shown in Subsection 702.08. Where no type is designated, use type 3 (lime).

Material

401.02 Conform to the following Subsections:

Aggregate	703.17
Antistrip additive	702.08
Asphalt binder	702.01
Mineral filler	725.05
Recycled asphalt pavement	703.19
Recycling agent	702.06

Construction Requirements

401.03 Composition of Mix (Job-Mix Formula). Furnish mixes of aggregate, asphalt binder, recycled asphalt pavement, and additives that meet the applicable material requirements and the appropriate design parameters in Table 401-1 and are capable of being placed and compacted as specified.

Compact specimens with the gyratory compactive effort specified in Table 401-1 for the specified ESAL or N_{Design}.

Table 401-1
Superpave Hot Asphalt Concrete Pavement Design Requirements (AASHTO MP2)

Design ESAL (Million)	Gyratory Compaction Level (% Theoretical Maximum Specific Gravity, Gmm) AASHTO PP 28			Minimum Voids-in-the-Mineral Aggregate (VMA), %(4) Nominal Maximum Size Aggregate (3)				Voids Filled with Asphalt (VFA), %(5) (6)	Dust-to-Binder Ratio(1)	Minimum Tensile Strength Ratio, AASHTO T 283(2)
	$N_{Initial}$	N_{Design}	N_{Max}	1 Inch	3/4 Inch	1/2 Inch	3/8 Inch			
< 0.3	6 (≤ 91.5 %)	50 (96 %)	75 (≤ 98 %)	12.0	13.0	14.0	15.0	70-80	0.8-1.6	0.80
0.3 to < 3	7 (≤ 90.5 %)	75 (96 %)	115 (≤ 98 %)					65-78		
3 to < 30	8 (≤ 89 %)	100 (96 %)	160 (≤ 98 %)					65-75		
≥ 30	9 (≤ 89 %)	125 (96 %)	205 (≤ 98 %)							

(1) Include non-liquid antistrip, baghouse fines, and other mineral matter added to the mixture. Calculate the ratio using effective asphalt content (calculated by mass of mix).

(2) Prepare specimens in accordance with AASHTO PP 28.

(3) The nominal maximum size is one size greater than the first sieve to retain more than 10 percent of the combined aggregate.

(4) When mineral filler or hydrated lime is used, include in the calculation for compliance with the VMA.

(5) For 3/8-inch nominal maximum size aggregate mixtures with ≥3 million ESALs, provide a VFA of 73 to 76 percent.

(6) For 1-inch nominal maximum size aggregate mixtures with < 0.3 million ESALs, provide a VFA ≥ 67 percent.

The combined aggregate gradation is classified as coarse graded when it passes below the primary control sieve control point in Table 703-14. All other gradations are classified as fine graded.

(a) Recycled asphalt pavement use. Do not use recycled asphalt pavement in the top lift.

Up to and including 15 percent recycled asphalt pavement material by mass may be used in the mix without adjusting the asphalt binder grade. For mixes with over 15 percent, and up to and including 25 percent, recycled asphalt pavement material by mass, decrease the asphalt binder grade one performance level for both the upper and lower grade level of the asphalt binder specified or use an approved blending procedure with a recycling agent. Do not use more than 25 percent recycled asphalt pavement by mass.

For mixture design, use the specific gravity of the new (virgin) asphalt binder as the specific gravity of the asphalt binder in the recycled asphalt pavement. For calculation purposes, use the effective specific gravity of the aggregate in the recycled asphalt pavement as the bulk specific gravity. When the recycled asphalt pavement contains highly absorptive materials, estimate the amount of absorbed asphalt from historical records, and use the estimate to back-calculate the bulk specific gravity of the aggregate.

(b) Submission. Submit written job-mix formulas with Form FHWA 1641 for approval at least 28 days before production. Include the location of all commercial mixing plants to be used and a separate job-mix formula for each plant. Include a signed statement prepared by the testing laboratory that certifies that the proposed job-mix formula meets the requirements of the contract and can be compacted in the field during production to meet contract requirements. For each job-mix formula, submit the following:

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each sieve size for the aggregate blend; and

(2) Designate target values within the gradation band specified for the nominal maximum size aggregate grading shown in Table 703-12.

(b) Source and percentage of each aggregate stockpile to be used.

(c) Average gradation of each aggregate stockpile.

(d) Representative samples from each aggregate stockpile. Use split samples of material taken at the same time samples are taken for testing by the Contractor's laboratory.

(1) 800 pounds of aggregates proportioned by stockpile according to the stockpile's proportion in the mix;

(2) 20 pounds of bag house fines if proposed for the mix; and

(3) 20 pounds of mineral filler if proposed for mix.

(e) Results of aggregate quality tests for Contractor selected sources. Include the sand equivalent, fractured faces, Los Angeles abrasion, sodium sulfate soundness, coarse durability, and fine durability results from tests performed within 1 year of aggregate use.

(2) Asphalt binder.

(a) Target asphalt binder content;

(b) Five 1-gallon samples of the asphalt binder to be used in the mix. Do not include antistrip additives in these samples;

(c) Recent test results from the manufacturer for the asphalt binder including a temperature-viscosity curve;

(d) Material safety data sheets; and

(e) Mixing temperature range and minimum compaction temperature for the performance grade asphalt to be used in the mix.

(3) Antistrip additives. If part of the job-mix formula:

(a) 1 pint of liquid antistrip additive or 10 pounds of cement, fly ash, or lime antistrip additive;

(b) Name of product;

(c) Manufacturer;

(d) Material safety data sheet; and

(e) Dosage rate.

(4) Recycled asphalt pavement material. If part of the job-mix formula:

(a) Source and percentage of recycled asphalt pavement material.

(b) Average gradation of the recycled asphalt pavement material.

(c) Percent asphalt binder in the recycled asphalt pavement.

(d) Target value for the asphalt binder content (that considers the percent asphalt binder in the recycled asphalt pavement) and the percent new (virgin) asphalt binder to be added to the mix.

(e) 200-pound representative sample of recycled asphalt pavement material. For existing pavements, mill where designated by the CO to the pavement removal depth. Sample the removed material and replace it with an approved asphalt concrete mix. Do not use the replacement material in the recycled mix.

(f) One gallon of recycling agent, if part of the job-mix formula.

(c) Verification. The CO will review and may perform design verification testing. If verification testing is performed, the information supplied in the contractor's design must agree with the verification test results within the tolerances shown below.

(1) Aggregate gradations. Representative aggregate samples from each stockpile, when combined according to the contractor's recommendation for stockpile percentages, shall be within the gradation defined by the target values plus or minus the following tolerance for each sieve.

Sieve Size	Tolerance, % (±)
1 inch	3.0
3/4 inch	3.0
1/2 inch	3.0
3/8 inch	3.0
No. 4	3.0
No. 8	3.0
No. 40	2.0
No. 200	1.0

(2) Voids in mineral aggregate (VMA). The Contractor's VMA result is verified if the CO's result is not below the minimum specification limit.

(3) Voids filled with asphalt (VFA). The Contractor's VFA result is verified if the CO's result is within the specification limits in Table 401-1.

(4) Air voids (Va). The Contractor's Va result is verified if the CO's result at the same design asphalt binder content is within 1.0 percent of the specification value.

(5) Tensile strength ratio (TSR). The Contractor's percent retained strength result is verified if the CO's result is above the minimum specification value.

(d) Changes and resubmissions. If a job-mix formula is rejected or a material source or the recycled asphalt pavement is changed, submit a new job-mix formula for acceptance. Up to 21 days may be required to evaluate a change. Approved changes in target values will not be applied retroactively for payment.

The CO will deduct all job-mix formula evaluation costs resulting from the following:

(1) Contractor-requested changes to the approved job-mix formula.

(2) Contractor requests for additional job-mix formula evaluations.

(3) Additional testing necessary due to the failure of a submitted job-mix formula.

(e) Acceptance. Do not begin mix production until the job-mix formula is accepted by the CO.

401.04 Mixing Plant. Use mixing plants conforming to AASHTO M 156 supplemented as follows:

(a) All plants.

(1) Automated controls. Control the proportioning, mixing, and discharging of the mix automatically.

(2) Dust collector. AASHTO M 156, Requirements for All Plants, Emission Controls is amended as follows:

Equip the plant with a dust collector. Dispose of the collected material. In the case of baghouse dust collectors, dispose of the collected material or return the collected material uniformly. Use of baghouse fines in asphalt concrete mixes requires approval unless included as part of the approved job-mix formula.

(3) Recycled asphalt pavement. When recycled asphalt pavement material is incorporated into the mixture, modify plants according to the plant manufacturer's recommendations to process reclaimed material.

(b) Drum dryer-mixer plants.

(1) Bins. Provide a separate bin in the cold aggregate feeder for each individual aggregate stockpile in the 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 2 stockpiles with different gradations. As a minimum, stockpile mostly coarse material in one stockpile and mostly fine material in another.

(c) Batch and continuous mix plants.

(1) Hot aggregate bin. Provide a bin with 3 or more separate compartments for storage of the screened aggregate fractions to be combined for the 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) Recycled asphalt pavement. Modify batch plants so the recycled asphalt pavement is introduced into the 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 a mix of uniform temperature within the range specified in the approved job-mix formula.

401.05 Pavers. Use pavers that are:

(a) Self-contained, power-propelled units with adjustable vibratory screeds with full-width screw augers;

(b) Heated for the full width of the screed;

(c) Capable of spreading and finishing courses of asphalt mix in widths at least 12 inches more than the width of one lane;

(d) Equipped with a receiving hopper having sufficient capacity to ensure a uniform spreading operation;

(e) Equipped with automatic feed controls, which are properly adjusted to maintain a uniform depth of material ahead of the screed;

(f) Operable at forward speeds consistent with satisfactory mix lay down;

(g) Capable of producing a finished surface of the required smoothness and texture without segregating, tearing, shoving, or gouging the mix; and

(h) Equipped with automatic screed controls with sensors capable of sensing 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.

401.06 Surface Preparation. Prepare the surface according to Subsection 410.05 as applicable. 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 hot asphalt concrete pavement on a dry, unfrozen surface when the air temperature in the shade is above 35 ºF and rising and the temperature of the road surface in the shade conforms to Table 401-2.

Table 401-2
Asphalt Concrete Mix Placement Temperature

Compacted Lift Thickness →	< 2 Inches	2 – 3 Inches	> 3 Inches
Road Surface Temperature °F	**Minimum Lay-Down Temperature(1) °F**		
< 35	(2)	(2)	(2)
35 –39.9	(2)	(2)	280
40 – 49.9	(2)	285	275
50 – 59.9	295	280	270
60 – 69.9	285	275	265
70 – 79.9	280	270	265
80 – 89.9	270	265	260
≥ 90	265	260	255

(1) Never heat the asphalt concrete mix above the temperature specified in the approved mix design.
(2) Paving not allowed.

401.08 Asphalt Preparation. Uniformly heat the asphalt binder to provide a continuous supply of the heated asphalt binder from storage to the mixer. Do not heat asphalt binder above 350 ºF.

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 nonliquid antistrip is used, adjust the aggregate moisture to at least 4 percent by mass of aggregate. Mix the antistrip uniformly with the aggregate before introducing the aggregate into the dryer or dryer drum. Mix with the aggregate particles to produce a uniform mixture. Use calibrated weighing or metering devices to measure the amount of antistrip and moisture added to the aggregate.

Treated aggregate may be held in stockpiles before mixing with asphalt, but the treated aggregate must be used during the same construction season in which it was produced.

For batch plants, heat, dry, and deliver aggregate for pugmill mixing at a temperature sufficient to produce a mix temperature within the approved range. Adjust flames used for drying and heating to prevent aggregate damage and contamination.

Control plant operations so the moisture content of the mix behind the paver is 0.5 percent or less according to AASHTO T 110 or FLH T 515.

401.10 Mixing. Measure the aggregate and asphalt into the mixer according to the approved job-mix formula. Mix until all the particles are completely and uniformly coated with asphalt according to AASHTO M 156. Maintain the discharge temperature within the approved range.

401.11 Hauling. Use vehicles with tight, clean, and smooth metal beds for hauling asphalt concrete mixes.

Thinly coat the beds with an approved material to prevent the 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 mix from the weather. When necessary to maintain temperature, use insulated truck beds and securely fastened covers. Provide access ports or holes for checking temperature of asphalt mix in the truck.

401.12 Production Start-Up Procedures.

(a) Pre-paving conference. At least 14 days before the start of paving operations, arrange for a pre-paving conference. Coordinate attendance with CO and all applicable subcontractors. Submit and prepare to discuss the following:

(1) Proposed schedule of paving operations;

(2) List of all equipment (excavation, compaction, laydown, haul, pugmill, etc.), 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) Contractor quality control plan for paving and sampling and testing according to Sections 153 and 154;

(5) Procedures for constructing the control strip including placing, finishing, compacting, and smoothness procedures; and

(6) Acceptance procedures according to Subsections 106.05 and 401.17.

(b) Control strip. Provide 7 days notice before beginning production of an asphalt concrete mix.

On the first day of production, produce sufficient 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 mix production, lay-down, and compaction procedures intended for the entire mix. Cease production after construction of the control strip until the asphalt concrete mix and the control strip are evaluated and accepted.

(1) Mixture. Take and test at least three control strip asphalt concrete mix samples and evaluate according to Subsection 401.17. The mix is acceptable if all test results are within specification limits for asphalt content, VMA, VFA; and the calculated pay factor for asphalt content, gradation, VMA, and VFA is 0.90 or greater.

(2) Compaction. Take nuclear density readings behind each roller pass to determine the roller pattern necessary to achieve required density.

At a minimum of five locations within the control strip, take nuclear gauge readings, and cut and test core samples according to Subsection 401.17. Density is acceptable if all tests are above the specification limit or the calculated pay factor is 0.90 or greater. Furnish the CO with the nuclear gauge readings and correlations of the readings to the core specific gravities.

Repeat the control strip process until an acceptable control strip is produced. See Subsection 106.01 for the disposition of material in unacceptable 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. When a control strip is accepted, full production may begin.

Use these start-up procedures when producing material from a different plant or when 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 job-mix formula, use material from the same sources, and are approved. Construct control strips according to Subsection 401.12 for each plant from which production is intended.

Place asphalt concrete mix at a temperature conforming to Table 401-2. Measure temperature of the mix in the hauling vehicle just before dumping into 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 is impractical, place and finish the 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 layer at least 6 inches from the joint in the layer immediately below. Make the longitudinal joint in the top layer along the centerline of two-lane roadways or at the lane lines of roadways with more than two lanes.

The CO will designate the job-mix formula to be used for wedge and leveling courses at each location. Place wedge and leveling courses in maximum 3-inch lifts. Complete the wedge and leveling before starting normal paving operations.

401.14 Compacting. Thoroughly and uniformly compact the asphalt surface by rolling. Do not cause cracking, shoving, or undue displacement. Continue rolling until all roller marks are eliminated, all cracks are sealed, and the required density is obtained. Do not roll the mix after the surface cools below 175 ºF.

Monitor the compaction process with nuclear density gauges calibrated to the control strip core density test results. Compact to a pavement specific gravity (density) that is no less than 91.0 percent of the maximum specific gravity (density) determined according to AASHTO T 209.

Cut 6-inch diameter core samples from the compacted pavement according to AASHTO T 230, method B. Fill and compact the core holes with asphalt concrete mixture. Label the cores and protect them from damage due to handling or temperature during storage. Perform specific gravity and thickness tests on the cores and deliver them to CO.

Along forms, curbs, headers, walls, and other places not accessible to the rollers, compact the mix with alternate equipment to obtain the required compaction.

401.15 Joints, Trimming Edges, and Cleanup. Complete pavement construction of adjacent traffic lanes to the same elevation within 24 hours. If drop-offs are left overnight, sign the drop-offs in excess of 2 inches with *"Uneven Lanes"* warning signs and provide a 1V:3H fillet for drop-offs in excess of 4 inches.

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.

To both transverse and longitudinal joints, apply an asphalt tack coat to the joint edge according to Section 412.

Place the asphalt concrete mix as continuously as possible. Do not pass rollers over the unprotected end of a freshly laid mix.

Dispose of material trimmed from the edges and any other discarded asphalt mix according to Subsection 211.02(a)(2).

401.16 Pavement Smoothness/Roughness. Measure the smoothness/roughness of the final paved surface course after final rolling, within 14 days of completing roadway paving, before placing a surface treatment, and according to the designated type below. In addition, construct all pavement surfaces to meet the requirements of (c) below.

(a) Profile ride index (PRI). For type I or II pavement smoothness, furnish a California type profilograph and personnel to operate the profilograph. The CO will direct and observe its operation. Operate the profilograph in the "mode" such that the continuous plot produced can be reduced according to FLH T 504. Measure in the middle portion of each lane and exclude areas according to FLH T 504. Measure excluded areas according to (c) below. Submit the trace to the CO.

A PRI will be calculated for each 0.1-mile lane of traveled way using a zero blanking-band. The PRI will be determined according to FLH T 504. Bumps will be located using a 0.4-inch bump template.

(1) Type I pavement smoothness (PRI measurements for reconstructed and new roads). Measure the smoothness of the final paved surface course. The upper specification limit is 24 inches per mile for reconstructed and new roads. Defective areas are bumps in excess of 0.4 inches in 25 feet, 0.1-mile profile ride index greater than 28.5 inches per mile, or surfaces with a pay factor less than 0.75 as determined under Subsection 106.05.

(2) Type II pavement smoothness (PRI measurements for overlay, recycle with overlay, or milling with overlay projects). Before construction traffic, measure the smoothness of the existing surface. The existing surface is the original surface before overlaying, recycling, or milling. The existing profile ride index and standard deviation will be used to determine the upper specification limit.

For one-lift placement of the final surface:

$USL_1 = 0.71 * PRI_0 + 0.39 * Sd_0$, but not less than 24 inches per mile

For two-lift placement of the final surface:

$USL_2 = 0.50 * PRI_0 + 0.30 * Sd_0$, but not less than 24 inches per mile

where:

USL_1 = Upper specification limit for one lift rounded to the nearest whole number (inches per mile)

USL_2 = Upper specification limit for two lifts rounded to the nearest whole number (inches per mile)

PRI_0 = Existing surface profile ride index (inches per mile)

Sd_0 = Existing surface profile standard deviation

Measure the smoothness of the final paved surface course. Defective areas are bumps in excess of 0.4 inches in 25 feet, 0.1-mile profile ride index greater than 1.5 times the calculated upper specification limit, or surfaces with a pay factor less than 0.75 as determined under Subsection 106.05.

(b) International roughness index (IRI). For type III or IV pavement roughness, furnish an inertial profiler conforming to AASHTO PP 50 and validated according to AASHTO PP 51. At least 21 days before use, submit results showing the inertial profiler conforms to AASHTO PP 51. Furnish personnel to operate the inertial profiler according to AASHTO PP 52. The CO will direct and observe its operation. Measure in the middle portion of each lane. Submit raw data files (*.ERD) that are compatible with FHWA Profile Viewer software on a compact disk to the CO.

Areas of localized roughness will be identified using a 25-foot moving average filter. The difference between the 25-foot moving average and the reported relative elevation for every profile point will be determined. Deviations greater than 0.15 inches are areas of localized roughness.

An IRI value will be determined for each for each 0.1-lane mile of traveled way. Cattle guards and bridges not being overlayed will be excluded from the calculation of IRI and determination of localized roughness. Measure excluded areas according to (c) below.

(1) Type III pavement roughness (IRI measurements for reconstructed and new roads). Measure the roughness of the final paved surface course. Defective areas are 0.1-mile segments with IRI values greater than 95 inches per mile or areas of localized roughness.

The pay adjustment factor for each 0.1-mile segment will be determined from Table 401-3.

Table 401-3
Type III Pavement Roughness

IRI (inches per mile)	Pay Adjustment Factor (PAF)
Less than 30.0	PAF = 12.500
30.0 to 59.9	PAF = 25 – 0.4167 (IRI)
60.0 to 65.0	PAF = 0.00
65.1 to 95.0	PAF = 81.25 – 1.25 (IRI)
Greater than 95.0	Rejected (1)

(1) Pay adjustment factor when corrections are not allowed equals minus 37.50.

(2) Type IV pavement roughness (IRI measurements for overlay, recycle with overlay, or milling with overlay projects). Before construction traffic, measure the roughness of the existing surface. The existing surface is the original surface before overlaying, recycling, or milling. The existing IRI will be used to determine the percent improvement for each 0.1-mile segment.

Measure the roughness of the final paved surface course. Defective areas are areas of localized roughness or 0.1-mile segments having a percent improvement less than 0.9 or 25.4 as determined from Table 401-4.

The percent improvement in IRI will be determined to one decimal place for each 0.1-mile segment according to the following formula:

% Improvement = [(Original IRI – Final IRI) / Original IRI] * 100

The pay adjustment factor (computed to two decimal points) for each 0.1-mile segment will be determined from Table 401-4.

Table 401-4
Type IV Pavement Roughness

Single Lift (1) Percent Improvement (%)	**Pay Adjustment Factor (1)**	**Multi-Lift (2) Percent Improvement** (%)	**Pay Adjustment Factor (2)**
Greater than 48.4	PAF = 12.50	Greater than 61.1	PAF = 12.50
24.8 to 48.4	PAF = 0.5274(%) – 13.027	43.3 to 61.1	PAF = 0.6983(%) – 30.168
12.4 to 24.7	PAF = 0.00	34.0 to 43.2	PAF = 0.00
0.9 to 12.3	PAF = 13.209(%) – 40.435	25.4 to 33.9	PAF = 4.3605(%) – 148.260
Less than 0.9	Reject (3)	Less than 25.4	Reject (3)

(1) For single lift overlays with no other corrective work such as milling, grinding or preleveling in excess of 25 percent of the surface area the of existing pavement.
(2) For multiple lift operations such as milling, grinding or preleveling followed by one or more lifts of pavement or two or more lifts of pavement without milling, grinding or preleveling.
(3) Pay adjustment factor when corrections are not allowed equals minus 37.5.

(c) Type V pavement smoothness/roughness (straightedge measurement). Use a 10-foot metal straight edge to measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 1/4 inch in 10 feet between any two contacts of the straightedge with the surface.

(d) Defective area correction. Correct defective areas from (a), (b), and (c) above. Obtain approval for the proposed method of correction. If no corrections are allowed, no adjustment will be made to the pay adjustment factors.

Re-measure corrected areas according to the specified type of pavement smoothness/roughness. The smoothness/roughness value obtained will replace the original.

401.17 Acceptance. Mineral filler, antistrip additive, and recycling agent will be evaluated under Subsections 106.02 and 106.03.

Asphalt binder will be evaluated under Subsections 106.04, 702.09, and Table 401-5.

Construction of the Superpave hot asphalt concrete pavement course will be evaluated under Subsections 106.02 and 106.04.

Asphalt content, VMA, density, and type I and II pavement smoothness will be evaluated under Subsection 106.05. Type III and IV pavement roughness, VFA, and aggregate gradation will be evaluated under Subsection 106.04. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04. See Table 401-6 for sampling and testing requirements and the acceptance quality characteristic category.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value plus or minus 0.4 percent.

(b) VMA. The lower specification limit is the value shown in Table 401-1.

(c) Density. The lower specification limit is 91 percent of the maximum specific gravity (density) determined according to AASHTO T 166 and T 209. The percent compaction using the maximum specific gravity (AASHTO T 209) will be determined from at least one production sample per day.

(d) Pavement smoothness/roughness. The evaluation will be made after all defective areas are corrected. See Subsection 401.16.

(e) VFA. The upper and lower specification limits are the values shown in Table 401-1.

(f) Aggregate gradation. The upper and lower specification limits are the approved job-mix formula target values plus or minus the allowable deviations shown in Table 703-13.

Measurement

401.18 Measure the Section 401 items listed in the bid schedule according to Subsection 109.02.

Payment

401.19 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 Superpave hot asphalt concrete pavement contract unit bid price will be adjusted according to Subsections 106.05 and 401.16. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for Superpave hot asphalt concrete pavement will be made at a price determined by multiplying the contract unit bid price by the material pay factor. The material pay factor is calculated as follows:

$$A1 = 1 + [(PF_{Superpave} - 1) + (PF_{PG} - 1)]$$

where:

$A1$ = Material pay factor

$PF_{Superpave}$=Pay factor for Superpave hot asphalt concrete pavement. $PF_{Superpave}$ is the lowest single pay factor determined for asphalt binder content, core density, and VMA.

PF_{PG} = Pay factor for asphalt binder. The PF_{PG} formula is as follows:

$$PF_{PG} = (PF_1 + PF_2 + PF_3 + \ldots PF_n)/n$$

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 asphalt binder (PF_{PG}) or the pay factor for Superpave hot asphalt concrete pavement ($PF_{Superpave}$) is below 0.75, then the lot for Superpave hot asphalt concrete pavement is in reject.

When the bid schedule contains a pay item for Superpave hot asphalt concrete pavement, type I or II pavement smoothness, a separate adjustment will be made for pavement smoothness according to the following formula:

$$A2 = 32{,}700(PF_{smooth} - 1.00)(L)$$

where:

$A2$ = Adjustment to contract payment in dollars for pavement smoothness.

L = Total project length in lane miles of traveled way including excluded areas. Measure project length to 3 decimal places.

PF_{smooth} = Pay factor for smoothness with respect to the upper specification limit determined according to Subsection 401.16 and 106.05 after completion of corrective work.

When the bid schedule contains a pay item for Superpave hot asphalt concrete pavement, type III or IV pavement roughness, a separate pay adjustment will be made. The dollar amount of the adjustment will be determined by summing the pay adjustment factors determined in Subsection 401.16 for each 0.1-mile and multiplying that sum by the contract unit bid price.

Table 401-5
Asphalt Binder Pay Factor Table

Tests on Original	Specifications (See 702.01)	Pay Factor =					
		1.05	**1.00**	**0.95**	**0.90**	**0.75**	**Reject**
Rotational Viscosity	≤ 3.0 Pa-s	N/A	≤ 3.0 Pa-s	> 3.0 Pa-s = Pay Factor 0.95			
Dynamic Shear Rhoemeter, kPa	≥ 1.00	≥ 1.12	1.00 to 1.11	0.99 to 0.88	0.87 to 0.71	0.70 to 0.50	< 0.50
Tests after Rolling Thin Film Oven (RTFO)							
Mass Loss, %	≤ 1.00	≤ 0.092	0.093 to 1.000	1.001 to 1.092	1.093 to 1.184	1.185 to 1.276	> 1.276
Dynamic Shear Rheometer, kPa	≥ 2.20	≥ 2.584	2.583 to 2.200	2.199 to 1.816	1.815 to 1.432	1.431 to 1.048	< 1.048
Tests on Pressure Aging Vessel (PAV)							
Dynamic Shear Rheometer, kPa	≤ 5,000	≤ 4,711	4,712 to 5,000	5,001 to 5,289	5,290 to 5,578	5,579 to 5,867	> 5,867
Bending Beam Rheometer, s, MPa	≤ 300	≤ 262	263 to 300	301 to 338	339 to 388	389 to 450	> 450
Bending Beam Rheometer, m	≥ 0.300	≥ 0.313	0.312 to 0.300	0.299 to 0.287	0.286 to 0.274	0.273 to 0.261	< 0.261
Direct Tension, %	≥ 1.00	≥ 1.14	1.13 to 1.00	0.99 to 0.86	0.85 to 0.71	0.70 to 0.56	< 0.56

Table 401-6
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality	Measured and tested for conformance (106.04 & 105)	LA abrasion (coarse)	—	AASHTO T 96	1 per type & source of material	Source of materials	Yes	Before producing
		Sodium sulfate soundness loss (coarse & fine)	—	AASHTO T 104	“	“	“	“
		Fine aggregate angularity	—	AASHTO T 304, method A	“	“	“	“
		Sand equivalent	—	AASHTO T 176, alternate method no. 2, reference method	“	“	“	“
Asphalt concrete (mix design)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	28 days before producing
		VMA	—	AASHTO PP 28	“	—	—	“
		VFA	—	“	“	—	—	“
		Voids	—	“	“	—	—	“
		TSR	—	AASHTO T 283	“	—	—	“

Table 401-6 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Asphalt binder	Measured and tested for conformance (106.04)	Quality	—	Subsection 702.01	1 per submitted source & mix design 1 per 2100 t of mix, but not less than 5 samples	In line between tank & mixing plant	2 – 1-quart samples	—
Asphalt concrete mixture (all)	Measured and tested for conformance (106.04)	Mix temperature	—	—	First load & as determined by the CO thereafter	Hauling vehicle before dumping or windrow before picking up	—	Upon completing test
Hot asphalt concrete pavement (control strip)	Statistical (106.05)	Gradation		AASHTO T 308 & T 30	3 minimum	Behind paver before compacting	Yes	4 hours
		No. 4	I					
		No. 30	I					
		No. 200	I					
		Other specified sieves	II					
		Asphalt content	I	AASHTO T 308	"	"	"	"
		VMA	I	AASHTO PP 28	"	"	"	"
		VFA	I	"	"	"	"	"
		Core density[1]	I	AASHTO T 166	5 minimum	In-place after compacting	Cores to CO after determining specific gravity & compaction	—
	Measured and tested for conformance (106.04)	Maximum specific gravity (density)	—	AASHTO T 209	3 minimum	Behind paver before compacting	Yes	24 hours

Table 401-6 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Hot asphalt concrete pavement (production)	Statistical (106.05)	Asphalt content	I	AASHTO T 308	1 per 700 tons	Behind paver before compacting	Yes	4 hours
		VMA	I	AASHTO PP 28	“	“	“	“
		Core density[1]	I	AASHTO T 166	“	In-place	Cores to CO after determining specific gravity	24 hours
	Measured and tested for conformance (106.04)	VFA	—	AASHTO PP 28	“	Behind paver before compacting	Yes	4 hours
		Gradation	—	AASHTO T 308 & T 30	“	“	“	“
		Maximum specific gravity (density)	—	AASHTO T 209	At least 1 per day	“	“	“
Hot asphalt concrete pavement (final surface)	Statistical (106.05)	Type I & II smoothness	I	FLH T 504	See Subsection 401.16	See Subsection 401.16	—	14 days after final paving

Table 401-6 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Hot asphalt concrete pavement (final surface)	Measured and tested for conformance (106.04)	Type III & IV roughness	—	AASHTO PP 50, PP 51, & PP 52	See Subsection 401.16	See Subsection 401.16	—	14 days after final paving

(1) Cut core sample from the compacted pavement according to AASHTO T 230, method B. Fill and compact the sample holes with asphalt concrete mixture. Cores shall be 6 inches in diameter. Perform specific gravity and thickness tests on cores and deliver to CO after testing is completed. Label cores and protect from damage due to handling or alteration due to temperature during storage or transfer.

Section 402. — HOT ASPHALT CONCRETE PAVEMENT BY HVEEM OR MARSHALL MIX DESIGN METHOD

Description

402.01 This work consists of constructing one or more courses of Hveem or Marshall hot asphalt concrete pavement.

The mix design method is designated as Hveem or Marshall. Hot asphalt concrete pavement class is designated as shown in Table 402-1. Aggregate grading is designated as show in Table 703-4. Pavement smoothness/roughness type is designated as shown in Subsection 401.16. Asphalt binder is designated as shown in AASHTO M 20, M 226, or M 320.

Antistrip additive type is designated as shown in Subsection 702.08. Where no type is designated, use type 3 (lime).

Material

402.02 Conform to the following Subsections:

Aggregate	703.07
Antistrip additive	702.08
Asphalt binder	702.01
Mineral filler	725.05
Recycled asphalt pavement	703.19
Recycling agent	702.06

Construction Requirements

402.03 Composition of Mix (Job-Mix Formula). Furnish mixes of aggregate, asphalt binder, recycled asphalt pavement, and additives that meet the applicable material requirements, appropriate design parameters in Table 402-1, and are capable of being placed and compacted as specified.

(a) Recycled asphalt pavement use. See Subsection 401.03(a).

(b) Submission. Submit written job-mix formulas with Form FHWA 1607 (Hveem) or Form FHWA 1608 (Marshall) for approval at least 28 days before production. Include the location of all commercial mixing plants to be used and a separate job-mix formula for each plant. Include a signed statement prepared by the testing laboratory that certifies the proposed job-mix formula meets the requirements of the contract and can be compacted in the field during production to meet contract requirements. For each job-mix formula, submit the following:

Table 402-1
Asphalt Concrete Mix Requirements

Design Parameters[(1)]	**Class of Mix**		
	A	**B**	**C**
(a) Hveem (AASHTO T 246 and T 247)			
(1) Stabilometer, minimum	37	35	30
(2) Percent air voids	3.0–5.0	3.0-5.0	3.0-5.0
(3) Voids in mineral aggregate, min. %	See Table 402-2		
(b) Marshall (AASHTO T 245)			
(1) Stability, pounds min.	1,800	1,200	1,000
(2) Flow, 0.01 inches	8-14	8-16	8-20
(3) Percent air voids	3.0-5.0	3.0-5.0	3.0-5.0
(4) Voids in mineral aggregate, min. %	See Table 402-2		
(5) Compaction, number of blows each end of test specimen	75	50	50
(c) Immersion – Compression (AASHTO T 165 and T 167)			
(1) Compressive strength, pounds per square inch min. (dry)	300	250	200
(2) Retained strength, min. %	70	70	70
(d) Dust-asphalt ratio[(2)]	0.8-1.6	0.8-1.6	0.8-1.6

(1) The percent of air voids are based on AASHTO T 166, T 209, and T 269. Maximum specific gravity (density) will be based on AASHTO T 209.
(2) Dust-asphalt ratio is defined as the percent of material including nonliquid antistrip and mineral filler passing the No. 200 sieve divided by the percent of effective asphalt (calculated by mass of mix).

Table 402-2
Voids in Mineral Aggregate (VMA)
Marshall or Hveem Mix Design

Sieve Size[(1)]	Minimum Voids [(2)(3)] Percent	
	Marshall	**Hveem**
No. 4	18.0	16.0
3/8 inch	16.0	14.0
1/2 inch	15.0	13.0
3/4 inch	14.0	12.0
1 inch	13.0	11.0

(1) The largest sieve size listed in the applicable specification upon which any material is permitted to be retained.
(2) VMA to be determined according to *AI Manual Series No. 2 (MS-2)*.
(3) When a mineral filler or nonliquid antistrip is used, include the percentage specified in the calculation for compliance with the VMA.

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each sieve size for the aggregate blend; and

(2) Designate target values within the gradation band specified for the grading designation shown in Table 703-4.

(b) Aggregate sources. See Subsection 401.03(b)(1)(*b*).

(c) Stockpile gradations. See Subsection 401.03(b)(1)(*c*).

(d) Representative samples. See Subsection 401.03(b)(1)*(d)*.

(e) Results of aggregate quality tests for contractor selected sources. See Subsection 401.03(b)(1)*(e)*.

(2) Asphalt binder. See Subsection 401.03(b)(2).

(3) Antistrip additives. See Subsection 401.03(b)(3).

(4) Recycled asphalt pavement material. See Subsection 401.03(b)(4).

(c) Verification. The CO will review and may perform design verification testing. If verification testing is performed, the information supplied in the Contractor's design must agree with the verification test results within the tolerances shown below.

(1) Aggregate gradations. See Subsection 401.03(c)(1).

(2) Hveem stabilometer. The Contractor's design stabilometer value at the contractor's selected design asphalt content is verified if it meets or exceeds the specification limit and differs from the CO's result by no more than six points and the average of the Contractor's results and the CO's results meets or exceeds the minimum contract specification.

(3) Hveem air void content. The Contractor's design air void content is verified if it meets the contract specification of 3.0 to 5.0 percent and differs from the CO's result by no more than 2.0 percent, and the CO's result does not exceed the specification limits by more than 0.5 percent.

(4) Voids in mineral aggregate (VMA). See Subsection 401.03(c)(2).

(5) Immersion-compression. The Contractor's dry strength result is verified if the CO's result is above the minimum contract specification, or the average of the Contractor's and the CO's result is above the minimum contract specification and the two values differ by no more than 50 pounds per square inch. The Contractor's percent retained strength result is verified if the CO's result is above the minimum contract specification.

(6) Marshall air voids, stability, and flow. The Contractor's results are verified if they meet the contract specifications in Table 402-1.

(d) Changes and resubmissions. See Subsection 401.03(d).

(e) Acceptance. See Subsection 401.03(e).

402.04 Mixing Plant. See Subsection 401.04.

402.05 Pavers. See Subsection 401.05.

402.06 Surface Preparation. See Subsection 401.06.

402.07 Weather Limitations. See Subsection 401.07.

402.08 Asphalt Preparation. See Subsection 401.08.

402.09 Aggregate Preparation. See Subsection 401.09.

402.10 Mixing. See Subsection 401.10.

402.11 Hauling. See Subsection 401.11.

402.12 Production Start-up Procedures. See Subsection 401.12.

(a) Pre-paving conference. See Subsection 401.12(a).

(b) Control Strip. See Subsection 401.12(b).

(1) Mixture. Take and test at least three control strip asphalt concrete mix samples and evaluate according to Subsection 402.17. The mix is acceptable if the calculated pay factor for asphalt content and aggregate gradation is 0.90 or greater.

(2) Compaction. See Subsection 401.12(b)(2).

402.13 Placing and Finishing. See Subsection 401.13.

402.14 Compacting. See Subsection 401.14.

402.15 Joints, Trimming Edges, and Cleanup. See Subsection 401.15.

402.16 Pavement Smoothness/Roughness. See Subsection 401.16.

402.17 Acceptance. See Table 402-3 for sampling and testing requirements and the acceptance quality characteristic category.

Mineral filler, antistrip additive, and recycling agent will be evaluated under Subsections 106.02 and 106.03.

Asphalt binder will be evaluated under Subsections 106.03(a), 106.04, and 702.09.

Construction of the Hveem or Marshall designed hot asphalt concrete pavement course will be evaluated under Subsections 106.02 and 106.04.

Asphalt content, aggregate gradation, density, and type I and II pavement smoothness will be evaluated under Subsection 106.05. Type III and IV pavement roughness and other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value plus or minus 0.4 percent.

(b) Aggregate gradation. The upper and lower specification limits are the approved job-mix formula target values plus or minus the allowable deviations shown in Table 703-4. See Table 402-3 for the acceptance quality characteristics category.

(c) Density. The lower specification limit is 91 percent of the maximum specific gravity (density) determined according to AASHTO T 209 as part of the job-mix formula evaluation specified in Subsection 402.03.

(d) Pavement smoothness/roughness. The evaluation will be made after all defective areas are corrected. See Subsection 401.16.

Measurement

402.18 Measure the Section 402 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 hot asphalt concrete pavement contract unit bid price will be adjusted according to Subsections 106.05 and 401.16. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for hot asphalt concrete pavement will be made at a price determined by multiplying the contract unit bid price by the material pay factor. The material pay factor is the lowest single pay factor determined for asphalt content, specific gravity (density), or any individual sieve of the aggregate gradation.

When the bid schedule contains a pay item for hot asphalt concrete pavement, type I or II pavement smoothness, a separate adjustment will be made for pavement smoothness according to the following formula:

$$A = 32{,}700(PF_{smooth} - 1.00)(L)$$

where:

A =	Adjustment to contract payment in dollars for pavement smoothness.
L =	Total project length in lane miles of traveled way including excluded areas. Measure project length to 3 decimal places.
PF_{smooth} =	Pay factor for smoothness with respect to the upper specification limit determined according to Subsection 401.16 and 106.05 after completion of corrective work.

When the bid schedule contains a pay item for hot asphalt concrete pavement, type III or IV pavement roughness, a separate pay adjustment will be made. The dollar amount of the adjustment will be determined by summing the pay adjustment factors determined in Subsection 401.16 for each 0.1-mile and multiplying that sum by the contract unit bid price.

Table 402-3
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality	Measured and tested for conformance (106.04)	LA abrasion (coarse)	—	AASHTO T 96	1 per type & source of material	Source of material	Yes	Before producing
		Sodium sulfate soundness loss (coarse & fine)	—	AASHTO T 104	“	“	“	“
		Sand equivalent	—	AASHTO T 176, alternate method no. 2, reference method	“	“	“	“
Asphalt concrete (mix design)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per submitted mix design	Stockpiles	Yes	28 days before producing
		Voids	—	AASHTO T 209	“	“	“	“
		Moisture susceptibility	—	AASHTO T 165 & T 167	“	“	“	“
Aggregates (production)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per 6 hours of production but not less than 2 per day	Flowing aggregate stream (bin or belt discharge) or off of conveyor belt	Yes, when requested	End of shift
		Sand equivalent	—	AASHTO T 176, alternate method no. 2, reference method,	1 per type & source of material	“	“	“
		Fractured faces	—	ASTM 5821	“	“	“	“
		Sample for job-mix formula verification	—	Subsection 401.03	1 per aggregate stockpile	“	—	21 days before approval of job-mix formula

Table 402-3 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Asphalt binder	Measured and tested for conformance (106.04)	Quality	—	Subsection 702.01	1 per submitted source & mix design 1 per 2100 t of mix but not less than 5 samples	In line between tank & mixing plant	2 – 1-quart samples provided to the government	—
Asphalt concrete mixture (all)	Measured and tested for conformance (106.04) & Section 105	Mix temperature	—	—	First load & as determined by the CO thereafter	Hauling vehicle before dumping or windrow before picking up	—	Upon completing test
Hot asphalt concrete pavement (control strip)	Statistical (106.05)	Gradation		AASHTO T 308, T 30, & T 110	3 minimum	Behind paver before compacting	Yes	4 hours
		1/2 inch	I					
		3/8 inch	II					
		No. 4	I					
		No. 8	I					
		No. 40	II					
		No. 200	I					
		Other specified sieves	II					
		Asphalt content	I	AASHTO T 308	“	“	“	“

Table 402-3 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Hot asphalt concrete pavement (control strip)	Statistical (106.05)	Core density(1)	I	AASHTO T 166 & T 209	At least 5 samples per control strip	In-place	Cores to CO after determining specific gravity & compaction	—
Hot asphalt concrete pavement (production)	Statistical (106.05)	Gradation		AASHTO T 308, T 30, & T 110	1 per 700 tons	Behind paver before compacting	Yes	4 hours
		1/2 inch	I					
		3/8 inch	II					
		No. 4	I	"	"	"	"	"
		No. 8	I					
		No. 40	II	"	"	"	"	"
		No. 200	I					
		Other specified sieves	II	"	"	"	"	"
		Asphalt content	I		"	"	"	
		Core density(1)	I	AASHTO T 166 & T 209	"	In-place	Cores to CO after determining specific gravity	24 hours
Hot asphalt concrete mixture (final surface)	Statistical (106.05)	Type I & II smoothness	I	FLH T 504	See Subsection 401.16	See Subsection 401.16	—	14 days after final paving

Table 402-3 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Hot asphalt xoncrete pavement (final surface)	Measured and tested for conformance (106.04)	Type III & IV roughness	—	AASHTO PP 50, PP 51, & PP 52	See Subsection 401.16	See Subsection 401.16	—	14 days after final paving

(1) Cut core sample from the compacted pavement according to AASHTO T 230, method B. Fill and compact the sample holes with asphalt concrete mixture. Cores shall be 6 inches in diameter. Perform specific gravity and thickness tests on cores and deliver to CO after testing is completed. Label cores and protect from damage due to handling or alteration due to temperature during storage or transfer.

Section 403. — HOT ASPHALT CONCRETE PAVEMENT

Description

403.01 This work consists of constructing one or more courses of hot asphalt concrete pavement.

Asphalt binder is designated according to AASHTO M 20, M 226, or M 320.

Antistrip additive type is designated as shown in Subsection 702.08. Where no type is designated, use type 3 (lime).

Material

403.02 Conform to the following Subsections:

Aggregate	703.07 or 703.17
Antistrip additive	702.08
Asphalt binder	702.01
Mineral filler	725.05
Recycled asphalt pavement	703.19
Recycling agent	702.06

Construction Requirements

403.03 Composition of Mix (Job-Mix Formula). Furnish mixes of aggregate, asphalt binder, recycled asphalt pavement, and additives that meet the applicable gradation and material requirements in one of the following:

- Superpave designed asphalt mixture as designated in Subsection 401.03 for the appropriate traffic level of the roadway.

- Hveem or Marshall designed asphalt mixture as designated in Subsection 402.03 for class A, B, or C mix.

- State Department of Transportation asphalt concrete pavement mixture. Meet the requirements for the location and type of facility being constructed as designated by the current State Department of Transportation specification. Submit the aggregate quality, gradation requirements, and mixture criteria for the asphalt concrete mix.

(a) Recycled asphalt pavement use. Up to 25 percent recycled asphalt pavement material by mass may be used in the mix.

(b) Submission. Submit written job-mix formulas for approval at least 28 days before production. Include the location of all commercial mixing plants to be used and a separate job-mix formula for each plant. Include a signed statement prepared by the testing laboratory that certifies the proposed job-mix formula meets the requirements of the contract and can be compacted in the field during production to meet contract requirements. For each job-mix formula, submit the following:

(1) Aggregate and mineral filler.

(a) Target values:

(1) Target value for percent passing each sieve size for the aggregate blend;

(2) Target value for percent passing each sieve size for each stockpile;

(3) Stockpile blend ratios;

(4) Target asphalt binder content; and

(5) Maximum density value according to AASHTO T 209.

(b) Aggregate sources. See Subsection 401.03(b)(1)*(b)*.

(c) Stockpile gradations. See Subsection 401.03(b)(1)*(c)*.

(d) Representative samples. See Subsection 401.03(b)(1)*(d)*.

(e) Results of aggregate quality tests for contractor selected sources. Results must be for tests performed on aggregates within 1 year of use.

(2) Asphalt binder. See Subsection 401.03(b)(2).

(3) Antistrip additives. See Subsection 401.03(b)(3).

(4) Recycled asphalt pavement material. See Subsection 401.03(b)(4).

(c) Verification. The CO will review and may perform design-verification testing. If verification testing is performed, the aggregate gradations of the stockpiles and the aggregate blend must agree with the target values plus or minus the allowable deviation in Subsection 401.03(c)(1).

(d) Changes and resubmissions. See Subsection 401.03(d).

(e) Acceptance. See Subsection 401.03(e)

403.04 Mixing Plant. See Subsection 401.04.

403.05 Pavers. See Subsection 401.05.

403.06 Surface Preparation. See Subsection 401.06.

403.07 Weather Limitations. See Subsection 401.07.

403.08 Asphalt Preparation. See Subsection 401.08.

403.09 Aggregate Preparation. See Subsection 401.09.

403.10 Mixing. See Subsection 401.10.

403.11 Hauling. See Subsection 401.11

403.12 Production Start-up Procedures. Arrange for a pre-paving conference according to Subsection 401.12(a). Provide 7 days notice before beginning production of an asphalt concrete mix.

403.13 Placing and Finishing. Do not use mixes produced from different plants unless the mixes are produced according to the same job-mix formula, use material from the same sources, and are approved.

Place asphalt concrete mix at a temperature conforming to Table 401-2. Measure temperature of the mix in the hauling vehicle just before dumping into 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 is impractical, place and finish the 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 layer at least 6 inches from the joint in the layer immediately below. Make the longitudinal joint in the top layer along the centerline of two-lane roadways or at the lane lines of roadways with more than two lanes.

403.14 Compacting. Thoroughly and uniformly compact the asphalt surface by rolling. Do not cause cracking, shoving or undue displacement. Continue rolling until all roller marks are eliminated, all cracks are sealed, and the required density is obtained. Do not roll the mix after the surface cools below 175 °F.

Monitor the compaction process with nuclear density gauges. Calibrate the gauge according to the ASTM D 2950 calibration section within 6 months before use and check the standard and reference on each day of use according to the ASTM D 2950 standardization and reference check sections. Compact to a pavement specific gravity (density) that is no less than 92 percent of the maximum specific gravity (density) determined according to AASHTO T 209.

Along forms, curbs, headers, walls, and other places not accessible to the rollers, compact the mix with alternate equipment to obtain the required compaction.

403.15 Joints, Trimming Edges, and Cleanup. See Subsection 401.15.

403.16 Pavement Smoothness. Use a 10-foot metal straight edge to measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 1/4 inch in 10 feet between any two contacts of the straightedge with surface.

Correct defective areas. Obtain approval for the proposed method of correction.

403.17 Acceptance. See Table 403-1 for sampling and testing requirements.

Mineral filler, antistrip additive, and recycling agent will be evaluated under Subsections 106.02 and 106.03.

Asphalt binder will be evaluated under Subsections 106.03(a), 106.04, and 702.09.

Construction of hot asphalt concrete pavement course will be evaluated under Subsections 106.02 and 106.04.

Asphalt content, aggregate gradation, density, and pavement smoothness will be evaluated under Subsection 106.04. Recycled asphalt pavement and aggregate quality properties will be evaluated under Subsections 106.02 and 106.03.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value plus or minus 0.4 percent.

(b) Density. The lower specification limit is 92 percent of the maximum specific gravity (density) determined according to AASHTO T 209 as part of the job-mix formula evaluation specified in Subsection 403.03.

(c) Aggregate gradation. The upper and lower specification limits are the approved job-mix formula target values plus or minus the allowable deviations shown in Table 703-4 or 703-13.

Measurement

403.18 Measure the Section 403 items listed in the bid schedule according to Subsection 109.02.

Payment

403.19 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	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Hot asphalt concrete pavement	Measured and tested for conformance (106.04)	Job-mix formula verification	—	Subsection 403.03	1 per aggregate stockpile	Flowing aggregate stream (bin or belt discharge) or off of conveyor	—	21 days before approval of job-mix formula
		Gradation	—	AASHTO T 30	1 per 700 tons	Behind paver before compacting	Yes, when requested	24 hours
		Asphalt content	—	AASHTO T 308	"	"	"	"
		Compaction	—	ASTM D 2950 or other approved procedures	"	Completed roadway after rolling	"	"
		Smoothness	—	Subsection 403.16	—	—	—	—
Asphalt binder		Quality	—	Subsection 702.01	1 per 130 tons of liquid	Line between storage tank & asphalt plant	2 — 1-quart samples	Tested by Government

Section 404. — MINOR HOT ASPHALT CONCRETE

Description

404.01 This work consists of constructing minor hot asphalt concrete for sidewalks, paved waterways, curbs, and roadways.

Construction Requirements

404.02 Composition of Mix (Job-Mix Formula). Provide a hot asphalt concrete mix composed of crushed stone or gravel and asphalt binder mixed in an approved plant. Use an aggregate gradation and asphalt binder of a quality conforming to those normally used locally by either Federal or State agencies for the type of work being constructed.

Submit the strength, quality, and gradation specifications for the asphalt concrete mix. Include copies of laboratory test reports that demonstrate the properties of the aggregates, asphalt binder, additives, and mix meet Federal or State agency specifications. Also submit the maximum specific gravity (density) of the mix as determined by AASHTO T 209.

404.03 Surface Preparation. Prepare the surface according to Section 209 or Subsection 410.05 as applicable.

404.04 Weather Limitations. Place asphalt concrete on a dry, unfrozen surface when the air temperature in the shade is at least 35 ºF and rising.

404.05 Hauling. Haul the asphalt mix using vehicles conforming to Subsection 401.11.

404.06 Placing. Place the mix with a mechanical paver. For roadway paving, do not place lifts thicker than 4 inches. In areas where mechanical spreading and finishing is impractical, spread and finish each course by hand raking, screeding, or by other approved methods. Construct a surface that is uniform in texture and cross-section. Construct joints according to Subsection 401.15.

404.07 Compacting.

(a) Roadway paving. Compact the mix to a minimum of 90 percent of maximum specific gravity (density). Complete compaction before the mix temperature falls below 160 ºF. Determine density by nuclear gauge.

(b) Non-roadway paving. Compact by rolling with a hand-operated roller weighing at least 300 pounds or with a small power roller.

Compact areas that are not accessible to rollers by other approved methods.

404.08 Pavement Smoothness. Use a 10-foot metal straightedge to measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 1/4 inch in 10 feet between any two contacts of the straightedge with the surface. Correct defective areas using approved methods.

404.09 Acceptance. See Table 404-1 for sampling and testing requirements.

Minor hot asphalt concrete mixture will be evaluated under Subsections 106.02 and 106.03.

Minor hot asphalt concrete construction work will be evaluated under Subsections 106.02 and 106.04.

Measurement

404.10 Measure the Section 404 items listed in the bid schedule according to Subsection 109.02.

Payment

404.11 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. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 404-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Asphalt mixture (404.07)	Measured and tested for conformance (106.04)	Compaction (roadway paving)	—	AASHTO T 310	1 per 1200 yd^2	In-place	—	Upon completing tests

Section 405. — OPEN-GRADED ASPHALT FRICTION COURSE

Description

405.01 This work consists of constructing an open-graded asphalt friction course.

Asphalt binder is designated according to AASHTO M 20, M 226, or M 320.

Antistrip additive type is designated as shown in Subsection 702.08. Where no type is designated, use type 3 (lime).

Material

405.02 Conform to the following Subsections:

Aggregate	703.08
Antistrip additive	702.08
Asphalt binder	702.01

Construction Requirements

405.03 Composition of Mix (Job-Mix Formula). Design an open-graded asphalt friction course mix of aggregate, asphalt, and additives according to the design procedure in *FHWA Technical Advisory T 5040.31, Open-Graded Friction Courses,* December 1990, or by other approved methods. Meet the aggregate gradation of Table 703-4 grading F. Provide an application temperature range.

Submit a written job-mix formula for approval at least 21 days before production. Submit the information and samples according to Subsection 401.03. The job-mix formula will be evaluated and approved according to Subsection 401.03.

405.04 Mixing Plant and Pavers. Use a mixing plant conforming to Subsection 401.04. Use pavers conforming to Subsection 401.05.

405.05 Surface Preparation. Prepare the surface according to Subsection 401.06.

405.06 Weather Limitations. Place open-graded asphalt friction course on a dry asphalt surface only when the air temperature in the shade is above 55 ºF and the road surface temperature at least 60 ºF. Stop placement if either temperature falls below these minimums.

405.07 Preparing and Mixing Material. Prepare, mix, and control material according to Subsections 401.08 through 401.10 except the temperature of the aggregate introduced into the mixer shall not exceed the optimum mixing temperature established in the job-mix formula.

405.08 Hauling, Placing, and Finishing. Construct the open-graded asphalt friction course according to Subsections 401.11 through 401.13. Place mix within the approved temperature range.

To minimize asphalt binder drainage, discharge the mix into the paver within 1.5 hours of loading the truck. When surge bins are used, begin the 1.5-hour limit at the time the mix is deposited into the surge bin.

405.09 Compacting. Roll asphalt mix parallel to centerline, commencing at the outside edge and progressing towards the center. Use a steel-wheeled roller in a manner that does not shove, distort, or strip the mix beneath the roller. On superelevated curves, begin the rolling on the low side and progress to the high side. Limit amount of rolling to that necessary for consolidating the asphalt mix and bonding it to the underlying surface.

Provide a smooth surface according to Subsection 404.08.

405.10 Joints and Cleanup. Use butt joints for longitudinal and transverse joints. Protect the completed open-graded asphalt friction course from all traffic until it has sufficiently hardened to resist abrasion, pickup, and raveling.

405.11 Acceptance. See Table 405-1 for sampling and testing requirements and the acceptance quality characteristic category.

Antistrip additive will be accepted under Subsections 106.02 and 106.03.

Asphalt will be evaluated under Subsections 106.04 and 702.09.

Construction of the open-graded asphalt friction course will be evaluated under Subsections 106.02 and 106.04.

Asphalt content and aggregate gradation will be evaluated under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value ±0.5 percent.

(b) Aggregate gradation. The upper and lower specification limits are the approved job-mix formula target values plus or minus the allowable deviations shown in Table 703-4 grading F.

Measurement

405.12 Measure the Section 405 items listed in the bid schedule according to Subsection 109.02.

Payment

405.13 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 open-graded asphalt friction course unit bid 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 open-graded asphalt friction course will be made at a price determined by multiplying the unit bid 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 405-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Open-graded asphalt friction course	Statistical (106.05)	Asphalt content	I	AASHTO T 308 or T 164	1 per 300 tons	Hopper of lay down machine after discharging from plant	Yes	—
		Gradation						
		No. 4	I	AASHTO T 30	1 per 300 tons	“	—	—
		No. 200	I					
		Other specified sieves	II					
Asphalt binder	Statistical (106.05)	Quality	—	Subsection 702.01	1 per 300 tons	Line between storage tank & asphalt plant	Yes	—

Section 406. — Reserved

Section 407. — Reserved

Section 408. — COLD RECYCLED ASPHALT BASE COURSE

Description

408.01 This work consists of constructing one or more courses of cold recycled asphalt base using recycled asphalt pavement and reclaimed aggregates combined with new aggregates, water, emulsified asphalt, recycling agents, and lime.

Emulsified asphalt grade is designated as shown in AASHTO M 140 or M 208.

Material

408.02 Conform to the following Subsections:

Aggregate (new)	703.06
Emulsified asphalt	702.03
Lime	702.08(c)
Recycled asphalt pavement	703.19
Recycling agent	702.06
Water	725.01(c)

Construction Requirements

408.03 Submittals. Submit the following at least 21 days before recycling:

(a) Aggregate.

(1) Sources of recycled asphalt pavement, reclaimed aggregates, and new aggregate.

(2) Proportional samples representing the recycled asphalt pavement, reclaimed aggregate, and new aggregate; about 700 pounds total. Obtain samples of existing pavement according to Subsection 401.03(b)(4)*(e)*.

(b) Emulsified asphalt and recycling agents.

(1) Percentage of emulsified asphalt and recycling agent to be added based on the total mass of the mixture or the application rate if spray application is used.

(2) Source of and 5-gallon sample of the emulsified asphalt and recycling agent to be used in the mixture. Furnish the samples in plastic containers.

(c) Water. Percentage of water to be added based on the total mass of the mixture.

(d) Lime. Percentage of lime added based on total mass of the mixture.

The CO will perform a mix design and provide an initial application rate for emulsified asphalt, recycling agent, and/or lime for the mix.

408.04 Surface Preparation. For inplace mixing, clear, grub, and dispose of all vegetation and debris within 12 inches of the pavement to be recycled. Perform the work according to Section 201. Prepare the surface according to Subsection 303.06.

408.05 Weather Limitations. Place the cold recycled asphalt base on a dry, unfrozen surface when the air temperature in the shade is above 50 ºF and the pavement surface temperature is above 40 ºF.

Do not place cold recycled asphalt base when fog, showers, rain, frost, or temperatures below 35 ºF are anticipated within 24 hours following the placement of the mix.

408.06 Mixing. Use rotary mixers, cold-milling machines, travel plants, stationary mixing plants, or other approved equipment for producing the completed base course mixture. If emulsified asphalt is used, mix as follows:

(a) Maintain the aggregate temperature between 60 and 175 ºF.

(b) Maintain emulsified asphalt temperature within the approved range.

(c) Combine and dry mix the aggregate for a period sufficient to provide a uniform gradation. Add additives and water first. Add the emulsified asphalt last. Mix the material until particles are uniformly coated, the mixture has a uniform color, and particles are evenly distributed coarse to fine.

For in-place mixing, use self-propelled equipment capable of scarifying, crushing, mixing, weighing, and placing the mixture. Use equipment with meters capable of registering the rate of addition of the emulsified asphalt, recycling agent, or water. Adjust the travel speed and number of passes to obtain a thorough and uniform mixture.

For central plant mixing, use suitable equipment for scarifying and crushing the existing pavement. Use acceptable continuous flow or batch-type mixer equipped with batching or metering devices designed to measure the specified quantities of the respective material.

The final emulsified asphalt, recycling agent, and lime content will be established by the CO after evaluation of field results.

408.07 Spreading, Finishing, and Compacting. Transport material according to Subsection 401.11. Spread and finish the mixture according to Subsection 416.08 except: If a paving machine is not used, spread the mixture on the prepared surface in a uniform layer. Shape the mixture to the line, grade, and cross-section. Route hauling equipment uniformly over the full width of the surface to minimize rutting or uneven compaction. Compact the mixture according to Subsection 416.08, type A.

Allow the pavement to cure according to Subsection 416.08 before sealing the surface with a fog seal according to Subsection 416.09.

408.08 Acceptance. See Table 408-1 for sampling and testing requirements.

Recycling agent and lime will be evaluated under Subsections 106.02 and 106.03.

Emulsified asphalt will be evaluated under Subsections 106.03, 106.04, and 702.09.

Aggregate (new) will be evaluated under Subsections 106.02, 106.03, and 106.04.

Construction of the cold recycled asphalt base course will be evaluated under Subsections 106.02 and 106.04. Cold recycled asphalt base density will be evaluated under Subsections 106.02 and 106.04.

Measurement

408.09 Measure the Section 408 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

When measurement is by the ton, do not deduct for the emulsified asphalt, recycling agent, water, and lime contained in the mixture.

Measure the square yard width horizontally to include the top of base width including designed widening. Measure the square yard length horizontally along the centerline of the roadway.

Measure fog seal under Section 409.

Payment

408.10 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 408-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Emulsified asphalt (702.03)	Measured and tested for conformance (106.04)	Quality	—	Subsection 702.03	1 per 130 tons but not less than 5 samples	Line between storage tank & mixing plant	Yes	—
	Measured and tested for conformance (106.04)	Density	—	AASHTO T 310	1 per 600 yd^2	In-place	—	24 hours

Section 409. — ASPHALT SURFACE TREATMENT

Description

409.01 This work consists of constructing a single or multiple asphalt surface treatment with aggregate or precoated aggregate. This work also includes constructing an asphalt fog seal without aggregate.

Surface treatment aggregate designation is designated as shown in Tables 409-1, 409-2, and 409-3.

Asphalt is designated as shown in AASHTO M 20 or M 226 for asphalt binder and AASHTO M 140 or M 208 for emulsified asphalt.

Material

409.02 Conform to the following Subsections:

Aggregate	703.10
Asphalt binder	702.01
Blotter	703.13
Emulsified asphalt	702.03

Construction Requirements

409.03 Composition. Submit the following information and samples for approval at least 21 days before placement:

(a) Aggregate samples. 80 pounds from each stockpile produced and the gradation range represented by each.

(b) Aggregate gradation target values. The proposed percentage of each stockpile to be used and the proposed target value for each sieve size.

(c) Asphalt samples. Two 1-quart samples of asphalt binder or emulsified asphalt from the same source and of the type to be used for the surface treatment.

(d) Asphalt temperature. Apply asphalt at temperatures according to Table 702-1.

(e) Spread rates. The proposed spread rate for the aggregate and asphalt material.

409.04 Equipment. Furnish equipment as follows:

(a) Asphalt distributor.

(1) Capable of heating asphalt evenly;

(2) Adjustable full circulation spray bar to 15-foot width;

(3) 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

(4) Thermometer for measuring the asphalt temperature in the tank.

(b) Rotary power broom.

(1) Self-propelled; and

(2) Capable of controlling the vertical broom pressure.

(c) Pneumatic-tire rollers. Furnish a minimum of two pneumatic-tire rollers both with the following capabilities:

(1) Self-propelled;

(2) Minimum compacting width – 5 feet; and

(3) Gross weight adjustable within the range of 200 to 360 pounds per inch of compaction width.

(d) Aggregate spreader.

(1) Self-propelled;

(2) Minimum of 4 pneumatic tires on 2 axles; and

(3) Positive controls to uniformly deposit the aggregate over the full width of asphalt within 10 percent by mass of the required rates.

(e) Other equipment. Other equipment of proven performance may be used in addition to or in lieu of the specified equipment when approved by the CO. Provide two-way communication between the asphalt distributor and the aggregate spreader if the roadway alignment does not permit visual contact.

409.05 Surface Preparation. On existing asphalt surfaces, ensure that the surface is dry. Immediately before placing the layer, remove loose dirt and other objectionable material from the surface by approved methods. Fog seal patches using a slow setting emulsion diluted with an equal part water. Apply the diluted emulsion at a rate of 0.17 gallons per square yard.

On existing aggregate surfaces, prime the surface according to Section 411. Allow the primed surface to cure at least 5 days for cutback asphalt or 24 hours for asphalt emulsions. Ensure that the primed surface is dry for surface treatments using asphalt binder or slightly damp for surface treatments using emulsified asphalt.

409.06 Weather Limitations. Apply surface treatments with aggregate only when ambient air and surface temperatures are above 60 °F and rising, when the weather is not foggy or rainy, and when rain is not anticipated for at least 24 hours after application.

Apply fog seals only when the ambient air and surface temperatures are above 50 °F and rising, when the weather is not foggy or rainy, and when rain is not anticipated for at least 24 hours after application.

Complete all surface treatment applications 2 hours before sunset.

409.07 Production Start-up Procedures for Surface Treatments. At least 10 days before the start of constructing all surface treatments containing aggregate, arrange for a pre-surface treatment conference. Coordinate attendance with the CO and any applicable subcontractors. Be prepared to discuss or submit the following:

(a) Proposed schedule of operations.

(b) List of all equipment and personnel to be used in the production and construction of the work.

(c) Proposed traffic control plan.

(d) Discuss Section 153, minimum frequency schedule for process control sampling and testing (to be performed by the Contractor).

(e) Discuss Subsections 409.07, 409.08, and 409.09.

(f) Discuss spill prevention and safety contingency plan.

Provide 7 days advance notice before constructing all asphalt surface treatments containing aggregate. Also use these start-up procedures when resuming production after termination due to nonconforming work.

On the first day of placement of each surface treatment layer, or whenever there is a change in the surface texture or aggregate gradation, construct a 500-foot control strip that is one-lane wide.

Construct the control strip using material, lay-down, and compaction procedures intended for the remainder of the surface treatment. Cease production after construction of the control strip until the material and the control strip are evaluated and accepted.

Acceptable control strips may remain in place and will be accepted as a part of the completed surface treatment.

Repeat the control strip process until an acceptable control strip is produced.

409.08 Asphalt Application. Calibrate the asphalt distributor spray bar height, nozzle angle, and pump pressure and check longitudinal and transverse spread rates weekly according to ASTM D 2995. If different asphalt distributors are used, calibrate each before use on the project. Ensure that the length of the spread is no more than can be covered with aggregate immediately after application.

Protect the surfaces of nearby objects to prevent spattering or marring. Spread building paper on the surface for a sufficient distance from the beginning and end of each application so the flow through the distributor nozzles may be started and stopped on the paper.

The CO will approve the exact application rate, temperature, and area to be treated before application and may make adjustments for variations in field conditions. Apply the asphalt uniformly with an asphalt distributor. Move distributor forward at the proper application speed at the time the spray bar is opened. Use care not to apply excess asphalt at the junction of spreads.

Correct skipped areas or deficiencies. Remove and dispose of paper or other material used.

409.09 Aggregate Application. When using asphalt binder, the aggregate surface should be dry. When using emulsified asphalt, the aggregate surface should be moist.

The CO will approve the exact application rate and area to be treated before application. Apply the aggregate uniformly with an aggregate spreader immediately after the asphalt is applied. Operate aggregate spreader so the asphalt is covered with the aggregate before wheels pass over it. During part-width construction, leave uncovered a strip of sprayed asphalt approximately 6 inches wide to permit an overlap of asphalt material.

Immediately correct excesses and deficiencies by brooming or by the addition or removal of aggregate until a uniform texture is achieved. Use hand methods in areas not accessible to power equipment.

When precoated aggregates are used, they may be mixed on the job or at a central mixing plant. Uniformly coat the aggregate with 1.0 to 2.0 percent residual asphalt, by weight of aggregate. Maintain the flow qualities of the precoated aggregate, so it is satisfactorily spread with an aggregate spreader.

Operate rollers at a maximum speed of 5 miles per hour. Do not permit the aggregate to be displaced by pickup or sticking of material to the tire surface. Sufficiently roll the surface to uniformly and thoroughly bond the aggregate over the full width. Complete rolling within 1 hour after the asphalt is applied to the surface.

409.10 Fog Seal. A fog seal consists of applying slow-setting emulsified asphalt diluted with water onto an existing asphalt surface. Apply the diluted emulsified asphalt according to Subsection 409.08 at a rate of 0.10 to 0.15 gallons per square yard depending on the condition of the existing surface. Allow the fog seal to penetrate undisturbed for at least 2 hours or until the emulsified asphalt breaks and is substantially absorbed into the existing surface. Then lightly cover remaining spots of excess asphalt with blotter according to Section 411 before opening the surface to traffic.

409.11 Single-Course Surface Treatment. A single-course surface treatment consists of applying asphalt material onto an existing surface immediately followed by a single, uniform application of aggregate. Apply the asphalt and aggregate according to Subsections 409.08 and 409.09 at the approximate rates shown in Table 409-1. Determine the exact rates based on approved control strips.

Use a pilot car according to Section 635 to limit traffic speeds. During the initial 45 minutes after completion of rolling, limit the traffic speeds to 10 miles per hour. Limit traffic speeds to 20 miles per hour for 24 hours.

Lightly broom the aggregate surface on the morning after construction. Maintain the surface for 4 days by distributing blotter according to Section 411 to absorb any free asphalt and by repairing areas deficient in aggregate. Sweep excess material from the surface using a rotary power broom when the temperature is less than 75 °F. Do not displace embedded material.

Table 409-1
Approximate Quantities of Material for Single-Course Surface Treatment

Designation	Nominal Maximum Size of Aggregate	Aggregate Gradation (1)	Estimated Quantity of Aggregate (2) pounds/yd^2	Estimated Quantity of Emulsified Asphalt (3) gallons/yd^2	Estimated Quantity of Asphalt Binder (3) gallons/yd^2
1A	3/4 inch	B	40 – 49	0.33 – 0.46	0.22 – 0.31
1B	1/2 inch	C	26 – 29	0.26 – 0.37	0.16 – 0.26
1C	3/8 inch	D	20 – 26	0.16 – 0.29	0.11 – 0.20
1D	No. 4	E	15 – 20	0.13 – 0.18	0.09 – 0.15
1E	Sand	F	9 – 15	0.09 – 0.15	0.07 – 0.13

(1) See Table 703-7 for aggregate gradations.
(2) Aggregate masses are for aggregates having a bulk specific gravity of 2.65, as determined by AASHTO T 84 and T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.
(3) Adjust the asphalt content for the condition of the road.

Table 409-2
Approximate Quantities of Material for
Double Course Surface Treatments

Designation (Thickness)	Nominal Maximum Size of Aggregate	Aggregate Gradation[(1)]	Estimated Quantity of Aggregate[(2)] pounds/yd^2	Estimated Quantity of Emulsified Asphalt [(3)] gallons/yd^2	Estimated Quantity of Asphalt Binder [(3)] gallons/yd^2
2A (1/2 inch)					
1st Application	3/8 inch	D	26 – 35	0.16 – 0.26	0.09 – 0.18
2nd Application	No. 4	E	9 – 15	0.26 – 0.33	0.15 – 0.24
2B (5/8 inch)					
1st Application	1/2 inch	C	29 – 40	0.26 – 0.33	0.15 – 0.24
2nd Application	No. 4	E	14 – 20	0.33 – 0.42	0.20 – 0.27
2C (3/4 inch)					
1st Application	3/4 inch	B	40 – 49	0.29 – 0.42	0.18 – 0.27
2nd Application	3/8 inch	D	20 – 26	0.42 – 0.49	0.27 – 0.35

(1) See Table 703-7 for aggregate gradations.
(2) Aggregate masses are for aggregates having a bulk specific gravity of 2.65, as determined by AASHTO T 84 and T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.
(3) Adjust the asphalt content of the first application for the condition of the road.

409.12 Double- and Triple-Course Surface Treatments. Double- and triple-course surface treatments consist of applying multiple layers of asphalt and aggregate. Apply each asphalt and aggregate layer according to Subsections 409.08 and 409.09 and at the approximate rates shown in Table 409-2 or 409-3. Determine the exact rates based on approved control strips.

Maintain the surface and limit traffic according to Subsection 409.11.

No wait is required between surface treatment applications when using an asphalt binder. Wait at least 24 hours between applications when using emulsified asphalt.

Table 409-3
Approximate Quantities of Material for Triple Course Surface Treatments

Designation (Thickness)	Nominal Maximum Size of Aggregate	Aggregate Gradation(1)	Estimated Quantity of Aggregate(2) pounds/yd^2	Estimated Quantity of Emulsified Asphalt (3) gallons/yd^2	Estimated Quantity of Asphalt Binder(3) gallons/yd^2
3A (1/2 inch)					
1st Application	3/8 inch	D	26 – 35	0.16 – 0.26	0.09 – 0.18
2nd Application	No. 4	E	9 – 15	0.20 – 0.29	0.13 – 0.22
3rd Application	Sand	F	9 – 15	0.16 – 0.26	0.09 – 0.18
3B (5/8 inch)					
1st Application	1/2 inch	C	29 – 40	0.16 – 0.26	0.09 – 0.18
2nd Application	3/8 inch	D	15 – 20	0.26 – 0.33	0.15 – 0.24
3rd Application	No. 4	E	9 – 15	0.16 – 0.26	0.09 – 0.18
3C (3/4 inch)					
1st Application	3/4 inch	B	35 – 46	0.20 – 0.29	0.13 – 0.22
2nd Application	3/8 inch	D	20 – 26	0.26 – 0.33	0.15 – 0.24
3rd Application	No. 4	E	9 – 15	0.20 – 0.29	0.13 – 0.22

(1) See Table 703-7 for aggregate gradations.
(2) Aggregate masses are for aggregates having a bulk specific gravity of 2.65 as determined by AASHTO T 84 and T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.
(3) Adjust the asphalt content of the first application for the condition of the road.

409.13 Acceptance. See Table 409-4 for sampling and testing requirements.

Asphalt binder, and emulsified asphalt, will be evaluated under Subsections 106.04 and 702.09.

Aggregate gradation for asphalt surface treatment 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 Table 703-7, except as follows:

(a) If the calculated mean value for any tested sieve exceeds the maximum gradation value shown in Table 703-7, the upper specification is equal to the maximum gradation value plus the allowable deviation, and the lower specification is equal to the maximum gradation value minus the allowable deviation.

(b) If the calculated mean value for any tested sieve is less than the minimum gradation value shown in Table 703-7, the upper specification is equal to the minimum gradation value plus the allowable deviation, and the lower specification is equal to the minimum gradation value minus the allowable deviation.

Construction of asphalt surface treatment course will be evaluated under Subsections 106.02 and 106.04.

Prime coat and blotter will be evaluated under Section 411.

Measurement

409.14 Measure the Section 409 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure surface treatment aggregate by the cubic yard in the hauling vehicle.

Measure prime coat and blotter under Section 411.

Payment

409.15 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 except the aggregate surface treatment contract unit bid 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 409-4
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate surface treatment source quality [1] (703.10)	Measured and tested for conformance (106.04 & 105)	LA abrasion	—	AASHTO T 96	1 per type & source of material	Source of material	Yes, when requested	Before using in work
		Sodium sulfate soundness loss (course & fine)	—	AASHTO T 104	“	“	“	“
		Fractured faces	—	ASTM D 5821	“	“	“	“
		Flat & elongated particles	—	ASTM D 4791	“	“	“	“
		Durability index (course & fine)	—	AASHTO T 210	“	“	“	“
		Clay lumps & friable particles	—	AASHTO T 112	“	“	“	“
Aggregate surface treatment aggregate [1]	Statistical (106.05)	Gradation. See Table 703-7 for applicable sieves.	I	AASHTO T 27 & T 11	1 per 750 tons	Production belt or spreader discharge	Yes	24 hours
	Measured and tested for conformance (106.04 & 106.05)	Fractured faces	—	ASTM D 5821	1 per 750 tons	Production belt or spreader discharge	Yes	24 hours
		Liquid limit [2]	—	AASHTO T 89	“	“	“	“
Asphalt binder [3] (702.01) or emulsified asphalt [3] (702.03)	Measured and tested for conformance (106.04)	Quality	—	Subsection 409.13	1 per tanker truck including trailer	Point of shipment delivery	2 — 1-quart samples	—

(1) Applies to each aggregate grade furnished.
(2) For blotter material only.
(3) Applied to each asphalt material furnished.

Section 410. — SLURRY SEAL

Description

410.01 This work consists of applying an asphalt slurry seal or a polymer modified micro-surfacing mix on an existing pavement surface.

Slurry seal type is designated as shown in Table 703-8 with following residual asphalt contents:

Type I — Residual asphalt between 10.0 and 16.0 percent

Type II — Residual asphalt between 7.5 and 13.5 percent

Type III — Residual asphalt between 6.5 and 12.0 percent

410.02 Conform to the following Subsections:

Aggregate	703.11
Emulsified asphalt	702.03
Emulsified asphalt, polymer modified	702.03(d)
Mineral filler	725.05
Water	725.01(c)

Construction Requirements

410.03 Composition of Mix (Job-Mix Formula). Furnish a slurry seal or micro-surfacing mixture of aggregate, water, emulsified asphalt, or polymer modified asphalt and additives according to ASTM D 3910 and ISSA T 114. Conform to the applicable aggregate gradation in Table 703-8 and the residual asphalt contents in Subsection 410.01.

Submit a written job-mix formula for approval at least 14 days before production that meets the mix design requirements in ISSA A105 for emulsified asphalt slurry seal and ISSA A143 for micro-surfacing. Submit the following:

(a) Aggregate gradation values. The representative value for each sieve size for the aggregate blend.

(b) Emulsified asphalt content. The residual asphalt content, as a percent by mass of dry aggregate.

(c) Aggregate samples. 100-pound sample of each aggregate.

(d) Emulsified asphalt sample. Source of and 5-gallon sample of the emulsified asphalt to be used in the mix.

(e) Mineral filler samples. 50-pound sample of each proposed mineral filler, when applicable.

The job-mix formula will be evaluated for approval.

410.04 Equipment. Furnish equipment with the following capabilities:

(a) Mixing equipment.

(1) Self-propelled;

(2) Continuous-flow mixing;

(3) Calibrated controls;

(4) Easily readable metering devices that accurately measure all raw material before entering the pugmill;

(5) Automated system for sequencing in all raw material to ensure constant slurry mix;

(6) Mixing chamber to thoroughly blend all ingredients together;

(7) Fines feeder with an accurate metering device for introducing additive into the mixer where the aggregate is introduced into the mixer;

(8) A pressurized water system with a fog-type spray bar capable of fogging the surface immediately ahead of the spreading equipment at a rate of 0.03 to 0.06 gallons per square yard;

(9) Proportioning system that is accurate for measuring all material independent of the engine speed;

(10) Minimum speed of 60 feet per minute and maximum speed of 180 feet per minute;

(11) Minimum storage capacity of 7 tons; and

(12) Capable according to ISSA Performance Guidelines A 105 or A 143.

(b) Mechanical-type single squeegee spreader box.

(1) Attaches to the slurry seal mixer;

(2) Flexible squeegee in contact with the surface to prevent loss of slurry;

(3) Adjustable to ensure a uniform spread over varying grades and crowns;

(4) Adjustable in width with a flexible strike-off; and

(5) Augers for uniform flow to edges.

(c) Auxiliary equipment. Furnish hand squeegees, shovels, and other equipment necessary to perform the work. Provide cleaning equipment including, but not limited to, power brooms, air compressors, water flushing equipment, and hand brooms for surface preparation.

410.05 Surface Preparation. Clean the existing surface of all loose material, dirt, or other deleterious substances by approved methods.

410.06 Weather Limitations. Apply the mixture when the air temperature in the shade and the surface temperature are at least 45 °F and rising and when the weather is not foggy, rainy, or overcast. Do not apply when there is a danger that the finished product will freeze within 24 hours.

410.07 Application. Mix the materials using a slurry seal mixer. Fog the surface with water immediately preceding the spreader.

Blend the additive with the aggregate using the fines feeder. Pre-wet the aggregate in the pugmill immediately before mixing with the emulsified asphalt.

Mix the surfacing materials a maximum of 4 minutes. Ensure the mix is of the desired consistency as it leaves the mixer and conforms to the approved job-mix formula. Adjustment of the mineral filler and the emulsified asphalt content during construction may be approved to adjust for variations in field conditions.

Carry sufficient mix in the spreader to completely cover the surface. Spread the mix with a mechanical-type single squeegee spreader box. In areas not accessible to the spreader box, use hand squeegees to work the mix.

Allow treated areas to completely cure before opening to traffic. Cure is complete when clear water can be pressed out of the mix with a piece of paper without discoloring the paper.

410.08 Acceptance. See Table 410-1 for sampling and testing requirements.

Emulsified asphalt or polymer modified asphalt will be evaluated under Subsections 106.03 and 702.09.

Aggregate for surfacing mixture will be evaluated under Subsections 106.02 and 106.04.

Construction of the surfacing will be evaluated under Subsections 106.02 and 106.04.

Measurement

410.09 Measure the Section 410 items listed in the bid schedule according to Subsection 109.02.

Payment

410.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 410 pay item 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregates for surfacing mixture (703.11)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per 500 tons	Production output or stockpile	Yes, when requested	Before using in work
		LA abrasion	—	AASHTO T 96	1 per aggregate	Aggregate source	“	“
		Soundness (micro-surfacing only)	—	AASHTO T 104	“	“	“	“
		Sand equivalent	—	AASHTO T 176, alternate method no. 2, reference method	“	Production output or stockpile	“	“

Section 411. — ASPHALT PRIME COAT

Description

411.01 This work consists of applying a cut-back or emulsified asphalt prime coat.

Prime coat asphalt grade is designated as shown in AASHTO M 140 or M 208 for emulsified asphalt and AASHTO M 81 or M 82 for cut-back asphalt.

Material

411.02 Conform to the following Subsections:

Blotter	703.13
Cut-back asphalt	702.02
Emulsified asphalt	702.03
Water	725.01(c)

Construction Requirements

411.03 Equipment. Use equipment conforming to Subsection 409.04.

411.04 Surface Preparation. Prepare the surface to be primed according to Subsection 301.05 and 301.06.

411.05 Weather Limitations. Apply prime coat on a dry or slightly damp surface when the air temperature in the shade and the pavement surface temperature are at least 50 ºF and rising and when the weather is not foggy or rainy.

411.06 Asphalt Application. When required, lightly spray the surface with water before applying the prime coat. Apply asphalt according to Subsection 409.08 at a rate of 0.10 to 0.50 gallons per square yard for optimum penetration.

Where using an emulsified asphalt that is not formulated as a penetrating prime coat material, dampen the roadway surface and scarify 1 to 2 inches deep. When required, dilute a slow-setting emulsified asphalt by adding an equal amount of water. Apply the emulsified asphalt at a rate of 0.10 to 0.30 gallons per square yard. Immediately process, respread, and compact the material.

Cure surfaces primed with emulsified asphalt for not less than 24 hours and surfaces primed with cut-back asphalt for not less than 3 days before covering with the next course.

Until the next course is placed, maintain the primed surface and keep it free of corrugations by broom dragging.

Where traffic is routed over a primed surface before the asphalt material has been completely absorbed, or to minimize damage by rain, spread blotter to cover the unabsorbed asphalt. Remove excess blotter as soon as practicable after excess asphalt is absorbed. Remove all dirt or other deleterious material and repair all damaged areas before placing the next course.

411.07 Acceptance. Emulsified asphalt and cut-back asphalt will be evaluated under Subsections 106.04 and 702.09.

Aggregate for blotter will be evaluated under Subsection 106.03.

Construction of the prime coat will be evaluated under Subsections 106.02 and 106.04.

Surface preparation will be evaluated under Section 301.

Measurement

411.08 Measure the Section 411 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure prime coat asphalt including water added for dilution.

Measure blotter by the cubic yard in the hauling vehicle.

Payment

411.09 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. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 412. — ASPHALT TACK COAT

Description

412.01 This work consists of applying an emulsified asphalt tack coat.

Tack coat emulsified asphalt grade is designated as shown in AASHTO M 140 or M 208.

Material

412.02 Conform to the following Subsection:

Emulsified asphalt	702.03

Construction Requirements

412.03 Equipment. Use equipment conforming to Subsection 409.04.

412.04 Surface Preparation. Clean the existing surface of all loose material, dirt, or other deleterious substances by approved methods. When the surface is concrete, remove excess joint and crack filler.

412.05 Weather Limitations. Apply asphalt tack coat on a dry, unfrozen surface when the air temperature in the shade is above 35 ºF and rising.

412.06 Asphalt Application. Where using slow-setting emulsified asphalt, dilute by adding an equal amount of water to the emulsified asphalt.

Apply the asphalt according to Subsection 409.08 at a rate of 0.03 to 0.15 gallons per square yard. When a tack coat cannot be applied with an asphalt distributor spray bar, apply the tack coat uniformly and completely by fogging with a hand spray attachment or by another approved method.

If excess asphalt material is applied, squeegee the excess from the surface. Allow the tacked surfaces to completely cure before placing the covering course. Place the covering course within 4 hours of placing the tack coat.

412.07 Acceptance. Emulsified asphalt will be evaluated under Subsections 106.04 and 702.09.

Construction of the tack coat will be evaluated under Subsections 106.02 and 106.04.

Surface preparation will be evaluated under Section 303.

Measurement

412.08 Measure the Section 412 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure tack coat including water added for dilution.

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.

Section 413. — ASPHALT PAVEMENT MILLING

Description

413.01 This work consists of removing asphalt pavement by a cold milling process.

Construction Requirements

413.02 Equipment — Milling Machine. Furnish equipment with the following capabilities:

(a) Self-propelled;

(b) Sufficient power, traction, and stability to accurately maintain depth of cut;

(c) Capable of removing the pavement thickness to provide profile and cross slope;

(d) Automatic system to control grade elevations by referencing from the existing pavement by means of a ski or matching shoe or from an independent grade control;

(e) Automatic system to maintain cross slope;

(f) System to effectively limit dust and other particulate matter from escaping removal operations;

(g) Loading system or adequate support equipment to completely recover milled material at removal rate; and

(h) Cutting width equal to at least one third of the lane width.

413.03 Milling. Use a longitudinal reference to accurately guide the machine. References may include a curb, edge of pavement, or string attached to the pavement surface. Mill in a longitudinal direction.

Mill the transverse slope to within 1/4 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 1/2 inch of depth per 10 feet. At the beginning 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. When the pavement remains open to traffic, limit differences in elevation between adjacent lanes according to Subsection 401.15.

Mill the surface to a smoothness conforming to Subsection 404.08.

Use a rotary broom and vacuum immediately behind the milling operations to remove and completely recover all loose material. Minimize the escape of dust into the air. Dispose of recovered milled material according to Subsection 211.02(a)(2).

Before opening to traffic, patch milled travel lanes according to Subsection 635.17.

413.04 Acceptance. Asphalt pavement milling will be evaluated under Subsections 106.02 and 106.04.

Smoothness of milled surface will be evaluated under Section 404.

Measurement

413.05 Measure the Section 413 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure square yard width horizontally. Measure the length horizontally along the centerline of the roadway.

Payment

413.06 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. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 414. — ASPHALT PAVEMENT CRACK AND JOINT SEALING

Description

414.01 This work consists of sealing cracks and joints.

Material

414.02 Conform to the following Section and Subsections:

Asphalt binder	702.01
Blotter	703.13
Emulsified asphalt	702.03
Fine aggregate	703.07(b)
Joint sealant	712.01(a)
Slurry seal	410

Construction Requirements

414.03 Equipment. Furnish equipment with the following capabilities:

(a) Power saw and blades. Saw and blades of such size and configuration that saw cuts can be made with one pass. Spacers are not allowed.

(b) Router. Power rotary impact router or vertical spindle router capable of cleaning cracks or joints to the required depth and width.

(c) Hot-compressed air lance. A lance capable of providing clean, oil-free compressed air at a volume of 100 cubic feet per minute at a pressure of 120 pounds per square inch and at a temperature of 2000 ºF.

(d) Application wand. A crack sealant applicator wand attached to a heated hose that is attached to a heated sealant chamber. The temperature controls shall maintain temperature of the sealant within manufacturer's tolerances.

(e) Heating kettle. An indirect-heating-type double boiler with the space between the inner and outer shells filled with oil or other heat transfer medium capable of constant agitation. Provide an accurate and calibrated thermometer having a range from 200 to 600 ºF in 5 ºF graduations. Locate the thermometer such that the temperature of the joint sealant may be safely checked.

(f) Squeegee. A hand-held squeegee for ensuring that the crack is filled to the existing surface.

414.04 Saw Cutting and Joint Sealing. Saw cut, clean, and seal joints in a continuous operation. Either dry or wet cutting is allowed.

Clean dry-sawed joints with a stream of air sufficient to remove all dirt, dust, or deleterious matter adhering to the joint walls or remaining in the joint cavity. Blow or brush dry material off the pavement surface.

Clean wet-sawed joints with a water blast, 50 pounds per square inch minimum, immediately after sawing to remove any sawing slurry, dirt, or deleterious matter adhering to the joint walls or remaining in the joint cavity. Immediately flush all sawing slurry from the pavement surface. Blow wet-sawed joints with air to dry joint surfaces.

Do not allow traffic to knead together or damage the sawed joints. If cleaning operations cause interference with traffic, provide protective screening.

Place the sealant when the pavement surface temperature is 40 ºF or higher. Discontinue operations when weather conditions detrimentally affect the quality of forming joints and applying sealants.

Submit a copy of and adhere to the manufacturer's recommendations for heating and applying the joint sealant. Heat the joint sealant in a heating kettle. Do not heat the sealant above the safe heating temperature recommended by the manufacturer. Do not hold the material at the pouring temperature for more than 6 hours and do not reheat the material.

Place a bond breaker tape designed for use with hot-poured sealant in the bottom of the saw cut joint.

Seal the joints with an applicator wand when the sealant material is at the pouring temperature. Heat or insulate the applicator wand to maintain the pouring temperature of the sealant during placing operation. Return the applicator wand to the machine and recirculate the joint sealant material immediately after sealing each joint.

Seal each joint such that, after cooling, the level of the sealant is no more than 1/8 inch below the pavement surface, but not above the pavement surface. Use a squeegee to ensure that a 3-inch wide band is centered on the finished sealed crack.

Wait for the sealant to be tack free before opening the joint to traffic. Do not spread blotter on the sealed joints to allow early opening to traffic.

414.05 Crack Cleaning and Sealing. Clean the existing surface of all loose material, dirt, or other deleterious substances by brooming, flushing with water, or other approved methods. When specified, rout and clean all cracks with an average opening of 1/4 inch or more to make a sealant reservoir to the depth of the routed crack or at least 3/4 inch deep. Dry cracks before sealing.

When using the hot-compressed air lance, keep it moving so as not to burn the surrounding pavement and the joint. Place and finish sealant within 5 minutes after heating with the hot-compressed air lance.

For cracks with a 1/2-inch width or less, seal with hot-poured elastic sealant according to Subsection 414.04.

For cracks with a width greater than 1/2 inch and less than 1 inch, seal with an approved slurry seal mix, fine aggregate-asphalt binder mix, or fine aggregate-emulsified asphalt mix. Use a squeegee or other suitable equipment to force the mix into the cracks.

Immediately screed the joint sealant or asphalt mix to the elevation of the existing surface. Use a squeegee to ensure that a 3-inch wide band is centered on the finished sealed crack. Cover the sealed crack with a light application of blotter.

For cracks with a width greater than or equal to 1 inch, fill flush to the existing surface with asphalt mix according to Section 401, 402, 403, 404, or 417.

414.06 Resealing Defective Joints or Cracks. Reseal areas exhibiting adhesion failure, damage, missed areas, foreign objects in the sealant, or other problems that can accelerate failure.

414.07 Acceptance. Material for asphalt pavement crack and joint sealing will be evaluated under Subsections 106.02 and 106.03.

Asphalt pavement crack and joint sealing will be evaluated under Subsection 106.04.

Measurement

414.08 Measure the Section 414 items listed in the bid schedule according to Subsection 109.02.

Payment

414.09 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. Payments 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 furnishing and placing a paving geotextile and asphalt sealant between pavement layers to form a waterproofing and stress-relieving membrane within the pavement structure.

Material

415.02 Conform to the following Subsections:

Asphalt binder	702.01
Blotter	703.13
Emulsified asphalt	702.03
Geotextile type VI	714.01
Joint sealant	712.01(a)

Construction Requirements

415.03 Surface Preparation. Prepare the surface to receive the geotextile fabric according to Subsection 410.05.

415.04 Weather Limitations. Apply asphalt sealant and paving geotextile on a dry surface when the pavement surface temperature is at least 55 ºF and rising.

415.05 Asphalt Sealant Application. Use asphalt binders within a temperature range of 290 to 325 ºF. Use emulsified asphalts within a temperature range of 130 to 160 ºF.

Apply the asphalt sealant to the pavement surface according to Subsection 409.08 at a rate of 0.20 to 0.30 gallons per square yard.

Spray the asphalt sealant 6 inches wider than the paving geotextile. Do not apply the asphalt sealant any farther in advance of the paving geotextile placement than can be maintained free of traffic.

Where emulsified asphalt is used, allow the emulsion to break before placing the paving geotextile.

Where asphalt binder is used, place the paving geotextile before the asphalt has cooled and lost tackiness.

415.06 Paving Geotextile Placement. Place the paving geotextile onto the asphalt sealant with minimal wrinkling. Slit, lay flat, and tack all wrinkles or folds higher than 1 inch. Broom and roll the paving geotextile to maximize fabric contact with the pavement surface.

At geotextile joints, overlap the geotextile 6 inches to ensure full closure. Overlap transverse joints in the direction of paving to prevent edge pickup by the paver. Apply additional asphalt sealant to paving geotextile overlaps to ensure proper bonding of the double fabric layer.

If asphalt sealant bleeds through the fabric, treat the affected areas with blotter. Minimize traffic on the geotextile. If circumstances require traffic on the membrane, apply blotter and place *"Slippery When Wet"* signs.

Broom the excess blotter from the geotextile surface before placing the overlay. Repair all damaged fabric before placing overlay. Apply a light tack coat according to Section 412 before placing the overlay. To avoid damaging the geotextile, do not turn equipment on the geotextile.

Place a hot asphalt concrete overlay within 48 hours after placing the paving geotextile. Limit the lay-down temperature of the mix to a maximum of 325 ºF except when the paving geotextile contains polypropylene fibers. For paving geotextiles containing polypropylene fibers, limit the lay-down temperature of the mix to a maximum of 300 ºF.

415.07 Acceptance. Asphalt binder will be evaluated under Subsections 106.04 and 702.09. Geotextile material will be evaluated under Subsections 106.02, 106.03, and 714.01.

Placement of the paving geotextile will be evaluated under Subsections 106.02 and 106.04.

Blotter will be evaluated under Section 411.

Surface preparation will be evaluated under Section 410.

Measurement

415.08 Measure the Section 415 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure blotter under Section 411.

Payment

415.09 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. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 416. — CONTINUOUS COLD RECYCLED ASPHALT BASE COURSE

Description

416.01 This work consists of constructing a recycled asphalt base course using methods and equipment capable of recycling and relaying the material in a one-pass operation.

Continuous cold recycled asphalt base course compaction is designated type A or B as shown in Subsection 416.08.

Emulsified asphalt grades for emulsified binder agent and sealing emulsion are designated as shown in AASHTO M 140 or M 208.

Material

416.02 Conform to the following Subsections:

Emulsified binder agent	702.03
Quicklime	702.08(c)
Recycling agent	702.06
Sealing emulsion	702.03
Water	725.01(c)

Construction Requirements

416.03 Submittals.

(a) Material. When type A compaction is designated, submit the following at least 28 days before recycling:

(1) Ten pavement cores at least 6 inches in diameter from randomly selected sites;

(2) Source of and 2 gallons of emulsified binder agent;

(3) Two pounds of quicklime if quicklime is included in the bid schedule; and

(4) Material safety data sheets.

The CO will perform a mix design and provide an initial application rate for emulsified binder agent, recycling agent, and quicklime, as applicable.

(b) Specialty qualifications. At least 14 days before recycling, submit the name, qualifications, and references of a competent person with extensive recycling experience to be responsible for the recycling operations. This individual's responsibilities are identified in Subsection 416.07(c).

(c) Sequence of operations. At least 14 days before recycling, submit the proposed equipment, manpower, and sequence of operations.

416.04 Surface Preparation. Clean the existing surface of all loose material, dirt, or other deleterious substances by approved methods. Clear, grub, and remove all vegetation and debris within 2 feet of the pavement to be recycled.

416.05 Weather Limitations. Place the emulsified asphalt pavement on a dry, unfrozen surface only when the air temperature in the shade is above 50 ºF and the pavement surface temperature is above 40 ºF.

Do not place emulsified asphalt mix when fog, showers, rain, frost, or temperatures below 35 ºF are anticipated within 24 hours following the placement of the mix.

416.06 Pavement Milling. Use equipment that is:

(a) Self-propelled;

(b) Equipped with automatic depth controls;

(c) Capable of maintaining the required cutting depth;

(d) Capable of milling to the required depth in a single pass of half the existing pavement width or one lane width, whichever is greater; and

(e) Capable of screening and crushing material.

Do not disturb underlying material.

Reduce oversize particles to a maximum particle size of 1 inch.

416.07 Mixing and Proportioning. Produce a homogeneous and uniformly-coated mixture of milled paving material, emulsified binder agent, and water.

(a) Equipment. Use self-propelled equipment with:

(1) A positive displacement pump with an automatic interlock system that allows the addition of emulsified binder agent and recycling agent only when milled material is present in the mixing chamber and automatically shuts off when the machine is stopped. The pump must be capable of supplying from 0 to 10 percent emulsified binder agent by mass of aggregate to within ±0.1 percent of the desired application rate.

(2) A weighing device calibrated and synchronized with the emulsified binder agent metering pump to regulate the emulsified binder agent added to the material in the mixing chamber.

(3) A meter for monitoring flow rate and total delivery of emulsified binder agent and recycling agent into the mix.

(b) Quicklime. When there is an item in the bid schedule for quicklime, incorporate quicklime using one of the following methods:

(1) Dry. Use a calibrated spreader to place pelletized quicklime on the existing pavement ahead of the recycling operation. Place quicklime within the width of the milling head. After milling, add sufficient water to slake the quicklime.

(2) Slurry. Use mixing equipment designed for producing lime slurries. Equip the slurry plant operations with scales and meters to proportion quicklime and water within 0.5 percent by mass. Agitate the transport tanks to keep the lime in suspension. Provide a consistent pumpable lime slurry with the appropriate amount of quicklime to be incorporated into the recycled asphalt pavement. Introduce the lime slurry at the milling head. Meter lime slurry to within ±10 percent of the required amount.

(c) Monitoring. Continuously monitor and evaluate the milling/mixing/placing operations and make adjustments to proportioning or operational procedures as appropriate to maximize the quality and serviceability of the final recycled asphalt base product. Adjustments may include the application rate for emulsified binder agent, application of quicklime, application of water, changes to the recycling operation to address distinct variations in existing pavement and material conditions, changes due to variation in shoulder material, and termination of operations due to abnormal or questionable product.

416.08 Spreading, Finishing, and Compacting. Use a paver conforming to Subsection 401.05 that is capable of picking up the entire windrow and feeding it into the paver hopper. Do not heat the screed.

Place, spread, and strike off the recycled mix to the required line, grade, and elevation.

(a) Initial compaction. Compact using the designated type:

(1) Type A. One to 2 hours after placing the recycled mix, compact the recycled mix according to Subsection 401.14 except use pneumatic roller(s) weighing at least 27 tons. Do not park or idle rollers on uncompacted recycled material. Initially compact with pneumatic rollers until no displacement is visible. Use steel-wheel roller(s), either in static or vibratory mode, to achieve final density.

Compact the recycled mix until it obtains a minimum density, immediately after placing and rolling, of 88 percent of a laboratory specimen prepared according to AASHTO T 247 at 140 ºF. Measure the density of the laboratory specimen according to AASHTO T 166. Measure the density of the inplace recycled mix according to AASHTO T 310.

(2) Type B. Compact the recycled mix using the following equipment, sequence, and number of roller passes:

(a) 6 to 8 roller passes with a double drum, vibratory roller having a minimum mass of 5.5 tons and equipped with frequency and amplitude controls.

(b) 8 to 12 roller passes with a pneumatic-tired roller having a minimum mass of 2000 pounds per wheel and a contact pressure of 80 pounds per square inch.

(c) 4 to 6 roller passes with a static steel-wheel roller with a minimum pressure of 250 pounds per square inch.

Keep all traffic and equipment off of the recycled asphalt base for at least 2 hours after completing initial compaction.

(b) Pavement smoothness. Immediately after initial compaction is complete, measure pavement smoothness according to Subsection 401.16(c). Defective areas are surface deviations in excess of 3/8 inch in 10 feet. Correct defective areas according to Subsection 401.16(d).

(c) Final compaction. Compact using the designated type:

(1) Type A. Before the next surfacing course is placed, compact the recycled mix until it obtains a minimum density of 92 percent of the laboratory specimen.

(2) Type B. At least 3 days after initial compaction, continue compactive effort with the pneumatic and static steel wheel rollers when the surface temperature is greater than 72 ºF. Use a minimum of four passes over the entire surface with each roller.

(d) Curing. Repair damage to the recycled asphalt base.

(1) Recycled mix with quicklime. Overlay the recycled base within 21 days after recycling.

(2) Recycled mix without quicklime. Overlay after the recycled base has cured 7 to 21 days. Do not overlay until the moisture content of the recycled base is less than or equal to 1.5 percent according to AASHTO T 310 or until 21 days after recycling.

416.09 Fog Seal. When there is a pay item for fog seal in the bid schedule and when directed by the CO, place a fog seal on the surface of the recycled base after final compaction. Dilute the fog seal 50 percent by volume with water and apply it at a rate of 0.04 to 0.20 gallons per square yard. Place blotter according to Section 411.

416.10 Acceptance. See Table 416-1 for sampling and testing requirements.

Emulsified binder material will be evaluated under Subsections 106.03, 106.04, and 702.09.

Quicklime will be evaluated under Subsection 106.03.

Construction of continuous cold 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.

Blotter material will be evaluated under Section 411.

Measurement

416.11 Measure the Section 416 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure the square yard width horizontally to include the top of base width including designed widening. Measure the square yard length horizontally along the centerline of the roadway.

Measure sealing emulsion including water used for dilution.

Payment

416.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 416 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 416-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Sampling Point	Split Sample	Reporting Time
Emulsified asphalt	Measured and tested for conformance (106.04)	Quality	—	Subsection 702.03	1 per submitted source	Line between storage tank & mixing plant	2 — 1-quart samples	—
Recycled mix	Measured and tested for conformance (106.04)	In-place density (1)	—	AASHTO T 310	1 per 1200 yd^2	In place after compaction(2)	—	4 hours
		Smoothness	—	Subsection 403.16	—	—	—	—
		Quality	—	Subsection 702.03	1 per 130 tons but not less than 5 samples	Line between storage tank & mixing plant	Yes	—

(1) Testing required when cold recycled asphalt base course compaction is designated type A.
(2) See Subsection 416.08.

Section 417. — MINOR COLD ASPHALT MIX

Description

417.01 This work consists of furnishing and placing one or more courses of cold asphalt mix. This work also consists of furnishing and placing cold asphalt mix as a patching material for temporary roadway maintenance.

Material

417.02 Conform to the following Subsection:

Cold asphalt mix	702.10

Construction Requirements

417.03 Composition of Mix (Job-Mix Formula). Submit the strength, quality, and gradation specifications for the cold asphalt mix. Include copies of laboratory test reports that demonstrate the properties of the aggregates, asphalt binder, additives, and mix meet Federal or State agency specifications.

417.04 Surface Preparation. Prepare the surface according to Subsection 303.05, 303.06, or 410.05 as applicable.

417.05 Placing. Place the mix with appropriate equipment to produce a uniform surface. For roadway paving, do not place lifts thicker than 4 inches. In areas where mechanical spreading and finishing is impractical, spread and finish each course by hand raking, screeding, or by other approved methods. Construct a surface that is uniform in texture and cross-section. Construct joints or tapers as required.

417.06 Compacting.

(a) Roadway paving. Compact by rolling with a steel-wheeled roller weighing at least 8 tons.

(b) Non-roadway paving and patching. Compact by rolling with a hand-operated roller weighing at least 300 pounds or with a small power roller.

Compact areas that are not accessible to rollers by other approved methods.

417.07 Acceptance. Minor cold asphalt mix will be evaluated under Subsections 106.02 and 106.03.

Minor cold asphalt mix construction work will be evaluated under Subsections 106.02 and 106.04.

Measurement

417.08 Measure the Section 417 items listed in the bid schedule according to Subsection 109.02.

Payment

417.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 417 pay item 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. — RIGID PAVEMENT

Description

501.01 This work consists of constructing rigid pavement on a prepared surface. This work also includes pavement rehabilitation consisting of full-depth, full-width removal and reconstruction of rigid pavement. Pavement smoothness/roughness type is designated as shown in Subsection 501.12.

Material

501.02 Conform to the following Subsections:

Air-entraining admixtures	711.02
Chemical admixtures	711.03
Coarse aggregate	703.02
Curing material	711.01
Epoxy grout	725.22(b)
Epoxy resin adhesives	725.21
Fine aggregate	703.01
Fly ash	725.04(a)
Hydraulic cement	701.01
Joint fillers and sealants	712.01
Non-shrink grout	725.22(c)
Reinforcing steel, tie bars, dowel bars, hook bolts, caps	709.01
Water	725.01

Construction Requirements

501.03 Composition of Mix (Concrete Mix Design). Design the concrete mix according to Subsection 552.03. Conform to Table 501-1.

501.04 Equipment. Furnish equipment conforming to the following:

(a) Forms. Furnish straight, steel forms. For edge radii less than 200 feet, furnish flexible or curved forms. Conform to all the following:

(1) Depth equal to edge of pavement thickness;

(2) 10-foot minimum length;

(3) Stabilizing devices to withstand paving operations;

(4) Joint locks to join form lengths tightly together; and

(5) Clean and oil before each use.

Table 501-1
Rigid Pavement Composition

Water/Cement Ratio (maximum)	Temperature of Concrete	Slump	Air Content (minimum)	Aggregate Size[(1)] (AASHTO M 43)	28-Day Compressive Strength (minimum)
0.49	70±20 ºF	1½±1 inches	4.5 %	No. 57 or 67	3500 pounds per square inch

(1) Other AASHTO M 43 aggregate sizes smaller than no. 57 or 67 may be used in the concrete mix design. If the nominal-maximum-sized aggregate is 1/2 inch or smaller, provide at least 5 percent air content.

(b) Paving. Furnish the paving and finishing equipment applicable to the type of construction as follows:

(1) Slip form construction. Furnish slip form machines capable of spreading, consolidating, screeding, and float-finishing the freshly-placed concrete in one complete pass of the machine to provide a dense and homogeneous pavement with minimal hand finishing.

Equip the paving machine with the following:

(a) Electronic controls to control line and grade from either or both sides of the machine.

(b) Vibrators to vibrate the concrete for the full width and depth of the strip of pavement being placed.

(c) A positive interlock system to stop all vibration and tamping elements when the forward motion of the machine is interrupted.

Operate the paving machine with a continuous forward movement and coordinate mixing, delivering, and spreading concrete to provide uniform progress without stopping and starting the paving machine. Apply no tractive force to the machine except that which is controlled from the machine.

(2) Side form construction. Furnish mechanical, self-propelled spreading and finishing machines capable of compacting and finishing the concrete with minimal hand finishing. Equip the machine with one 18-inch minimum width screed with compensating springs to minimize the effect of the screed's momentum on the side forms, or 2 independently-operated screeds.

Coordinate the number of driving wheels, power of the motor, and the machine's mass to prevent slippage. Any machine that displaces the side forms will not be permitted.

(3) Vibrators. Furnish internal immersed tube or multiple spud type vibrators for all 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. Attach vibrators to the spreader or finishing machine or mount on a separate carriage. For construction of irregular areas, use hand-held vibrators according to Subsection 552.11(d).

(c) Joint sealing. Furnish sealing equipment according to the sealant manufacturer's recommendations.

(d) Joints and concrete removal. Furnish an adequate supply of concrete saws with sufficient power to saw full depth and complete the work with water-cooled, diamond-edged blades or abrasive wheels. Equip saws with blade guards and guides or devices to control alignment and depth. Furnish and maintain standby equipment and an adequate supply of replacement blades or wheels.

(e) Concrete removal. Furnish concrete saws, drop hammers, hydrohammers, and jack hammers to break concrete. Concrete saws shall conform to (d) above. Ball-drop breakers are not permitted.

Furnish equipment that will not damage the subgrade, subbase, base, or existing concrete slabs designated to remain.

If new or existing slabs not scheduled for replacement are chipped, spalled, or damaged during the removal operations, replace the damaged slabs.

501.05 Preparing Roadbed. Prepare the roadbed according to Subsection 303.07 and Section 301. Uniformly dampen the roadbed before placing the concrete. If traffic is allowed to use the prepared roadbed, check and correct the surface immediately before the concrete is placed.

Full-depth, full-width reconstruction shall conform to Subsection 501.13.

501.06 Placing Concrete. For storing, handling, batching, and mixing material and delivering concrete, conform to Subsections 552.04 through 552.08 and 552.10.

Do not place concrete on frozen subgrade. Place concrete with side form or slip form paving machines. Where a paving machine is impractical, place concrete according to Subsection 501.07.

When concrete is placed adjoining a previously-constructed lane of pavement, do not allow mechanical equipment to be operated on the existing lane until the lane has attained a minimum flexural strength of 550 pounds per square inch according to AASHTO T 97 or compressive strength of 3,500 pounds per square inch according to AASHTO T 22. Protect the previously constructed lane from damage by the paving equipment.

Construct reinforcing steel according to Section 554. Firmly position the reinforcement on acceptable supports before placing the concrete, or after spreading, mechanically place or vibrate the reinforcement to the required depth in the plastic concrete.

501.07 Construction of Irregular Areas. In irregular areas or areas inaccessible to paving equipment, construct the pavement using side forms. Strike-off, consolidate, float, and surface finish the concrete as follows:

(a) Thoroughly and uniformly vibrate and compact the concrete during placement without segregating the material.

(b) Using templates or screeds, strike-off the concrete to shape it to the required cross-section between the forms. Carry a slight excess of concrete in front of the leading edge of the template or screed.

(c) Float the surface to the required grade and cross-section.

(d) Finish the surface according to Subsection 501.09.

501.08 Joints. Do not vary longitudinal joints more than 1/2 inch and transverse joints more than 1/4 inch from the true alignment. When curbs or medians are constructed integral with the pavement, construct transverse joints continuous through the curb or median. Protect all joints from the intrusion of deleterious matter until sealed.

Form isolated joints at structures by placing 1/2-inch expansion joint filler around each structure that extends into or through the pavement before concrete is placed.

Remove and replace all newly-placed concrete pavement where uncontrolled cracking occurs.

(a) Longitudinal joints. Construct longitudinal joints by forming or sawing. Construct sawed longitudinal joints (with tie bars) when the concrete pavement placement width exceeds 15 feet. Construct the longitudinal joint continuous with no gaps in either the transverse or longitudinal joints at intersections.

Place tie bars perpendicular to the longitudinal joints with mechanical equipment or rigidly secured chairs without damaging or disrupting the concrete. Do not paint or coat tie bars with any material or enclose them in tubes or sleeves.

Where adjacent lanes of pavement are constructed separately, use slip form paving machines or steel side forms to form a keyway along the construction joint. 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 badly-damaged tie bars.

Threaded hook bolts may be used instead of tie bars. Fasten hook bolts to the form of the longitudinal construction joint. With slip form paving, tie bars may be hydraulically inserted through metal keyways.

(1) Formed joints. Form joints with an approved nonmetallic or removable device while the concrete is plastic. When adjacent lanes are constructed separately, form the sealant reservoir in the lane placed last.

(2) Sawed joints. After placing concrete, saw joints as soon as equipment can be supported and before uncontrolled cracking occurs. 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. Saw sealant reservoirs no sooner than 72 hours after placing the concrete.

If necessary, continue sawing day and night, regardless of weather conditions. Clean the saw cut and adjacent concrete surface of slurry residue after sawing each joint.

Do not saw a joint if a crack occurs at or near the joint location before sawing. Discontinue sawing when a crack develops ahead of the saw.

If a crack develops in reinforced concrete pavement, remove and replace at least a 10-foot long, full-width slab properly attached to adjacent slabs.

If a crack develops in plain concrete pavement, remove and replace a full slab properly attached to adjacent slabs.

(b) Transverse expansion joints. Form transverse expansion joints according to (a)(1) above. Place dowel bars through transverse joints. Hold dowels parallel to the surface and center line of the slab by a metal device that remains in the pavement.

Dowel placement implanters may be used while the concrete is plastic provided they conform to the dowel tolerance specified. Remove all concrete that leaks into the joint expansion space.

Install the preformed joint filler full-depth, perpendicular to the subgrade, and continuous across the full-pavement width. Do not use damaged or repaired joint filler. If joint filler is assembled in sections, construct without an offset between adjacent sections.

(c) Transverse contraction joints. Where required by the contract, place dowel bars according to (b) above. Dowel bar sleeves and finishing caps are not required. Saw joints according to (a)(2) above. For adjacent lanes placed separately, construct joints continuously across full width of pavement.

Concrete edges adjacent to the joint may be rounded or beveled to a radius or length as approved. Resaw or grind any joint having an insufficient opening. Where a joint is larger than required, furnish a larger size joint seal as approved.

(d) Transverse construction joints. Unless an expansion joint occurs at the same location, construct a transverse construction joint at the end of each day's work or where concrete placement is interrupted for more than 30 minutes. Do not construct a transverse joint within 10 feet of any parallel joint.

If sufficient concrete has not been mixed to form a slab at least 10 feet long when an interruption occurs, remove and dispose of the excess concrete back to the last preceding joint.

Use a metal or wooden bulkhead to form the joint, shaped to the pavement cross-section, and designed to permit the installation of dowel bars.

Install dowel bars in all transverse construction joints whose location does not coincide with the location of a transverse expansion or contraction joint.

501.09 Surface Finishing. Protect the surface from rain damage.

After floating, check the surface of the fresh concrete with a 10-foot straightedge. Remove high areas indicated by the straightedge. Lap each successive check with the straightedge 5 feet over the previous check path.

Correct pavement edge slump in excess of 1/4 inch in 10 feet before the concrete has hardened. If edge slump exceeds 1 inch on any 1 foot or greater length of hardened concrete, remove and replace the entire panel between the transverse and longitudinal joints.

Before the concrete has initially set, work the pavement edges on each side of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints to produce a 1/4 -inch continuous radius and a smooth, dense mortar finish. Do not use mortar buildup to round edges.

Finish the surface according to Subsection 552.14(c)(1).

501.10 Curing. Immediately after finishing and when marring will not occur, cure the concrete for a minimum of 72 hours. Do not leave the concrete exposed for more than one half hour during the curing period. Cure using one of the following methods:

(a) Water method. Cure according to Subsection 552.15(b). Entirely cover the surface of the pavement and the edges of the slab with water saturated mats. Extend mats at least twice the thickness of the pavement beyond the edges of the slab. Place the mats in complete contact with the surface. Use masses or other approved methods to maintain contact.

(b) Liquid membrane curing compound method. Cure according to Subsection 552.15(c). Protect sawed joints from intrusion of foreign material into the joint before sealing. Repair damaged areas immediately with additional compound.

(c) Waterproof cover method. Thoroughly wet the surface using a fog mist applicator. Cover the entire surface with a waterproof cover. Lap the cover at least 18 inches. Extend the cover beyond the edges of the slab at least twice the thickness of the pavement. Place the cover in complete contact with the surface.

Use masses or other approved methods to maintain contact. Seal, sew, or cement lap joints to prevent opening or separating while curing.

When the air temperature is expected to drop below 35 ºF, furnish a sufficient supply of insulating material. Insulate the pavement surface and sides to a depth that maintains a temperature above 40 ºF for 3 days. Furnish and place continuously recording thermometers according to Subsection 552.10.

Remove forms when the concrete has hardened sufficiently to resist damage but not earlier than 12 hours after placing concrete. Protect the sides of the exposed slabs immediately 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. Do not saw sealant reservoirs within 72 hours after placing concrete.

Clean each joint of all foreign material, including membrane curing compound and concrete slurry, immediately after sawing the joint. Blow dry joints with compressed air. Do not apply sealing material unless the joint faces are clean and surface dry.

Use preformed joint seals, silicone sealant, or hot-poured sealant for expansion 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 poured joint sealing material when the air temperature is over 40 ºF. Immediately remove any excess or spilled material, and clean the pavement surface. Do not use sand or similar material to cover the seal.

(b) Preformed joint seals. Furnish the seal in one piece in the size specified for the joint opening. Install seals with a lubricant adhesive covering both sides of the concrete joint. Compress the seal to between 20 and 50 percent of its nominal width. Install the top of the seal about 1/4 inch below the pavement surface.

Remove and replace seals that are damaged, twisted, improperly positioned, or stretched more than 3 percent.

501.12 Pavement Smoothness/Roughness. Measure the smoothness/roughness of the final pavement surface after the concrete has sufficiently hardened and according to the designated type below. In addition, construct all pavement surfaces to meet the requirements of (c) below.

(a) Type A smoothness (profile ride index (PRI)). For type A pavement smoothness, furnish a California type profilograph and personnel to operate the profilograph. The CO will direct and observe its operation. Operate the profilograph in the "mode" such that the continuous plot produced can be reduced according to FLH T 504. Measure in the middle portion of each lane and exclude areas according to FLH T 504. Measure excluded areas according to (c) below. Submit the trace to the CO.

A PRI will be calculated for each 0.1-mile lane of traveled way using a zero blanking-band. The PRI will be determined according to FLH T 504. Bumps will be located using a 0.4-inch bump template.

The upper specification limit is 24 inches per mile. Defective areas are bumps in excess of 0.4 inches in 25 feet, 0.1-mile profile ride index greater than 28.5 inches per mile, or surfaces with a pay factor less than 0.75 as determined under Subsection 106.05.

(b) Type B roughness (international roughness index (IRI)). For type B pavement roughness, furnish an inertial profiler conforming to AASHTO PP 50 and validated according to AASHTO PP51. At least 21 days before use, submit results showing the inertial profiler conforms to AASHTO PP 51. Furnish personnel to operate the inertial profiler according to AASHTO PP 52. The CO will direct and observe its operation. Measure in the middle portion of each lane. Submit raw data files (*.ERD) that are compatible with FHWA Profile Viewer software on a compact disk to the CO.

Areas of localized roughness will be identified using a 25-foot moving average filter. The difference between the 25-foot moving average and the reported relative elevation for every profile point will be determined. Deviations greater than 0.15 inches are areas of localized roughness.

An IRI value will be determined for each 0.1-lane mile of traveled way. Cattle guards and bridges not being overlayed will be excluded from the calculation of IRI and determination of localized roughness. Measure excluded areas according to (c) below.

Defective areas are 0.1-lane mile segments with IRI values greater than 95 inches per mile or areas of localized roughness.

The pay adjustment factor for each 0.1-mile segment will be determined from Table 401-3.

(c) Type C pavement smoothness/roughness (straightedge measurement). Use a 10-foot metal straightedge to measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 1/4 inch in 10 feet between any two contacts of the straightedge with the surface.

(d) Defective area correction. Correct defective areas from paragraphs (a), (b), and (c) above. Obtain approval for the proposed method of correction. If no corrections are allowed, no adjustment will be made to the pay adjustment factors.

Re-measure corrected areas according to the specified type of pavement smoothness/roughness. The smoothness/roughness value obtained will replace the original.

501.13 Full-Depth, Full-Width Patching. Construct the pavement patch to provide a similar appearance to the existing pavement. Prepare test panels using the same materials proposed for the work.

Begin pavement work after the test panels have been inspected and approved for appearance and the concrete mix design 28-day compressive strength is verified.

(a) Concrete removal. For mesh-reinforced, plain dowel, or plain jointed concrete pavement, saw cut slabs full depth leaving vertical edges at the limits of the patch.

For continuously reinforced concrete pavement, saw cut the exterior transverse patch limits to a depth of 1¾±¼ inches. Do not allow the saw cut to penetrate the steel reinforcement. Saw cut longitudinal limits full depth. Break up the concrete with a chipping hammer down to the steel.

If replacement steel is welded, cut the existing reinforcing steel and leave 8 inches of steel exposed. If replacement steel is tied, cut the existing steel to leave the lap length plus 2 inches. Lap lengths are shown in Table 501-2.

Table 501-2
Reinforcing Steel Splices

Bar Size	L ngth of Overlap (inches)
No. 4	15
No. 5	18
No. 6	22

Remove the concrete by either or both of the following methods:

(1) Break-up and clean-out method. Break up the concrete from the center of the patch area toward the end saw cuts. Remove the concrete pieces with equipment that will not damage the underlying surface.

(2) Lift-out method. Lift the slab in one or more pieces without disturbing the underlying surface. Clean out the area with hand tools.

Dispose of the concrete according to Section 203. When directed, excavate the underlying material to a maximum depth of 12 inches, and replace with aggregate base according to Sections 204 and 301. Prevent adjacent concrete slabs from being undermined.

Remove and replace adjacent slabs damaged by concrete removal. Repair spalls using partial-depth patching methods according to Section 502.

Repair all saw overcuts at the corner of repair areas and nicks to adjacent pavement outside the perimeter of the repair area with non-corrosive, non-shrink grout.

(b) Replacing reinforcing steel. For continuously reinforced concrete pavement, if more than 10 percent of the reinforcing steel is visibly corroded or damaged, extend the limits of the patch over the required lap length. The required lap lengths for various sizes of reinforcing steel bars are shown in Table 501-2.

For concrete pavement patches, provide a 3-inch clearance between the ends of new reinforcing steel and the existing slab face. Match the number, type, and spacing of the new reinforcement to the existing pavement. Support reinforcing steel with bar chairs or other approved methods while placing concrete.

(c) Joints. Construct joints according to Subsection 501.08. Field adjust locations and lengths of joints as directed at intersections, median openings, and other areas of odd-shaped slabs such that no joint is less than 18 inches long and no slab has an angle less than 60 degrees. Construct joints perpendicular to the edge of pavement.

Place dowels or tie bars into the existing slab. Drill the dowel or tie bar holes into the face at the required diameter with the drill rigidly supported. Completely fill the holes around the dowels and tie bars with an epoxy or nonshrink grout for a permanent fastening to the existing concrete. Furnish a plug or donut to prevent epoxy or grout loss.

Edge all transverse and longitudinal joints against forms or existing pavement. Transverse joints in a continuous lane pour or longitudinal joints in a continuous dual lane pour do not require edging.

Clean the exposed faces of joints according to Subsection 502.06(a). Seal joints according to Subsection 501.11.

(d) 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.

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.

(e) Finishing. Finish patches according to Subsection 501.09 to match the plane and texture of the contiguous pavement.

501.14 Opening to Traffic. Do not allow traffic on new concrete pavement earlier than 14 days after concrete placement unless concrete tests indicate one of the following conditions is obtained:

(a) Flexural strength of 550 pounds per square inch according to AASHTO T 97; or

(b) Compressive strength of 3,500 pounds per square inch according to AASHTO T 22.

Cure specimens according to AASHTO T 23, Curing, Curing for Determining Form Removal Time or When a Structure May be Put into Service.

Do not allow traffic on the pavement when joint sealant is tacky and traffic debris would imbed into the sealant.

501.15 Acceptance. Material (except reinforcing steel) for rigid pavement will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification for the hydraulic cement.

The concrete mixture's slump, air content, unit mass, and temperature will be evaluated under Subsections 106.02 and 106.04. See Table 501-3 for sampling and testing requirements.

Type B pavement roughness will be evaluated under Subsection 106.04. See Subsection 501.12.

Concrete compressive strength, pavement thickness, and type A pavement smoothness will be evaluated under Subsection 106.05. See Table 501-3 for sampling and testing requirements.

(a) Compressive strength. The lower specification limit is the minimum required compressive strength at 28 days (f_c') specified in Table 501-1. A single compressive strength test result is the average result from 2 cylinders cast from the same load and tested at 28 days. See Table 501-3 for the acceptance quality characteristic category.

(b) Pavement thickness. The lower specification limit is the required thickness minus 1/4 inch. See Table 501-3 for the acceptance quality characteristic category.

(c) Pavement smoothness. The evaluation will be made after all defective areas are corrected. See Subsection 501.12.

Construction (including batching, placing, finishing, and curing concrete) of the rigid pavement will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Measurement

501.16 Measure the Section 501 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure the square yard width horizontally including allowable curve widening. Measure the square yard length horizontally along the centerline of the roadway.

Measure sealing joints under Section 502.

Measure removal and disposal of unsuitable material in the subbase or subgrade under Section 204.

Measure patching and leveling material used to replace unsuitable material removed from the roadbed under the applicable Sections.

Payment

501.17 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 except the rigid pavement unit bid price will be adjusted according to Subsections 106.05 and 501.12. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment for rigid pavement will be made at a price determined by multiplying the unit bid price by the material pay factor. The material pay factor is the lowest single pay factor determined for either compressive strength or pavement thickness.

When the bid schedule contains a pay item for rigid pavement, type A pavement smoothness, a separate adjustment will be made for pavement smoothness according to the following formula:

$$A2 = 32{,}700(PF_{smooth} - 1.00)(L)$$

where:

A2	=	Adjustment to contract payment in dollars for pavement smoothness.
L	=	Total project length in lane miles of traveled way including excluded areas. Measure project length to 3 decimal places.

PF_{smooth} = Pay factor for smoothness with respect to the upper specification limit is determined according to Subsection 501.12(a) and 106.05 after completion of corrective work.

When the bid schedule contains a pay item for rigid pavement, type B pavement roughness, a separate pay adjustment will be made. The dollar amount of the adjustment will be determined by summing the pay adjustment factors determined in Subsection 401.16 for each 0.1-mile and multiplying that sum by the contract unit bid price.

Table 501-3
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality (703.02)	Measured and tested for conformance (106.04 & 105)	Quality	—	AASHTO M 80	1 per material type	Source of material	Yes	Before producing
Concrete composition (mix design)	Measured and tested for conformance (106.04 & 105)	All	—	Subsection 552.03	1 per mix design	Source of material	Yes	Before producing
Produced aggregate (fine & coarse)	Measured and 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, when requested	Before batching
		Fineness modulus	—	AASHTO T 27	—	“	“	“
		Moisture test	—	AASHTO T 255	—	“	“	“

Table 501-3 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Concrete[1] (552.09 (b)(3))	Measured and tested for conformance (106.04)	Unit mass	—	AASHTO T 121	1 per load	Point of discharge	—	Upon completing tests
		Air content	—	AASHTO T 152 or T 196	"	"	—	"
		Slump	—	AASHTO T 119	"	"	—	"
		Temperature	—	Field measured	"	"	—	"
Structural concrete (552.09 (b)(3))	Statistical (106.05)	Compressive strength[(2)(3)]	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	Note 4	Subsection 552.09(b)(4)
Concrete pavement	Statistical (106.05)	Type A smoothness	I	See Subsection 501.12	See Subsection 501.12	See Subsection 501.12	—	Upon completing paving
	Measured and tested for conformance (106.04)	Type B roughness	—	See Subsection 501.12	See Subsection 501.12	See Subsection 501.12	—	"
	Statistical (106.05)	Pavement thickness[(5)]	II	AASHTO T 24	1 core per 2400 yd^2	In place after sufficient hardening	—	72 hours

(1) Sample according to AASHTO T 141 except composite samples are not required.

(2) Cast at least 4 compressive strength test cylinders and carefully transports the cylinders to the job site curing facility.

(3) A single compressive strength test result is the average result from 2 cylinders cast from the same lead and tested at 28 days.

(4) Deliver cylinders to designated laboratory for test.

(5) Thickness is not a statistically evaluated parameter unless concrete pavement payment is by the square yard.

Section 502. — RIGID PAVEMENT RESTORATION

Description

502.01 This work consists of the restoration of rigid pavement. This work includes partial-depth patching, pavement jacking, subsealing, surface grinding, crack and joint repair, and breaking and seating before a pavement overlay.

Material

502.02 Conform to the following Section and Subsections:

Epoxy grout	725.22(b)
Epoxy resin adhesives	725.21
Joint fillers and sealants	712.01
Non-shrink grout	725.22(c)
Polymer grout	725.22(b)
Rigid pavement	501
Water	725.01

Construction Requirements

502.03 Composition of Mix (Concrete Mix Design). Design the concrete mix according to Subsection 501.03. Provide cement which is similar in color to that used in existing pavement. Provide aggregates which are similar in gradation, color, and hardness to those used in existing pavement.

502.04 Equipment. Furnish equipment conforming to Section 501 and the following:

(a) Rigid pavement removal. Furnish removal equipment that will not fracture the concrete below the necessary patch depth.

(b) Routing. Furnish routers that control and maintain the required cutting depth and width without damaging the adjacent concrete or remaining joint material.

(c) Sandblasting. Furnish sandblasting equipment that will remove any residual sealant, oil, or other foreign material in joints that may prevent bond of new sealant.

(d) Jet waterblasting. Furnish a high-pressure water jet machine that is capable of removing all residual sealant, oil, or other foreign material in joints that may prevent the new sealant from bonding.

(e) Air compressors. Furnish air compressors with a minimum nozzle pressure of 100 pounds per square inch and capable of dislodging loose debris and drying joints and cracks.

(f) Joint and crack sealing. Furnish sealing equipment according to the manufacturer's recommendations for the sealing material furnished.

(g) Grouting. Furnish a grout plant which consists of a positive displacement cement injection pump and a high-speed colloidal mill. Operate colloidal mixing machine at speeds necessary to make a homogeneous mixture.

Furnish 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 and that continuously pumps 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.

Batch water through a meter or scale capable of measuring the total day's consumption. Furnish hoses, fittings, and control which provide a positive seal during grout injection.

(h) Drilling. Furnish rock drills capable of drilling straight and true minimum 1½-inch holes through the concrete slab, steel reinforcement, and base material.

Furnish rock drills weighing less than 60 pounds that are capable of drilling with a downward pressure of less than 200 pounds. Furnish an auger to open clogged holes and existing pavement jacking holes.

(i) Slab stabilization testing. Furnish testing equipment including the following:

> **(1)** A 2-axle truck with dual rear wheels. Load the rear axle to 18 kips evenly distributed between the 2 wheel paths;
>
> **(2)** Static load measuring gauges consisting of 4 gauges on 2 gauge mounts, 2 gauges per mount, capable of detecting slab movement under load; and
>
> **(3)** A modified Benkelman beam or similar approved device.

(j) Surface diamond grinding. Furnish power driven, self-propelled grinding equipment, specifically designed to smooth and texture concrete pavement with diamond blades. Furnish equipment that:

> **(1)** Cuts or planes at least 3 feet in width;
>
> **(2)** Does not encroach on traffic movement outside of the work area; and
>
> **(3)** Grinds the surface without spalling at joints and cracks or fracturing surface aggregates.

(k) Fracturing and seating. Furnish an approved fracturing device capable of producing the desired fracturing pattern without displacing or spalling the pavement. "Headache balls" and vibratory pneumatic hammers will not be permitted.

Furnish at least a 35-ton pneumatic tired roller to seat the broken pavement. Towing equipment shall have pneumatic tires and shall move the roller forward and backward along predetermined lines.

502.05 Partial-Depth Patching. This work consists of patching spalls, potholes, corner breaks, or other surface distresses in concrete pavement.

Construct the pavement patch similar in appearance to the existing pavement. Prepare test panels using the same material proposed for the work. Begin concrete pavement work after approval of the concrete mix design and the test panel appearance.

(a) Patch material. Use an epoxy grout or polymer concrete patch material for patches less than or equal to 1½ inches deep. Use hydraulic cement concrete for patches greater than 1½ inches deep.

(b) Patch area preparation. Extend the limits of repair areas a minimum of 4 inches outside the area of delamination. Saw cut the perimeter of the patch area, parallel to the existing joint, to a minimum depth of 1½ inches and provide a vertical face at the edge of the patch. Near vertical edges from milling or grinding machines are acceptable. Repair all saw overcuts at corners of repair areas and nicks to adjacent pavement outside the perimeter of the repair area with noncorrosive, nonshrink grout.

Break out concrete within the patch area to a minimum depth of 1½ inches to expose sound and clean concrete. If the depth of the repair exceeds 4 inches, remove and replace the repair area as a full-width, full-depth slab according to Subsection 501.13.

Sandblast exposed concrete faces clean of loose particles, oil, dust, traces of asphalt concrete, and other contaminants before patching. Remove sandblasting residue immediately before placing the epoxy resin adhesive.

Remove shoulders adjacent to the patch longitudinally to the depth of the patch and to a maximum width of 12 inches to facilitate placing form work. Patch and compact shoulders with material similar to the existing shoulder. Dispose of the concrete according to Section 203.05.

(c) Placing patch material. Apply an epoxy resin adhesive according to the manufacturer's recommendations. Delay concrete placement until the epoxy becomes tacky. Place and consolidate the patch mixture to eliminate voids at the interface of the patch and existing concrete. Finish patches according to Subsection 501.09 to match the plane and texture of the contiguous pavement. Cure according to Subsection 501.10.

(d) Joints. If a partial-depth 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. Seal the joint according to Subsection 502.06.

502.06 Joint and Crack Repair. This work consists of repairing and resealing joints and cracks in existing concrete pavement.

(a) Preparation of joints and cracks. Clean and reseal longitudinal and transverse joints as required. Remove the existing material in the joints, and clean the joint no earlier than 1 day before resealing. Do not damage joints or previously-repaired patches.

Remove sealant with a router to a minimum depth of 2.5 times the joint width to accommodate the backer rod and to provide the required depth for the new sealant. After routing, clean the adjacent pavement surfaces.

Reface cracks with a concrete saw. Remove old sealant from the crack faces to expose new, clean concrete. When the crack widths vary and the crack faces are ravelled and irregular, cut a crack reservoir depth of 3/4 inch.

Thoroughly clean the joint or crack of all foreign material. Clean the joint by sandblasting, high-pressure water jet, 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 minimum allowable cut of 1/16 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 workday.

(c) Sealant application. Seal joints and cracks immediately after placing the backer rod. Apply sealant at the air and surface temperatures recommended by the sealant manufacturer. 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. Immediately after application, tool the sealant to provide firm contact with the joint faces and to form the required recess below the slab surface.

502.07 Pavement Jacking. This work consists of raising and supporting the concrete pavement to the specified grade tolerances by drilling and injecting non-shrink hydraulic cement grout.

(a) Drilling holes. Determine a pattern for grout injection holes and submit for approval. Drill holes vertically, round, and less than 2 inches in diameter. Prevent breaking out the bottom of the pavement.

(b) Jacking. Establish string lines from the pavement high points to monitor slab movement. Lower an expanding rubber packer or hose, providing a positive seal and connected to the discharge hose on the grout plant, into the holes. Do not allow the discharge end of the packer or hose to extend below the lower surface of the concrete pavement.

When jacking continuously-reinforced concrete pavement, allow pumping to raise the pavement to within 1/8 inch of the string line grade. When jacking jointed pavement and bridge approach slabs, allow pumping to raise the pavement to within 1/4 inch of the transverse and longitudinal grades.

Continuous pressures to 200 pounds per square inch are permitted. Use pressures to 300 pounds per square inch only for short periods (30 seconds or less). If the pavement is bonded to the subbase, brief pressure rises (10 seconds or less) to 600 pounds per square inch may be allowed. Stop pumping if grout extrudes through cracks, joints, shoulders, or from back pressure in the hose.

(c) Overjacking. Grind pavement raised above the specified tolerances to grade. If the overjacking is greater than 1 inch, remove and replace the pavement or a portion thereof, according to Subsection 501.13.

(d) Cracks. New cracks radiating through the grout injection holes are presumed to have been caused by improper injection techniques. If any cracks emanate from any grout injection hole, remove and replace the slab or a portion of the slab according to Subsection 501.13.

(e) Hole patching. After the grout has set and the hole plugs are removed, remove all grout from the holes for the full depth of the slab, and fill the holes with an epoxy mortar. Repair damaged holes.

502.08 Undersealing and Slab Stabilization. This work consists of pumping a non-shrink hydraulic cement grout mixture through holes drilled in the pavement into voids underneath the slabs to stabilize and underseal concrete pavement.

(a) Preliminary testing. Perform all 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. Furnish testing equipment as provided in Subsection 502.04(i).

Test each designated slab using a static method as follows:

(1) Position one set of gauges with one gauge referenced to the corner of each slab on both sides of the joint near the pavement edge.

(2) Set the gauges to zero with no load on the slab on either 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.

(5) Repeat for each joint to be tested. Underseal all slabs with a deflection of more than 1/32 inch.

(b) Drilling Holes. Drill holes using the required hole pattern. An altered hole pattern may be approved based on slab testing and field conditions. Size drilled holes to provide a positive seal for the pumping nozzle. For the first undersealing, drill holes to a depth of 3 inches beneath the bottom of the concrete.

Submit the number, depth, and location of holes for the second undersealing for review and approval.

(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 all holes. 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.

Continue pumping into a hole until grout flows out other holes, joints, or cracks, or until the slab begins to lift. Stop grouting if there is any lift in the slab or the adjacent shoulder.

During pumping and grouting, closely monitor lift measuring devices to prevent pumping pressures greater than 100 pounds per square inch and slab lift greater than 0.05 inches total accumulative movement measured at the outside joint corner. Do not plug holes while grouting.

Prevent the slab from cracking or breaking. Remove and replace damaged slabs according to Subsection 501.13.

(e) Permanently sealing holes. After the grout has set, remove all grout from the holes for the full depth of the slab and fill the holes with a non-shrink grout or epoxy mortar. Repair damaged holes.

(f) Stability testing. After the designated slabs have been undersealed and tested according to (a) above and after 24 hours have elapsed, underseal any slab that continues to show excess movement. The CO may accept or direct replacement of any slab that continues to show movement in excess of that specified after undersealing twice. Remove and replace designated slabs according to Subsection 501.13.

502.09 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.

Remove solid residue from pavement surfaces before it is blown by traffic or wind. Do not allow residue to flow across lanes used by public traffic or into drainage facilities.

Produce a surface texture consisting of parallel grooves 0.11±0.02 inches wide. Provide an area between the grooves 0.085±0.025 inches, and a difference between the peaks of the ridges and the bottom of the grooves of approximately 0.0625 inches.

Test the ground pavement surfaces for pavement smoothness according to Subsection 501.12(b). Check transverse joints and random cracks with a 10-foot straightedge. Misalignment of surface planes on adjacent sides of the joints or cracks and between each grinding pass shall be less than 1/16 inch. The transverse slope of the pavement shall have no depressions or slope misalignment greater than 1/4 inch in 10 feet tested perpendicular to the centerline. Straightedge requirements do not apply across longitudinal joints or outside of ground areas.

502.10 Fracturing Concrete Pavement. This work consists of fracturing existing concrete pavement and firmly seating or compacting the pavement before a pavement overlay. Use one of the following methods:

(a) Crack and seat. Crack the existing concrete pavement into full-depth hairline cracks with pieces approximately 18 to 36 inches in size. Seat the pieces firmly into the foundation.

(b) Break and seat. Break the existing concrete pavement into full-depth hairline cracks with pieces approximately 16 to 24 inches in size. Rupture the reinforcement or break the concrete bond and seat the pieces firmly into the foundation.

(c) Rubblize and compact. Completely fracture the existing pavement into pieces approximately 2 to 6 inches in size. Remove exposed reinforcing steel and wire mesh. Compact the pieces into a layer.

The CO will designate a test section. Fracture the test section using varying energy and striking heights to establish a satisfactory, evenly-distributed crack pattern. Obtain 6-inch diameter pavement cores at 10 designated locations over the cracks to verify that the cracks are full depth.

When fracturing a test section, furnish and apply water to dampen the pavement following fracturing to enhance visual determination of the fracturing pattern. Furnish and apply water to a checked section at least once a day to verify that a satisfactory fracture pattern is maintained. If approved, adjust the energy and striking height based on check sections.

Seating consists of rolling the rigid pavement, 2 passes minimum with a 50-ton roller or 4 to 7 passes with a 35-ton roller, until the concrete pieces are firmly seated. Compacting consists of rolling the rigid pavement, 2 passes minimum with a 10-ton vibratory roller. The CO will determine the maximum number of roller passes on the test section to ensure seating or compacting without damaging the pavement. Remove all loose pieces of broken concrete that are not firmly seated.

Tack the near vertical sides where full-depth broken concrete is removed according to Section 412. Fill the hole with asphalt concrete according to Section 404.

Prevent the formation of continuous longitudinal cracks. Do not fracture pavement within 10 feet of existing box or pipe culverts.

Fill 1-inch or greater depressions, resulting from the compaction, with graded aggregate and recompact.

If unable to fracture pavement to the specified size due to poor subgrade, remove the pavement and replace with aggregate according to Section 301.

Clean and seal existing joints and cracks greater than 1/2-inch width according to Subsection 414.05.

Place the first course of asphalt concrete within 48 hours following the fracturing operation. If the pavement is used to maintain traffic after fracturing, but before the asphalt concrete overlay, sweep and patch to maintain a safe riding surface.

502.11 Opening to Traffic. Do not allow traffic on patched pavement until the concrete has a compressive strength of 3,500 pounds per square inch when tested according to AASHTO T 22 or until the grout used for jacking or undersealing the pavement has attained 600 pounds per square inch when tested with a 0.25 square inch probe according to AASHTO T 197.

Do not allow traffic on sealed joints when the sealant is tacky and traffic debris embeds into the sealant.

502.12 Acceptance. See Table 502-1 for sampling and testing requirements.

Material for rigid concrete pavement restoration will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification for the hydraulic cement.

The concrete mixture's slump, air content, unit mass, and temperature will be evaluated under Subsections 106.02 and 106.04.

The concrete compressive strength will be evaluated under Subsection 106.04. The lower specification limit is the minimum required compressive strength at 28 days (f_c') specified in Table 501-1. A single compressive strength test result is the average result from two cylinders cast from the same load and tested at 28 days.

Construction (including batching, placing, finishing, and curing concrete) of the concrete will be evaluated under Subsections 106.02 and 106.04.

Grout will be evaluated under Subsections 106.02 and 106.03.

Rigid pavement restoration work (including partial-depth patching, pavement jacking, subsealing, surface grinding, crack and joint repair, and breaking and seating) will be evaluated under Subsections 106.02 and 106.04.

Measurement

502.13 Measure the Section 502 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure grout for pavement jacking and undersealing by the cubic foot by metering.

Measure full-depth, full-width pavement patches under Section 501.

Measure slabs ordered replaced after undersealing twice under Section 501.

Measure aggregate base under Section 301.

Payment

502.14 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality (703.02)	Measured and tested for conformance (106.04 & 105)	Quality	—	AASHTO M 80	1 per material type	Source of material	Yes	Before producing
Concrete composition	Measured and tested for conformance (106.04 & 105)	All	—	Subsection 552.03	1 per mix design	Source of material	Yes	Before producing
Produced aggregate (fine & coarse)	Measured and 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, when requested	Before batching
		Fineness modulus	—	AASHTO T 27	—	“	“	“
		Moisture test	—	AASHTO T 255	—	“	“	“

Table 502-1 (continued)
Sampling Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Concrete (552.09(b)(3))	Measured and tested for conformance (106.04)	Unit mass	—	AASHTO T 121	1 per load (2)	Point of discharge (1)	—	Upon completing tests
		Air content	—	AASHTO T 152 or T 196	"	"	—	"
		Slump	—	AASHTO T 119	"	"	—	"
		Temperature	—	Field measured	"	"	—	"
Structural concrete (552.09(b)(3))	Statistical (106.05)	Compressive strength(3)	II	AASHTO T 23 & T 22	1 set per 30 yd^3 but not less than 1 per day	Discharge stream at point of placing	Note 4	See 552.09(b)(4)

(1) Sample according to AASHTO T 141 except composite samples are not required.

(2) Cast at least 4 compressive strength test cylinders and carefully transport the cylinders to the job site curing facility.

(3) A single compressive strength test result is the average result from 2 cylinders cast from the same lead and tested at 28 days.

(4) Deliver cylinders to designated laboratory for test.

DIVISION 550

BRIDGE CONSTRUCTION

Section 551. — DRIVEN PILES

Description

551.01 This work consists of furnishing and driving piles. This work also includes furnishing and placing reinforcing steel and concrete in concrete-filled steel shell and concrete-filled pipe piles.

Piles are designated as steel H-piles, concrete-filled steel shell piles, concrete-filled pipe piles, precast concrete piles, prestressed concrete piles, sheet piles, or timber piles. Pile load tests are designated as static or dynamic.

Material

551.02 Conform to the following Sections and Subsections:

Concrete piles	715.03
Grout	725.22(b)
Paint	708
Pile shoes	715.08
Reinforcing steel	709.01
Sheet piles	715.07
Splices	715.09
Steel H-piles	715.06
Steel pipes	715.05
Steel shells	715.04
Structural concrete	552
Treated timber piles	715.02
Untreated timber piles	715.01

Construction Requirements

551.03 Pile Driving Equipment. Furnish equipment meeting the following requirements.

(a) Pile hammers.

(1) Gravity hammers. Gravity hammers may only be used to drive timber piles. Furnish a hammer with a ram weighing between 2,000 and 3,500 pounds and limit the drop height to 15 feet. The ram mass shall be 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. Equip open-end (single acting) diesel hammers with a device, such as rings on the ram or a scale (jump stick) extending above the ram cylinder, to permit visual determination of hammer stroke. Submit 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.

(3) Closed-end diesel hammers. Submit 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. Equip hammers with a dial gauge for measuring pressure in the bounce chamber. Make the gauge 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 attain cylinder lift at the maximum energy-bounce chamber pressure relationship given in the hammer specification.

(4) Air or steam hammers. Furnish plant and equipment for steam and air hammers with sufficient capacity 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 equal to or greater than one third the combined mass of the driving head and pile. The combined mass shall be at least 2,750 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, such as vibratory hammers, only when permitted in writing or when specified in the contract. If permitted, use such equipment for installing production piles only after the pile tip elevation or embedment length for safe support of the pile load is established by static or dynamic load testing. 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. On one out of every 10 piles driven, strike with an impact hammer of suitable energy to verify the required pile capacity is obtained.

(6) Hydraulic hammers. 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. Furnish pile-driving equipment of such size that the permanent piles can be driven with reasonable effort to the required lengths without damage.

Approval of pile-driving equipment will be based on a wave equation analysis unless the contract specifies the dynamic formula to determine the ultimate driven pile capacity. If the contract specifies the dynamic formula, approval of pile-driving equipment will be based on minimum hammer energy in Table 551-1. The CO will evaluate the proposed equipment and accept or reject the driving system within 14 days of receipt of the pile and driving equipment information.

Use only the approved equipment 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. The CO will accept or reject the revised driving system within 14 days of receipt of the revised submittal. Approval of a pile hammer does not relieve the Contractor of responsibility for piles damaged due to driving stress.

(1) Equipment submittal. Submit the following pile-driving equipment information to the CO at least 30 days before driving piles. Include a wave equation analysis for the proposed pile driving system, unless the contract specifies the use of the dynamic formula to determine the ultimate driven pile capacity. Use a professional engineer with at least 3 years experience in wave equation analyses to perform the wave equation analysis. Submit a resume of the engineer for approval.

(a) 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.

(b) Hammer. Manufacturer, model, type, serial number, rated energy (_____ at _____ length of stroke), and modifications.

(c) Capblock (hammer cushion). Material, thickness, area, modulus of elasticity (E), and coefficient of restitution (e).

(d) Pile cap. Helmet mass, bonnet mass, anvil block mass, and drivehead mass.

(e) Pile cushion. Material, thickness, area, modulus of elasticity (E), and coefficient of restitution (e).

(f) Pile. Pile type, length (in leads), mass per foot, wall thickness, taper, cross-sectional area, design pile capacity, description of splice, and tip treatment description.

(2) Wave equation. The required number of hammer blows indicated by the wave equation at the ultimate pile capacity shall be between 3 and 10 per inch.

Use the following hammer efficiencies in the wave equation analysis unless more specific hammer efficiency information is available:

Hammer Type	Efficiency in Percent
Single acting air/stream	67
Double acting air/stream	50
Diesel	72

In addition, the pile stresses resulting from the wave equation analysis shall not exceed the values at which pile damage is impending. The point of impending damage is defined for steel, concrete, and timber piles as follows.

(a) Steel piles. Limit the compressive driving stress to 90 percent of the yield stress of the pile material.

(b) Concrete piles. Limit the tensile (*TS*) and compressive (*CS*) driving stresses to:

$$TS \leq 3f_c'^{1/2} + EPV$$

$$CS \leq 0.85f_c' - EPV$$

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

(c) Timber piles. Limit the compressive driving stress to 3 times the allowable static design stress.

(3) Minimum hammer energy. The energy of the driving equipment submitted for approval, as rated by the manufacturer, shall be at least the energy specified in Table 551-1 that corresponds to the required ultimate pile capacity.

Table 551-1
Minimum Pile Hammer Energy

Ultimate Pile Capacity (tons)	Minimum Rated Hammer Energy (foot-pounds)
≤ 90	10,300
150	15,600
180	20,700
210	26,500
240	32,100
270	40,100
> 270	Wave equation required

(c) Driving appurtenances.

(1) Hammer cushion. Equip all 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 beginning 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 and 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. Do not use swinging leads unless permitted in writing or specified in the contract. When swinging leads are permitted, 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. Adequately 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 will permit proper alignment of battered piles.

(4) Followers. Followers are not permitted unless approved in writing. When followers are permitted, 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 attained to develop the required ultimate capacity. Provide a follower of such material and dimensions that will permit the piles to be driven to the required penetration. Hold and maintain follower and pile in proper alignment during driving.

(5) Jetting. Do not use jetting unless approved in writing. Provide jetting equipment with sufficient capacity to deliver a consistent pressure equivalent to at least 100 pounds per square inch at two 3/4-inch jet nozzles. Jet so as not to affect the lateral stability of the final inplace 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 ultimate capacity with an impact hammer. Control, treat if necessary, and dispose of all 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 it begins 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. When specified, provide shoes to protect the pile-tip from damage during driving. Fabricate all 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 all holes, cuts, or caps in treated timber piles with 2-brush applications of creosote-coal tar solution.

551.04 Pile Lengths. Furnish piles with sufficient length to obtain the required penetration and to extend into the pile cap or footing as indicated on the plans. In addition, increase the length to provide fresh heading and to provide for the Contractor's method of operation. When test piles are required, furnish piles in the lengths determined by the test piles.

551.05 Test Piles. Install test piles when specified in the contract. 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. Furnish 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 ultimate capacity at the estimated tip elevation. Allow test piles that do not attain the required ultimate capacity at the estimated tip elevation to *"set up"* for 24 hours before re-driving. Warm the hammer before re-driving begins by applying at least 20 blows to another pile. If the required ultimate capacity is not attained on re-driving, drive a portion or all of the remaining test pile length, and repeat the *"set up"* and re-drive procedure as directed. Splice and continue driving until the required ultimate pile capacity is obtained.

Test piles to be used in the completed structure shall conform to the requirements for production piles. Remove test piles not incorporated in the completed structure to at least 2 feet below finished grade.

551.06 Driven Pile Capacity. Drive piles to the specified penetration and to the depth necessary to obtain the required ultimate pile capacity. Splice piles not obtaining the required ultimate capacity at the ordered length, and drive with an impact hammer until the required ultimate pile capacity is achieved.

Use the wave equation to determine ultimate pile capacity of the in-place capacity of the in-place pile.

(a) Wave equation. Adequate penetration will be considered to be obtained when the specified wave equation resistance criteria is 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. Drive the piles to a penetration necessary to obtain the ultimate pile capacity according to the following formula:

$$R_u = 1.6\sqrt{eE}\log_{10}(10N)) - 100$$

where:

R_u = Ultimate pile capacity in kips

E = Manufacturer's rated hammer energy in foot·pounds at the ram stroke observed or measured in the field

log(10N) = Logarithm to the base 10 of the quantity 10 multiplied by N

e = Hammer efficiency factor

Use: 0.72 for all diesels

0.67 for conventional single acting ECH (external combustion hammers), including rope driven hammers

0.50 for conventional double acting ECH

0.95 for free fall rams or hammers with internally measured impact velocities

N = Number of hammer blows per inch at final penetration

(1) Jetted piles. Determine the inplace ultimate capacity of jetted piles based on impact hammer blow counts (dynamic formula) after the jet pipes have been removed. After the pile penetration length necessary to produce the required ultimate pile capacity has been determined by impact hammer blow count, install the remaining piles in each group or in each substructure unit to similar depths with similar methods. Confirm the required ultimate pile capacity has been achieved by using the dynamic formula.

(2) Conditions for dynamic formula. The dynamic formula is applicable only if all of the following apply:

(a) The hammer is in good condition and operating in a satisfactory manner;

(b) The hammer ram falls freely;

(c) A follower is not used; and

(d) The head of the pile is not broomed or crushed.

551.07 Preboring. Use auguring, wet rotary drilling, or other approved methods of preboring.

In compacted embankments more than 5 feet deep, prebore the pile hole to natural ground. Prebore holes 6 inches greater than the diameter of the pile. For square, rectangular or H piles, make the diameter of the hole equal to the diagonal of the pile cross-section plus 6 inches.

For piles end-bearing on rock or hardpan, preboring may extend to the surface of the rock or hardpan. Seat the pile into the end-bearing strata.

For piles not end-bearing on rock or hardpan, 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 ultimate pile capacity. Prebore holes smaller than the diameter or diagonal of the pile cross-section while allowing penetration of the pile to the specified depth.

If the subsurface obstructions such as boulders or rock layers are encountered, the hole diameter may be increased to the least dimension adequate for pile installation. After driving is complete, fill all remaining void space around the pile with sand or other approved material. Do not use a punch or a spud in lieu of preboring.

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 ultimate capacity of piles and structures by approved methods.

551.08 Preparation and Driving. Perform the work under Section 208. Make the heads of all 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 piles to within 2 inches of plan location at cutoff elevation for cutoff locations above ground and within 6 inches of plan location for cutoff locations below ground. The pile shall not be closer than 4 inches to any cap face. Drive piles so that the axial alignment is within1/4 inch per foot, along the longitudinal axis, of the required alignment. The CO may stop driving to check the pile alignment. Check alignment of piles that cannot be internally inspected after installation before the last 5 feet are driven. 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 all 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. Obtain approval for the proposed method(s) of correcting or repairing deficiencies.

(a) Timber piles. Do not use piles with checks wider than 1/2 inch. Drive treated timber piles within 6 months after treatment. Handle and care for pressure-treated piles according to AWPA Standard M 4.

(b) Steel piles. Furnish full-length, unspliced piles for lengths up to 60 feet. If splices are required in the first pile driven and it is anticipated that subsequent piles will also require splices, place the splices in lower third of the pile. Splice lengths less than 10 feet are not permitted and only 2 splices per pile are allowed.

Load, transport, unload, store, and handle steel piles so the metal is kept clean and free from damage. Do not use piles that exceed the camber and sweep permitted by allowable mill tolerance. Steel piles damaged during installation are considered unsatisfactory unless the bearing capacity is proven to be 100 percent of the required ultimate capacity by load tests. Perform tests at no cost to the Government.

(c) Precast and prestressed concrete piles. Support concrete piles during lifting or moving at the points shown on the plans or, if not so shown, provide support at the quarter points. Provide slings or other equipment when raising or transporting concrete piles to avoid bending the pile or breaking edges.

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.

(d) Concrete-filled pipe or steel shell piles. Furnish and handle the steel shells or pipes in accordance with (b) above. Cutting shoes for shells or pipes may be inside or outside the shell. Use high-carbon structural steel with a machined ledge for shell bearing or cast steel with a ledge designed for attachment with a simple weld.

When practicable, drive all pile shells or pipes for a substructure unit before placing concrete in any of the shells or pipes. Do not drive pile shells or pipes within 15 feet of any concrete-filled pile shell or pipe until the concrete has cured for at least 7 days or 3 days if using high-early-strength concrete. Do not drive any pile shell or pipe after it is filled with concrete.

Remove and replace shells that are determined to be unacceptable for use due to breaks, bends, or kinks.

551.09 Splices. Submit details for pile field splices for approval. Align and connect pile sections so the axis of the spliced pile is straight.

(a) Steel piles. Submit a welder certification for each welder. Use welders certified for structural welding.

Make surfaces to be welded smooth, uniform, and free from 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 AASHTO/AWS D 1.5 Bridge Welding Code. 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.

(b) Concrete pile splices. Use dowels or other acceptable mechanical means to splice precast concrete or precast prestressed concrete piles. Submit drawings of proposed splices for acceptance.

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. Separate the ends of the piles by at least 1/2 inch. Clean all surfaces and dowel holes. Grout the dowels in place and allow the grout to cure. Enclose the gap with forms and inject a bonding agent capable of withstanding the impact and driving forces and having the same compressive strength as the pile. Follow the manufacturer's recommendations regarding the use and curing of grouting and bonding products.

Attach manufactured splices to the concrete piles as recommended by the manufacturer. The splice shall develop strengths in compression, tension, and bending equal to or exceeding 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 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 suitable bonding material. Place concrete of the same mix design and quality as that used in the pile. Keep forms in place for not less than 7 days after the concrete has been placed. Cure and finish according to Section 552.

(2) Prestressed piles. Extend prestressed precast piles according to (b) above. 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.

551.10 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 all piles that heave more than 1/4 inches. Re-drive to the specified resistance or penetration.

551.11 Pile Load Tests. Pile load tests are not required unless specified to be performed in the contract.

(a) Dynamic load test. Use a qualified pile specialty consultant with at least 3 years experience in dynamic load testing and analysis to perform the dynamic load test, the case pile wave analysis program (CAPWAP), and the wave equation analysis including the initial wave equation analysis specified in Subsection 551.03(b). Submit a resume of the specialty consultant for approval.

Furnish equipment and perform dynamic load tests according to ASTM D 4945 under the supervision of the CO.

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, and take wave speed measurements. Place the designated pile in the leads. Provide at least a 4-foot by 4-foot rigid platform with a 3½-foot safety rail that can be raised to the top of the pile.

Drive the pile to the depth at which the dynamic test equipment indicates that the required ultimate pile capacity is achieved. If necessary to maintain stresses in the pile below the values in Subsection 551.03(b)(2), reduce the driving energy transmitted to the pile by using additional cushions or reducing the energy output of the hammer. If nonaxial driving is indicated, immediately realign the driving system.

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 6 inches, a maximum of 50 blows, or to practical driving refusal, whichever occurs first. Practical driving refusal is defined as 15 blows per inch for steel piles, 8 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 551.03(b) using CAPWAP. 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 CAPWAP results. Provide a graph showing blow count versus ultimate capacity. For open-ended diesel hammers, provide a blow count versus stroke graph for the ultimate capacity. Provide the driving stresses, transferred energy, and pile capacity as a function of depth for each dynamic load test.

Based on the results of the dynamic load testing, CAPWAP 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 all required test data for the test piles driven.

(b) Static load tests. Perform static load tests according to ASTM D 1143 using the quick load test method except as modified herein. Submit drawings of the proposed loading apparatus for acceptance according to the following:

(1) Have a professional engineer prepare the drawings.

(2) Furnish a loading system capable of applying 150 percent of the ultimate pile capacity or 1,000 tons, whichever is less.

(3) Construct the apparatus to allow increments of load to be placed gradually without causing vibration to the test pile.

When tension (anchor) piles are required, drive tension piles at the location of permanent piles when feasible. 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 allowable axial pile load is defined as 50 percent of the failure load. The failure load is defined as follows:

• For piles 24 inches or less in diameter or diagonal width, the load that produces a settlement at failure of the pile head equal to:

$$S_f = S + (0.15 + 0.008D)$$

• For piles greater than 24 inches in diameter or diagonal width:

$$S_f = S + \frac{D}{30}$$

where:

S_f = Settlement at failure in inches

D = Pile diameter or diagonal width in inches

S = Elastic deformation of pile in inches

Determine top elevation of the test pile immediately after driving and again just before load testing to check for heave. Wait a minimum of 3 days between the driving of any anchor or load test piles and the commencement of the load test. Before testing, re-drive or jack to the original elevation any pile that heaves more than 1/4 inch.

After completion of the load testing, remove or cut off any test or anchor piling not a part of the finished structure at least 2 feet below either the bottom of footing or the finished ground elevation.

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 all required test data for the test piles driven.

551.12 Pile Cutoffs. Cut off the tops of all permanent piles and pile casings at the required elevation. Cut off the piles clean and straight parallel to the bottom face of the structural member in which they are embedded. Dispose of cutoff lengths according to Subsection 203.05(a).

(a) Steel piles. Do not paint steel to be embedded in concrete. Before painting the exposed steel pile, thoroughly clean the metal surface of any substance that may inhibit paint adhesion. Use aluminum colored paint system 2 according to Section 563. Paint piles before driving. Use one prime coat and 2 finish coats on trestles or other exposed piling to at least 4 feet below the finished groundline or waterline. Paint exposed piling above finished groundline or waterline with one field finish coat.

(b) Wood piles. Treat the heads of all treated timber piles which are not embedded in concrete by one of the following methods.

(1) 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 3 layers of asphalt or tar and 2 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 2 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.

(2) Cover the sawed surface with 3 applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brush coat with 3 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.

551.13 Unsatisfactory Piles. Correct unsatisfactory piles by an approved method. Methods of correcting unsatisfactory piles may include one or more of the following:

(a) Use of the pile at a reduced capacity;

(b) Install additional piles;

(c) Repair damaged piles; and

(d) Replace damaged piles.

551.14 Placing Concrete in Steel Shell or Pipe Piles. After driving, clean the inside of shells and pipes by removing all loose material. Keep the shell or pipe substantially water tight. Provide suitable equipment for inspecting the entire inside surface of the driven shell or pipe just before placing concrete.

(a) Reinforcing steel. When reinforcing steel is required, make the spacing between adjacent cage elements at least 5 times the maximum size of aggregate in the concrete.

Securely tie concrete spacers or other approved spacers at fifth points around the perimeter of the reinforcing steel cage. Install spacers at intervals not to exceed 10 feet measured along the length of the cage.

Place the reinforcement cage into the driven shell or 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. Before the initial concrete set, consolidate the top 10 feet of the concrete pile using approved vibratory equipment.

551.15 Acceptance. Pile material will be evaluated under Subsections 106.02 and 106.03.

Furnish production certifications with each shipment of the following:

(a) Concrete piles;

(b) Sheet piles, steel H-piles, steel shells, and steel pipes; and

(c) Treated timber piles. Stamp each pile with an identification mark and date of inspection.

Driving piles and related work will be evaluated under Subsections 106.02 and 106.04.

Concrete for steel shells or pipe piles will be evaluated under Section 552.

Reinforcing steel for steel shells or pipe piles will be evaluated under Section 554.

Measurement

551.16 Measure the Section 551 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

When measurement is by the linear foot, measure the length of pile from the cutoff elevation to the tip.

Measure splices required to drive piles deeper than the estimated tip elevation.

Payment

551.17 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 except the concrete-filled pipe or steel shell pile unit bid 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 concrete-filled pipe or steel shell piles will be made at a price determined by multiplying the unit bid price by an adjusted pay factor (*PFa*) determined as follows:

$$PFa = 1 - 0.5\,(1 - PF)$$

where:

PF = Pay factor for concrete as determined under Section 552.

Section 552. — STRUCTURAL CONCRETE

Description

552.01 This work consists of furnishing, placing, finishing, and curing concrete in bridges, culverts, and other structures.

Structural concrete class is designated as shown in Table 552-1.

Material

552.02 Conform to the following Subsections:

Air-entraining admixture	711.02
Chemical admixtures	711.03
Coarse aggregate	703.02
Color coating	725.24
Curing material	711.01
Elastomeric bearing pads	717.10
Elastomeric compression joint seals	717.16
Fine aggregate	703.01
Fly ash	725.04
Ground iron blast-furnace slag	725.04
Hydraulic cement	701.01
Joint fillers and sealants	712.01
Latex modifier	711.04
Linseed oil	725.14
Masonry cement	701.02
Silica fume (microsilica)	725.04
Water	725.01

Construction Requirements

552.03 Composition (Concrete Mix Design). Design and produce concrete mixtures that conform to Tables 552-1 and 552-2 for the class of concrete specified. Determine design strength values according to ACI 318. Structural concrete shall also conform to the following ACI specifications.

• ACI 211.1 Standard Practice for Selecting Proportions for Normal, Heavy Weight and Mass Concrete;

- ACI 211.2 Standard Practice for Selecting Proportions for Structural Light Weight Concrete; and

- ACI 211.3 Guide for Selecting Proportions of No-Slump Concrete.

Table 552-1
Composition of Concrete

Class of Concrete	Minimum Cement Content (pounds per cubic yard)	Maximum W/C Ratio	Slump[(1)] (inches)	Nominal Maximum Aggregate Size (inches)
A	611	0.49	2 to 4	1½
A(AE)	611	0.44	1 to 4	1½
B	517	0.58	2 to 4	2½
B(AE)	517	0.58	2 to 4	2½
C	658	0.49	2 to 4	3/4
C(AE)	658	0.44	1 to 3	3/4
D(AE)[(2)]	611	0.40	1 to 3	1½
E(AE)[(3)]	611	0.40	4 to 6[(4)]	3/4
P (Prestressed)	658	0.44	0 to 4	1
Seal	658	0.54	4 to 8	1½

(1) Maximum slump is 8 inches if approved mix design includes a high-range water reducer.

(2) Concrete with a water reducing and retarding admixture conforming to AASHTO M 194, type D.

(3) A latex modified concrete with 0.037 gallons of modifier per pound of cement.

(4) Measure the slump 4 to 5 minutes after the concrete is discharged from the mixer.

Table 552-2
Minimum Air Content for Air Entrained Concrete

Nominal Maximum Aggregate Size	As Delivered Minimum Air Content (1) (%)
3 inch	3.0
2½ inch	3.5
2 inch	3.5
1½ inch	4.0
1 inch	4.5
3/4 inch	4.5
1/2 inch	5.5

(1) These air contents apply to the total mix. When testing these concretes, aggregate larger than 1½ inches is removed by handpicking or sieving, and air content is determined on the minus 1½-inch fraction of the mix. Air content of the total mix is computed from the value determined on the minus 1½-inch fraction.

Submit concrete mix designs on FHWA Form 1608.

Verify mixture design with trial mixes prepared according to ACI 318 from proposed source(s) or with previous concrete production data for the mixture design submitted from proposed source(s). Submit written concrete mix designs for approval at least 36 days before production. Each mix design submittal shall include all of the following:

(a) Project identification;

(b) Name and address of Contractor and concrete producer;

(c) Mix design designation;

(d) Class of concrete and intended use;

(e) Material proportions;

(f) Name and location of material sources for aggregate, cement, admixtures, and water; and

(g) Type of cement and type of cement replacement if used. Fly ash, ground iron blast-furnace slag, or silica fume may partially replace cement in any mix as follows:

(1) Fly ash.

(a) Class F. Not more than 20 percent of the minimum mass of portland cement in Table 552-1 may be replaced with class F fly ash at the rate of 1.5 parts fly ash per 1 part portland cement.

(b) Class C. Not more than 25 percent of the minimum mass of portland cement in Table 552-1 may be replaced with class C fly ash at the rate of 1 part fly ash per 1 part portland cement.

(2) Ground iron blast-furnace slag. Not more than 50 percent of the minimum mass of portland cement in Table 552-1 may be replaced with ground iron blast-furnace slag at the rate of 1 part slag per 1 part portland cement.

(3) Silica fume (microsilica). Not more than 10 percent of the minimum mass of portland cement in Table 552-1 may be replaced with silica fume at the rate of 1 part silica fume per 1 part portland cement.

For concrete exposed to deicing chemicals, fly ash will constitute no more than 25 percent and silica fume no more than 10 percent of the total replacement weight. Additionally, fly ash, slag, and silica fume will constitute no more than 50 percent of the total replacement weight.

The water/cement ratio for modified concrete is the ratio of the mass of water to the combined masses of hydraulic cement and cement substitute.

(h) Cement content in pounds per cubic yard of concrete.

(i) The saturated surface dry batch mass of the coarse and fine aggregate in pounds per cubic yard of concrete.

(j) Water content in pounds per cubic yard of concrete.

(k) Water/cement ratio.

(l) Dosage of admixtures. When requested by the CO, provide a qualified person from the admixture manufacturer to help establish the proper dosage. Do not mix chemical admixtures together in a mix unless they are compatible. Furnish supporting documentation of compatibility from the manufacturers. Do not use high range water reducers for bridge decks.

(1) Air-entraining admixtures. Entrained air may be obtained with either an air entraining hydraulic cement or an air entraining admixture.

(2) Set accelerating admixtures. Do not use chloride accelerators. Do not use set accelerating admixtures with class P (prestressed) concrete.

(3) 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 in the dosage submittal. The maximum allowable design discharge time is 3.50 hours.

(m) Sieve analysis of fine and coarse aggregate.

(n) Absorption of fine and coarse aggregate.

(o) Bulk specific gravity (dry and saturated surface dry) of fine and coarse aggregate.

(p) Dry rodded unit mass of coarse aggregate in pounds per cubic foot.

(q) Fineness modulus (FM) of fine aggregate.

(r) Material certifications for cement, admixtures, and aggregate.

(s) Target values for concrete slump with and without high-range water reducers.

(t) Target values for concrete air content. Include the proposed range of air content for concrete to be incorporated into the work. Describe the methods by which air content will be monitored and controlled. Provide acceptable documentation that the slump and compressive strength of the concrete are within specified limits throughout the full range of proposed air content.

(u) Concrete unit mass.

(v) Specified design strength (f'_c) and required average strength (f'_{cr}) for the concrete mixture at 28 days based on ACI 318. When insufficient data is available, select (f'_{cr}) from Table 552-3. Pending 28-day strength results, a mix design may be approved on the basis that 7-day compressive strength results meet or exceed 85 percent of the required average strength (f'_{cr}) at 28 days.

Table 552-3
Required Average Strength

Specified Design Strength (f'_c) (pounds per square inch)	Required Average Strength (f'_{cr}) (pounds per square inch)
Less than 3000	$f'_c + 1000$
3000 to 5000	$f'_c + 1200$
Greater than 5000	$f'_c + 1500$

(w) Compressive strengths test results at 7 and 28 days. Each compressive strength test consists of two or more cylinders tested according to AASHTO T 22 at the same age.

(x) Material samples if requested.

Begin production only after the mix design is approved.

Furnish 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.

552.04 Storage and Handling of Material. Store and handle all material in a manner that prevents segregation, contamination, or other harmful effects. Do not use cement and fly ash containing evidence of moisture contamination. Store and handle aggregate in a manner that ensures a uniform moisture content at the time of batching.

552.05 Measuring Material. Batch the concrete according to the approved mix design and the following tolerances:

Cement	±1 percent
Water	±1 percent
Aggregate	±2 percent
Additive	±3 percent

A calibrated volumetric system may be used if the specified tolerances are maintained.

552.06 Batching Plant, Mixers, and Agitators. Use a batching plant, mixer, and agitator conforming to AASHTO M 157. Continuous volumetric mixing equipment shall conform to AASHTO M 241.

552.07 Mixing. Mix the concrete in a central-mix plant or in truck mixers. Operate all equipment within manufacturer's recommended capacity. Produce concrete of uniform consistency.

(a) 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. Begin 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.

(b) Truck mixer. Do not use mixers with any section of the 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 water before or during mixing.

Charge the batch into the drum so a portion of the mixing water enters in advance of the cement.

Mix each batch of concrete according to AASHTO M 157.

552.08 Delivery. Produce and deliver concrete to permit a continuous placement with no concrete achieving initial set before the remaining concrete being placed adjacent to it. Deliver, handle, and place concrete in such a manner as to minimize rehandling of the concrete and prevent any damage to the structure.

Do not place concrete that has developed an initial set. Never 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 sit to ensure proper placement and testing.

(a) Truck mixer/agitator. Use the agitating speed for all 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 manufacturer's recommended 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. The total of all water in the mix shall not exceed the maximum water/cement 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 specified in Table 552-4. After the beginning of the addition of the cement, complete the discharge of the concrete within the time specified in Table 552-4.

Table 552-4
Concrete Remixing and Discharge Time Limits

Cement Type	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 (1)	None	0.50	0.75
Type III (1)	AASHTO M 194, type B, D, or G	1.00	1.25

(1) AASHTO M 85, type III.

(b) Nonagitating equipment. Nonagitating equipment may be used to deliver concrete if the concrete discharge is completed within 20 minutes from the beginning of the addition of the cement to the mixing drum. Use equipment with smooth, mortar tight, metal containers capable of discharging the concrete at a controlled rate without segregation. Provide covers when needed for protection.

552.09 Quality Control of Mix. Submit and follow a quality control plan according to Sections 153 and 154 as applicable and the following.

(a) Mixing. Designate a competent and experienced concrete technician to be at the mixing plant in charge of the mixing operations and to be responsible for the overall quality control including:

(1) The proper storage and handling of all components of the mix;

(2) The proper maintenance and cleanliness of plant, trucks, and other equipment;

(3) The gradation testing of fine and coarse aggregates;

(4) The determination of the fineness modulus of fine aggregate;

(5) The measurement of moisture content of the aggregates and adjusting the mix proportions as required before each day's production or more often if necessary to maintain the required water/cement ratio;

(6) The computation of the batch masses for each day's production and the checking of the plant's calibration as necessary; and

(7) The completion of batch tickets. Include the following information:

(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 and time at which discharge must be completed;

(k) Maximum water that may be added to the mix at the project; and

(l) If a hydration stabilizing admixture is used, record the slump at the plant after adding the stabilizer.

Provide equipment necessary for the above tests and controls. Furnish copies of work sheets for (3), (4), (5), and (6) as they are completed.

(b) Delivery and sampling. Designate at least one competent and experienced concrete technician to be at the project and be responsible for concrete delivery, discharge operations, and sampling that include the following:

(1) The verification that adjustments to the mix before discharge comply with the specifications.

(2) The completion of the batch ticket, the recording of the apparent water/cement ratio, and the time discharge is completed. Furnish a copy of each batch ticket at the time of placement.

(3) The furnishing of all equipment and the performing of temperature, unit mass, air content, slump, and other tests to verify specification compliance before and during each placement operation.

If hydration stabilizing admixture is used, determine the slump before placement. Do not use concrete with a slump loss of more than 2 inches as compared to the slump recorded at the batch plant.

Sample every batch after at least 0.25 cubic yards are discharged and before placing any of the batch in the forms. When continuous mixing is used, sample approximately every 10 cubic yards. Test the air content according to AASHTO T 152 or T 196.

Test unit mass, slump, and temperature according to Subsection 552.19.

If 3 successive samples are tested and compliance to the specifications is indicated, screening tests may be reduced to an approved frequency. Resume initial testing frequency if a test shows a failing temperature, air content, slump or when directed.

If there is no prior experience with the approved mix design or if special handling procedures, such as pumping, change one or more of the characteristics between discharge of the load and placing in the forms, correlate the discharge tests with the placement tests to define these changes. Provide documentation. Repeat the correlations as often as necessary or as directed.

(4) Take samples according to AASHTO T 141 from specified loads. Composite samples are not required. The point of sampling is from the discharge stream at the point of placement. Provide cylinder molds. Make at least 4 compressive strength test cylinders, provide the appropriate initial curing, and carefully transport the cylinders to the project curing facility. Two of the 4 cylinders will be used for 28-day compressive strength tests. The remaining cylinders will be used for verification, projected strengths, or other purposes specified. Assist in the performing of other tests as requested.

552.10 Temperature and Weather Conditions. Maintain the temperature of the concrete mixture just before placement between 50 and 90 ºF, except maintain the concrete for bridge decks between 50 and 80 ºF.

(a) Cold weather. Cold weather is defined as a period when, for more than 3 consecutive days, the following conditions exist: (1) the average of the highest and the lowest temperatures occurring during the period from midnight to midnight is less than 40 °F and (2) the air temperature is not greater than 50 °F for more than one-half of any 24-hour period.

When cold weather is reasonably 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. ACI 306 may be used for guidance in developing the plan. Include procedures for accommodating abrupt changes in weather conditions. Do not commence placement until plan is accepted. Acceptance of a plan will take at least 1 day.

Have all material and equipment required for protection available at or near the project before commencing cold weather concreting.

Remove all snow, ice, and frost from the surfaces, including reinforcement and subgrade, against which the concrete is to be placed. The temperature of any surface that comes into contact with fresh concrete shall be at least 35 ºF and shall be maintained at a temperature of 35 ºF or above during the placement of the concrete.

Place heaters and direct ducts so as not to cause concrete drying or fire hazards. Vent exhaust flue gases from combustion heating units to the outside of any enclosures.

Heat the concrete components in a manner that is not detrimental to the mix. Do not heat cement or permit the cement to come into contact with aggregates that are hotter than 100 ºF. Concrete at the time of placement shall be of uniform temperature and free of frost lumps. Do not heat aggregates with a direct flame or on sheet metal over fire. Do not heat fine aggregate by direct steam. The addition of salts to prevent freezing is not permitted.

During cold weather, protect all concrete for at least 72 hours according to Table 552-5. Protect concrete exposed in the final construction for at least 7 days according to Table 552-5.

Furnish and place continuously recording surface temperature measuring devices that are accurate within ±2 ºF.

At the end of the protection period, allow the concrete to cool gradually over 24 hours at a rate not to exceed the maximum values shown in Table 552-5. All protection may be removed when the concrete surface temperature is within 25 ºF of the ambient air temperature.

Table 552-5
Cold Weather Concrete Surface Temperatures

Minimum section size dimension, inches	< 12	12 - 36	36 - 72	> 72
Minimum temperature of concrete during protection period	55 ºF	50 ºF	45 ºF	40 ºF
Maximum allowable temperature drop in any 24-hour period after end of protection	50 ºF	40 ºF	30 ºF	20 ºF

(b) Hot weather. Hot weather is any time during the concrete placement that the ambient temperature at the work site is above 90 ºF.

In hot weather, cool all surfaces that come in contact with the mix to below 90 ºF. Cool 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; and

(3) Cool aggregate and water by refrigeration or replacing a portion or all of 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 (b) above.

(d) Rain. At all times during and immediately after placement, protect the concrete from rain.

552.11 Handling and Placing Concrete. Perform the work under Section 208. Construct reinforcing steel, structural steel, bearing devices, joint material, and miscellaneous items according to the appropriate Sections.

(a) General. Design and construct falsework and forms according to Section 562. 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. Placement methods shall not cause displacement of reinforcing steel or other material that is embedded in the concrete. Place and consolidate concrete before initial set. Do not retemper concrete by adding water to the mix.

Do not place concrete until the forms, all embedded material, and the adequacy of the foundation material have been inspected.

Remove all mortar, debris, and foreign material from the forms and reinforcing steel before commencing placement. Thoroughly moisten the forms and subgrade immediately before concrete is placed against them. Temporary form spreader devices may be left in place until concrete placement precludes their need, after which they shall be removed.

Place concrete continuously without interruption between planned construction or expansion joints. The delivery rate, placing sequence, and methods shall be such that fresh concrete is always placed and consolidated against previously placed concrete before initial set has occurred in the previously placed concrete. Do not allow the time between the placement of successive batches to exceed 30 minutes.

During and after placement of concrete, 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.

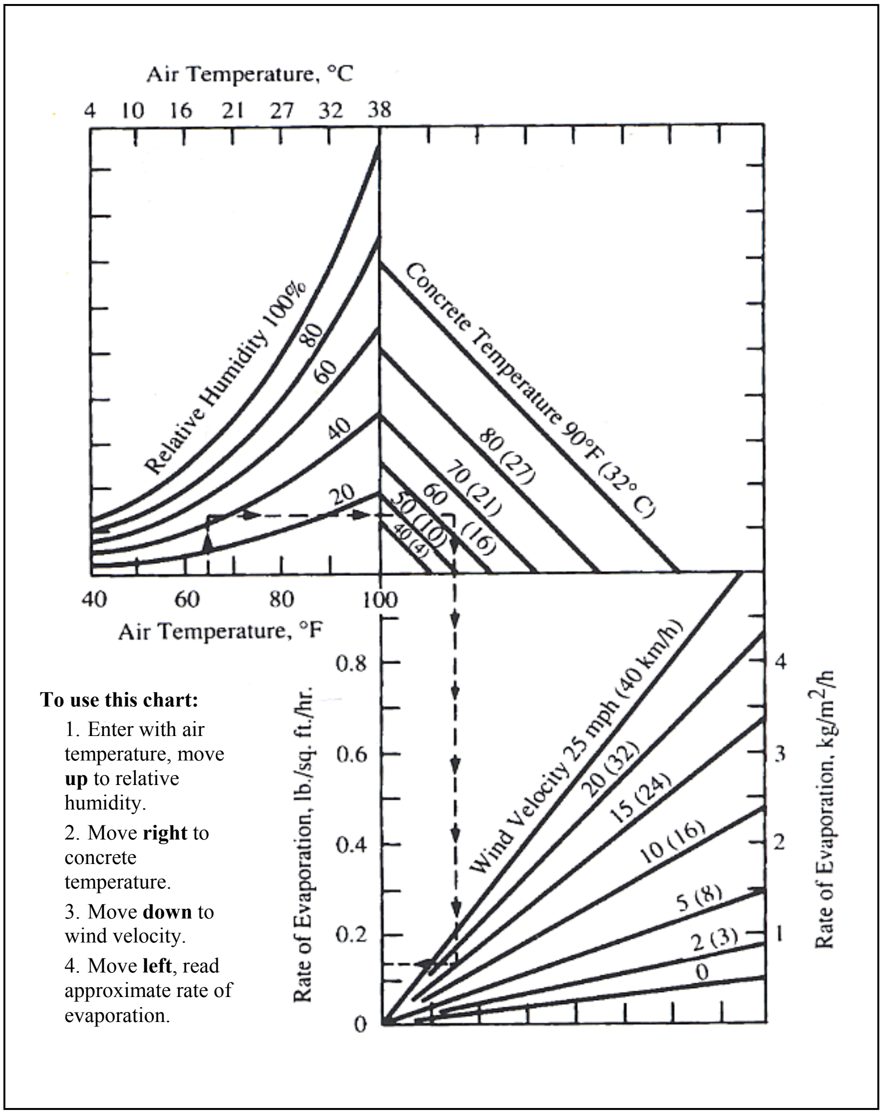

Figure 552-1
Evaporation Rate of Surface Moisture

Note: Example shown by dashed lines is for an air temperature of 65 ºF, relative humidity of 45 percent, concrete temperature of 65 ºF, 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.

(b) Sequence of placement.

(1) Substructures. Do not place loads on finished bents, piers, or abutments until concrete cylinder tests from the same concrete cured under the same conditions as the substructure element indicate that all 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 over 15 feet in height, allow at least 12 hours. Do not transfer loads from horizontal members until the concrete has reached 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 reached specified strength.

(3) Superstructures. Place concrete in the superstructure only after the substructure forms are stripped to allow inspection of the supporting concrete.

For concrete placed in T-beams or deck girders with depths greater than 4 feet, allow 5 days cure time for the stem concrete before placement of the top or deck slab.

For box girders, place the bottom slab and stems in one or separate placements. Do not place the top slab until the stems have 5 days cure time.

(4) Arches. To minimize shrinkage stresses, place concrete for arches in alternate lateral sections. Placement sequence should take into account deflections of the arch centering, with the abutment sections preferably placed last. 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 such joint independently of the centering to avoid relative settlements. Bond the sections together with suitable keys or dowels.

(5) Box culverts. Place the base slab of box culverts and allow to set 24 hours before the remainder of the culvert is constructed.

(6) Precast elements. Place and consolidate concrete so that shrinkage cracks are not produced in the member.

(c) 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 near as possible to its final position. Do not place concrete in horizontal layers greater than 1.5 feet 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, when corrected for temperature, 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 device that prevents mix segregation and mortar spattering. This does not apply to cast-in-place piling when concrete placement is completed before initial set occurs in the concrete placed first.

Operate concrete pumps so that a continuous stream of concrete without air pockets is delivered at the tube discharge. Do not use conveyor belt systems longer than 550 feet when measured from end to end of the total belt assembly. Arrange the belt assembly so that each section discharges into a vertical hopper to the next section without mortar adhering to the belt. Use a hopper, chute, and deflectors at the discharge end of the conveyor belt system to cause the concrete to drop vertically.

(d) Consolidation. Provide sufficient hand-held internal concrete vibrators suitable for the conditions of concrete placement. Use vibrators conforming to Table 552-6. Provide rubber-coated vibrators when epoxy-coated reinforcement is used.

Provide a sufficient number of vibrators to consolidate each batch as it is placed. Provide a spare vibrator at the site in case of breakdown. Use external form vibrators only when the forms have been designed for external vibration and when internal vibration is not possible.

Table 552-6
Hand Held Vibratory Requirements

Head Diameter (inches)	Frequency vibrations/minute)	Radius of Action (inches)
3/4 to 1½	10,000 to 15,000	3 to 5
1¼ to 2½	9,000 to 13,500	5 to 10
2 to 3½	8,000 to 12,000	7 to 9

Consolidate all 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 underwater. 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 1.5 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. The vibration shall be of sufficient duration and intensity to thoroughly consolidate the concrete but not to cause segregation. Do not vibrate at any one point long enough to cause localized areas of grout to form. Do not vibrate reinforcement.

(e) Underwater placement. Underwater placement of concrete is permitted only for seal concrete and drilled shafts. If other than seal concrete is used, increase the minimum cement content by 10 percent. Use tremies, concrete pumps, or other approved methods for placement.

(1) Tremies. Use watertight tremies, with a diameter of 10 inches or more. Fit the top with a hopper. Use multiple tremies as required. Make tremies capable of being rapidly lowered to retard or stop the flow of concrete.

At the start of concrete placement, seal the discharge end and fill the tremie tube with concrete. 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. Use more than one tremie or pump as necessary to ensure compliance with this requirement. Keep the concrete surface as horizontal as practicable. 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 all laitance or other unsatisfactory material from the exposed concrete.

(f) Concrete railings and parapets. Use smooth, tight-fitting, rigid forms. Neatly miter corners. Place concrete railings and parapets after the centering or falsework for the supporting span is released. Remove forms without damaging the concrete. Finish all corners to be true, clean-cut, and free from cracks, spalls, or other defects.

Cast precast railing members in mortar-tight forms. Remove precast members from molds as soon as the concrete has sufficient strength to be self-supporting. Protect edges and corners from chipping, cracking, and other damage. Cure according to Subsection 552.15(b). The curing period may be shortened, as approved, by using moist heat, type III portland cement, or water reducing agents.

552.12 Construction Joints. Provide construction joints at locations shown on the plans. Written approval is required for any additional construction joints.

Extend reinforcing steel uninterrupted through construction joints. Do not lap splice or mechanically splice reinforcing in the construction joint. Embed lap splices or mechanical splices within the concrete. Do not use dowels. At horizontal construction joints, place gauge strips inside the forms along all exposed faces to produce straight joint lines.

When the joint is between two fresh concrete placements, rough float the first placement to thoroughly consolidate the surface and leave the joint surface in a roughened condition. Keep the joint surface saturated. Immediately before placing the new concrete, draw the forms tightly against previously placed concrete and, where accessible, thoroughly coat the joint surface with a very thin coating of cement mortar.

When the joint is between existing concrete and a new placement, abrasive blast clean or use other approved methods to remove all 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 recommendation.

552.13 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 premolded 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 acceptable means. Splice according to the manufacturer's recommendations. After form removal, remove and neatly cut all concrete or mortar that has sealed across the joint. Fill all joint gaps 1/8 inch or wider with hot asphalt or other approved filler. Place all necessary dowels, load transfer devices, and other devices as shown on the plans or as directed.

(c) Steel joints. Fabricate plates, angles, or other structural shapes accurately to conform to the concrete surface. Set joint opening to conform to the ambient temperature at the time of concrete placement. Securely fasten the joints to keep them in 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 practicable 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 as recommended by the manufacturer. Make sure the seal is in full contact with the joint walls throughout its length.

Remove and discard all 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 all excess lubricant-adhesive before it dries.

(e) Elastomeric expansion joint seal. Install the joint according to the manufacturer's recommendations and in conformance with the plans.

552.14 Finishing Plastic Concrete. Strike off concrete surfaces that are not placed against forms. Float finish the concrete surface. Remove any laitance or thin grout. Carefully tool all nonchamfered edges with an edger. Leave edges of joint filler exposed.

Protect the surface from rain damage.

Provide at least two work bridges capable of supporting the workers and equipment during placement, curing, and finishing operations without sagging or vibrating. 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. If approved, use hand-finishing methods for irregular areas where the use of a machine is impractical.

Strike off all surfaces using equipment supported by and traveling on screed rails or headers. Do not support rails within the limits of the concrete placement without approval.

Set rails or headers on nonyielding 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 steel girder superstructures.

Adjust rails, headers, and strike-off equipment to the required profile and cross-section allowing for anticipated settlement, camber, and deflection of falsework.

Before beginning 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 begins.

After placing the concrete, operate finishing machine over the concrete as needed to obtain the required profile and cross-section. Keep a slight roll of excess concrete in front of the cutting edge of the screed at all times. 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 device as necessary to remove all local irregularities.

Remove all excess water, laitance, or foreign material brought to the surface using a squeegee or straightedge drawn from the center of the slab towards either edge. Do not apply water to the surface of the concrete during finishing operations.

(b) Straightedging. Check all slab and sidewalk surfaces. Check the entire surface parallel to the centerline of the bridge with a 10-foot metal straightedge. Overlap the straightedge at least half the length of the previous straightedge placement.

Correct deviations in excess of 1/8 inch from the testing edge of the straightedge. For deck surfaces that are to receive an overlay, correct deviations in excess of 1/4 inch.

(c) Texturing. Finish after floating or at a time when finishing operations will not displace aggregate. Produce a skid-resistant surface texture on all driving surfaces by grooving. Use one of the following finishes or a combination thereof for other surfaces as required.

(1) Grooved finish. Use a float having a single row of fins or an approved machine designed specifically for sawing grooves in concrete pavements. Space fins 1/2 to 3/4 inch on centers. Make the grooves 1/16 to 3/16 inch wide and 1/8 to 3/16 inch deep. Groove perpendicular to the centerline without tearing the concrete surface or loosening surface aggregate.

If grooves are sawn, cut the grooves approximately 1/4 inch wide at a spacing of 1/2 to 1 inch.

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 1/8 inch in depth without tearing the concrete. While the concrete is plastic, correct porous spots, irregularities, depressions, small pockets, and rough spots. 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 all 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.

As soon as the concrete hardens sufficiently to prevent particles of gravel from being dislodged, broom the surface. Use stiff brushes approved by the CO. Exercise care to prevent marring of the surface and cracking or chipping of slab edges or joints. If approved by the CO, apply a light spray of retardant to the unfinished surface to facilitate this work.

First, broom transversely across the pavement. Pull the loosened semi-stiff mortar entirely off the pavement. Remove the mortar from all adjacent pavements. Then broom parallel to the pavement centerline. Continue this operation until a sufficient amount of coarse aggregate is exposed. Other methods of aggregate exposure, such as using a water spray attachment on a special exposed aggregate broom, will be permitted if satisfactory results are demonstrated.

After curing according to Subsection 552.15(b) or (c), wash the surface with brush and water to remove all laitance and cement from the exposed coarse aggregate.

(d) Surface underneath bearings. Finish all bearing surfaces to within 1/8 inch of plan elevation. When a masonry plate is to be placed directly on the concrete or on filler material less than 1/8 inch thick, finish the surface with a float to an elevation slightly above plan elevation. After the concrete is set, grind the surface as necessary to provide a full and even bearing.

When a masonry plate is to be set on filler material between 1/4 and 1/2 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 5/8 inch.

When a masonry plate is to be set on filler material greater than 1/2 inch thick or when an elastomeric bearing pad is to be used, finish the surface to a plane surface free of ridges.

When required under a masonry plate or elastomeric bearing pad, use mortar in the proportions of 1 part masonry or hydraulic cement and 1.5 parts clean sand. Thoroughly mix sand and cement before adding water. Mix only enough mortar for immediate use. Discard mortar that is more than 45 minutes old. Do not re-temper mortar. Cure mortar at least 3 days and do not apply loads to mortar for at least 48 hours. Do not mix and use mortar during freezing conditions. Mortar sand shall conform to AASHTO M 45. Proprietary products may be used with approval.

(e) Surface underneath waterproofing membrane deck seal. Surfaces that are to be covered with a waterproofing membrane deck seal shall not be coarse textured, but shall be finished to a smooth surface and free of ridges and other projections.

552.15 Curing Concrete. Begin curing immediately after the free surface water has evaporated and the finishing is complete. If the surface of the concrete begins 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 all concrete uninterrupted for at least 7 days. If pozzolans in excess of 10 percent by mass of the hydraulic cement is used in the mix, cure uninterrupted for at least 10 days.

(a) Forms inplace method. For formed surfaces, leave the forms inplace 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 all seams with pressure sensitive tape, mastic, glue, or other approved methods. Secure all 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 permitted only if the compound is removed by sandblasting before placement of concrete against the joint.

Use type 2, white-pigmented, liquid membrane only on the top surfaces of bridge decks or on surfaces not exposed to view in the completed work. Use type 1 or 1-D clear curing compounds on other surfaces.

Mix membrane curing solutions containing pigments before use. Continue to agitate during application. Use equipment capable of producing 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 2 applications, follow the first application with the second application within 30 minutes, and apply at right angles to the first application.

If the membrane is damaged by rain or other means during the curing period, immediately apply a new coat over the damaged areas.

(d) Steam curing method. Prepare and cure precast members according to ACI 517.2R.

552.16 Finishing Formed Concrete Surfaces. Remove and replace or repair, as approved, all rock pockets or honeycombed concrete. 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) Inside 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.

Begin finishing as soon as the forms are removed. Remove fins and irregular projections from all 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.

Clean and point all 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 it according to (b) below.

(b) Class 2 — Rubbed finish. Finish the following surfaces with a class 2, rubbed finish:

(1) All surfaces of bridge superstructures except those surfaces designated to receive a class 1 or other finish;

(2) All surfaces of bridge piers, piles, columns and abutments, and retaining walls above finished ground and to at least 12 inches below finished ground;

(3) All surfaces of open spandrel arch rings, spandrel columns and abutment towers;

(4) All surfaces of pedestrian undercrossings except floors and surfaces to be covered with earth;

(5) Surfaces above finished ground of culvert headwalls and endwalls when visible from the traveled way or walkway;

(6) Inside surfaces of culvert barrels higher than 4 feet 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) All surfaces of railings.

Complete a class 1 finish according to paragraph (a) above. Saturate the concrete surface with water. Rub the surface with a medium coarse carborundum stone using a small amount of mortar on its face. Use mortar composed of cement and fine sand mixed in the same proportions as the concrete being finished. Continue rubbing until form marks, projections, and irregularities are removed and a uniform surface is obtained. Leave the paste produced by this rubbing in place.

After other work, which could affect the surface, is complete, rub with a fine carborundum stone, and water until the entire surface has a smooth texture and uniform color. After the surface has dried, rub it with burlap to remove loose powder. Leave it free from all unsound patches, paste, powder, and objectionable marks.

(c) Class 3 — Tooled finish. Let the concrete set for at least 14 days or longer if necessary to prevent the aggregate particles from being *"picked"* out of the surface. Use air tools such as a bush hammer, pick, or crandall. Chip away the surface mortar, and break the aggregate particles to expose a grouping of broken aggregate particles in a matrix of mortar.

(d) Class 4 — Sandblasted finish. 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. Begin 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 amount of ammonia.

(f) Class 6 — Color finish. Build a sufficient number of 2 by 4-foot concrete color sample panels to obtain a color acceptable to the CO. Protect the approved color sample panel at all times during the work. Color all designated surfaces to match the color of the approved sample.

Complete a class 1 finish according to (a) above. Do not apply the color finish until all concrete placement for the structure is complete. Remove all dust, foreign matter, form oil, grease, and curing compound with a 5 percent solution of trisodium phosphate and then rinse the concrete surface with clean water.

Use paper, cloth, or other means to protect surfaces not to be color finished. Apply the finish to a dry concrete surface when the surface temperature is 40 ºF or higher and the air temperature in the shade is anticipated to be 40 ºF or higher during the 24 hours following application.

Apply the color finish according to the manufacturer's recommendations. Spray, brush, or roll on the first coat of penetrating sealer and color base. Spray, brush, or roll on the finish coat after the first coat has thoroughly dried. Apply finish to provide a uniform, permanent color, free from runs and sags to the surfaces.

Clean concrete areas not intended to be covered by the finish using an approved method.

(g) Class 7 — Bush hammered finish. Do not use mortar blocks or wires to set reinforcing steel near the formed surface of areas to be bush hammered. Let the concrete cure for at least 14 days. Bush hammer a small test area for approval before proceeding. Adjust the work procedures to produce a satisfactory finish, and use those same procedures to bush hammer the designated area.

552.17 Concrete Anchorage Devices. Use chemical, grouted, or cast-in-place concrete anchorage devices for attaching equipment or fixtures to concrete.

Furnish the following for approval:

(a) Concrete anchorage device sample;

(b) Manufacturer's installation instructions; and

(c) Material data and certifications.

Fabricate all 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. Supply anchorage devices complete with all 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 E 488. Demonstrate that the anchorage device can withstand a sustained direct tension test load not less than the values shown in Table 552-7 for a period of at least 48 hours with movement not to exceed 1/32 inch. Also 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 552-7
Sustained Load Test Values

nchorage Device tud Size (inches)	ension Test Load (pounds)
3/4	5,000
5/8	4,100
1/2	3,200
3/8	2,100
1/4	1,000

Install concrete anchorage devices as recommended by the device manufacturer and so that the attached equipment or fixtures bear firmly against the concrete. Torque installed nuts to the values specified in Table 552-8 unless otherwise specified in the manufacturer's instructions. Set bearing anchor bolts according to the requirements of Section 564.

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 any anchor fails, reset the failed anchor and proof load the reset anchor and 100 percent of all 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 method approved by the CO. After proof loading, release the load on the anchor and retighten the nuts to the torque specified in Table 552-8 or according to the manufacturer's instructions.

Table 552-8
Torque for Anchorage Devices

Anchorage Device Stud Diameter (inches)	Torque (foot • pounds)
3/4	125
5/8	90
1/2	60
3/8	35
1/4	10

552.18 Loads on New Concrete Structures. Do not allow traffic on concrete bridge decks until all deck 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 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 3,000 pounds per square inch and tie rods have been tightened.

For post-tensioned concrete structures, do not allow vehicles over 4.500 pounds on any span until the prestressing steel for that span is tensioned, grouted, and cured, the grout has obtained a strength of 3,000 pounds per square inch, and the tie rods are tightened. Vehicles weighing less than 4,500 pounds may be permitted on a span provided the mass of the vehicle was included in the falsework design.

552.19 Acceptance. See Table 552-9 for sampling and testing requirements and the acceptance quality characteristic category.

Material for concrete will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification for the hydraulic cement.

The concrete mixture's slump, air content, unit mass, 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 in the contract. A single compressive strength test result is the average result from 2 cylinders cast from the same load and tested at 28 days.

Remove and replace concrete if the compressive strength test results are less than 90 percent of specified design strength (f'c) at the specified test age.

Construction (including batching, placing, finishing, and curing concrete) of concrete structures will be evaluated under Subsections 106.02 and 106.04.

Falsework and forms will be evaluated under Section 562.

Measurement

552.20 Measure the Section 552 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure structural concrete and seal concrete by the cubic yard in the structure.

Payment

552.21 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 unit bid 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 a structural concrete will be made at a price determined by multiplying the unit bid price by the compressive strength pay factor.

Table 552-9
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality (703.02)	Measured and tested for conformance (106.04 & 105)	Quality	—	AASHTO M 80	1 per material type	Source of material	Yes	Before producing
Concrete composition (mix design)	Measured and tested for conformance (106.04 & 105)	All	—	Subsection 552.03	1 per mix design	Source of material	Yes	Before producing
Produced aggregate (fine & coarse)	Measured and 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, when requested	Before batching
		Fineness modulus	—	AASHTO T 27	—	“	“	“
		Moisture test	—	AASHTO T 225	—	“	“	“

Table 552-9 (continued)
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Concrete (552.09(b)(3))	Measured and tested for conformance (106.04)	Unit mass	—	AASHTO T 121	1 per load	Point of discharge	—	Upon completing tests
		Air content	—	AASHTO T 152 or AASHTO T 196	"	"	—	"
		Slump	—	AASHTO T 119	"	"	—	"
		Temperature	—	Field measured	"	"	—	"
Structural concrete (552.09(b)(3))	Statistical (106.05)	Compressive strength(3)	II	AASHTO T 23 & T 22	1 set per 30 yd^3 but not less than 1 per day	Discharge stream at point of placing	Note 4	See Subsection 552.09(b)(4)

(1) Sample according to AASHTO T 141 except composite samples are not required.

(2) Cast at least 4 compressive strength test cylinders and carefully transport the cylinders to the job site curing facility.

(3) A single compressive strength test result is the average result from 2 cylinders cast from the same lead and tested at 28 days.

(4) Deliver cylinders to designated laboratory for test.

Section 553. — PRESTRESSED CONCRETE

Description

553.01 This work consists of prestressing precast or cast-in-place concrete by furnishing, placing, and tensioning prestressing steel. It also includes installing all precast, prestressed members except piling.

Material

553.02 Conform to the following Section and Subsections:

Anchorage devices	722.01
Concrete	552
Elastomeric bearing pads	717.10
Grout for post-tensioned structures	725.22(d)
Prestressing steel	709.03
Reinforcing steel	709.01

Construction Requirements

553.03 Method Approval. Perform prestressing by either pretensioning 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. Show the following:

(a) Method and sequence of stressing;

(b) Complete specifications, 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 to be used;

(f) Number, spacing, and method of draping pretensioned strands;

(g) Other substantiating calculations for the prestressing method;

(h) Type of tendon ducts for post-tensioning;

(i) Pressure grouting material and equipment for post-tensioning; and

(j) Samples of wire or strand taken according to Subsection 709.03.

For on-site casting, submit drawings showing anticipated leveling or alterations to the site. After completion of casting, clear the site of equipment and rubbish, and restore it to an acceptable condition.

553.04 Prestressing Steel. Use prestressing steel that is bright and free of corrosion, dirt, grease, wax, scale, rust, oil, or 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.

One splice per strand is permitted when single strand jacking is used. When multi-strand jacking is used, splice all the strands or no more than 10 percent of the strands. Use strands having similar properties, from the same source, and having the same "twist" or "lay." Locate splices outside the casting bed and between members.

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 a tensile strength not less than the tensile strength of the bars.

Protect all prestressing steel against physical damage, rust, or corrosion at all times. Do not use damaged prestressing steel.

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. Immediately 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 amount 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 all wire, strand, anchorage assemblies, or bars shipped to the site.

553.05 Concrete. Construct prestressed concrete according to Section 552. Construct reinforcing steel according to Section 554.

Make at least 2 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. Surfaces that are to be covered with a waterproofing membrane deck seal are not to be coarse textured but finished to a smooth surface free of ridges and other projections.

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 means of 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 all exposed concrete surfaces with plastic sheeting or liquid membrane curing compound according to Subsection 552.15. Sandblast curing compound from all surfaces to which concrete will be bonded.

Envelop the entire surface with saturated steam. Completely enclose the casting bed with a suitable type of housing, tightly constructed 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.

With hot air, the CO will approve the method to envelop and maintain the girder in a saturated atmosphere. Never allow dry heat to touch the girder surface.

With all heat curing methods:

(a) Keep all unformed girder surfaces in a saturated atmosphere throughout the curing time.

(b) Embed a thermocouple (linked with a thermometer accurate to ±5 ºF) 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 ºF) arranged and calibrated to continuously record, date, and identify concrete temperature throughout the heating cycle.

(d) Make the temperature record available to the CO.

(e) Heat concrete to no more than 100 ºF during the first 2 hours after placing concrete, and increase the temperature no more than 25 ºF per hour to a maximum of 175 ºF.

(f) Cool concrete, after curing is complete, no more than 25 ºF per hour, to 100 ºF.

(g) Keep the temperature of the concrete above 60 ºF until the girder reaches release strength.

Cure precast, prestressed members until the concrete has attained the release compressive strength, required by the contract. The average strength of 2 test cylinders shall be greater than the minimum required strength. The individual strength of any one cylinder shall not be more than 5 percent below the required strength.

553.06 Tensioning. Use hydraulic jacks to tension prestressing steel. Use a pressure gauge or load cell for measuring jacking force.

Calibrate measuring devices at least once every 6 months or 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, do not gauge loads less than 1/4 nor more than 3/4 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 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 reached, strand elongation measurements are only required 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 a working stress after all losses of not less than those required.

For pretensioned 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.

553.07 Pretensioned Members. Cast pretensioned 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.

Free all strands of kinks or twists. Accurately hold prestressing steel in position and tension according to Subsection 553.06. 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. Include in elongation computations 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. All computations must be prepared by a professional engineer.

Maintain the prestress bed forms, strands, and reinforcement bar temperature within 25 ºF 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. Make the load, as computed from the sum of elongations produced by jacking at both ends, agree within 5 percent of the jack load.

Within 3 hours before placing concrete, check the tension on the prestressing strands. The method and equipment for checking the loss of prestress shall be subject to approval by the CO. If strands are tensioned individually, check each strand for loss of prestress. Retension to the original computed jacking stress all strands that show a loss of prestress in excess of 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 in excess of 3 percent or if any individual strand appears 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. Do not expose the concrete to temperatures below freezing for at least 7 days after casting. Cut or release strands such that lateral eccentricity of the prestress force is minimized. Cut prestressing steel off flush with the end of the member.

553.08 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 except decked bulb-T sections must be at least 10 days old.

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 storage, hoisting, and handling of the precast units. Replace units damaged by improper storage or handling.

553.09 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 conforming to the following minimum wall thicknesses:

(1) Metal duct (2⅝ inches diameter):	26 gage
(2) Metal duct (> 2⅝ inches diameter):	24 gage
(3) High density polyethylene (HPDE):	14 gage
(4) High density polypropylene (HDPP):	14 gage
(5) Metal duct with bar tendons preassembled with duct:	32 gage

For tendons composed of single prestressing bars, provide ducts with a minimum internal duct diameter of at least 1/4 inch larger than the outside diameter of the prestressing bar. For multiple wire, bar, or strand tendons, provide a duct nominal internal cross-sectional area of at least 2.25 times the net area of the prestressing steel. When tendons are to be placed by the pull through method, provide a duct nominal internal cross-sectional area of at least 2.5 times the net area of the prestressing steel.

Make positive joints between duct sections. Do not make angles at the joints. Use waterproof tape at the joints. Bend ducts without crimping or flattening. Use ferrous metal or polyethylene couplings to connect ducts to anchoring devices.

Protect ducts against crushing, excessive bending, dirt contamination, and corrosive elements during transport, storage, and handling of ducts.

In case of duct damage, seal duct with tape, or splice a duct coupler over the damaged section to form a seal that prevents cement paste from entering the duct during the placement of concrete and to prevent leakage during grouting operations.

Provide all ducts and anchorage assemblies with inlets for the injection of grout into the duct after prestressing according to the *PTI Guide Specification for Grouting of Post-Tensioned Structures*.

Provide all ducts with outlets to allow the escape of air, water, grout, and bleed water according to the *PTI Guide Specification for Grouting of Post-Tensioned Structures*.

Provide inlets and outlets with an inner diameter of at least 3/4 inch for strand tendons and of at least 3/8 inch for single bar tendons. Extend the length of outlets a sufficient distance out of the concrete member to allow for the proper closing of the outlets.

Place inlets and outlets, at a minimum, in the following locations:

- The anchorage area of the tendon;
- All high points of the duct, when the vertical distance between the highest and lowest point is more than 2 feet;
- Place an inlet at or near the lowest point of the tendon;
- Place a free draining outlet at all low points of the duct;
- At major changes in the cross-section of the duct, such as couplers and anchorages; and
- An outlet at a distance less than 3 feet downstream from high point outlets.

Show all inlet and outlet locations on drawings.

Provide positive mechanical shut-off valves for all inlets and outlets. Provide inlets and outlets with valves, caps, or other devices capable of withstanding the grouting pressure.

Securely fasten ducts in place to prevent movement. Maintain distances from the forms by stays, blocks, ties, hangers, or other approved supports. Use precast mortar blocks of approved shape and dimensions. Separate layers of ducts by mortar blocks.

Space all duct supports according to the *PTI Guide Specification for Grouting of Post-Tensioned Structures.* Cover the ends of ducts to prevent the entry of water or debris.

Connect inlets and outlets to the duct with metallic or plastic structural fasteners. Do not use components that react with the concrete, cause corrosion of the prestressing steel, or contain water soluble chlorides.

(b) Placing concrete. Where the end of a post-tensioned assembly will not be covered by concrete, recess the anchoring devices so that the ends of the prestressing steel and all parts of the anchoring devices are at least 2 inches inside the end surface of the members.

Before placing concrete, demonstrate that all ducts are unobstructed. Immediately after concrete placement, blow out the metal conduit with compressed, oil-free air to break-up and remove all mortar in the conduit before it hardens. Approximately 24 hours after the concrete placement, flush the metal conduits with water containing lime (calcium oxide) or slaked lime (calcium hydroxide) in the amount of 0.1 pounds 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. Give at least 10 days advanced 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 1/4 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 means of permanent type anchoring devices capable of developing not less than 95 percent of the ultimate tensile strength of the prestressing steel. If the anchoring device is sufficiently large and is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the anchor load to the concrete, the steel distribution plates or assemblies may be omitted.

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 of 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 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 all side forms for girders before post-tensioning.

Record gauge pressures and prestressing steel elongation at all times while tensioning prestressing steel and submit records.

Determine the friction loss in the prestressing process (i.e., the difference between tension at the jack and minimum tension in the prestressing steel) according to the AASHTO *Standard Specifications for Highway Bridges.*

Use suitable shims or other approved devices to attain the specified anchor set loss.

(f) Grouting. Provide Class A, B, C, or D grout as specified and prestressing steel that is free of dirt, loose rust, grease, or other deleterious substances. Bond all post-tensioned prestressing steel to the concrete by filling the void space between the duct and tendon with grout according to the *PTI Guide Specification for Grouting of Post-Tensioned Structures.*

Perform all grouting operations using staff with grouting experience on projects of a similar type and magnitude. Perform grouting operations under the immediate supervision of an individual skilled in various aspects of grouting and who is certified by the American Segmental Bridge Institute (ASBI) Grouting Certification program. Furnish the name of the grouting operations supervisor and proof of their ASBI certification and grouting experience to the CO before beginning grouting operations.

Make available on-site, before beginning grouting operations, all the required testing equipment for checking grout workability (flow-cone), temperatures, and other specified tests.

Use grouting equipment capable of continuous operation with little variation of pressure, which also includes a system for recirculating the grout while actual grouting is not in progress. Use grouting equipment capable of maintaining a pressure on completely grouted ducts and fitted with a valve that can be locked off without loss of pressure in the duct.

Provide written certification that all ingredients used in the grout meet the ASTM requirements contained in the *PTI Guide Specification for Grouting of Post-Tensioned Structures.* This includes, but is not limited to, the following:

- Cement mill test reports;
- Mineral additives test reports;

- Chemical admixtures reports; and
- Test reports for any other ingredients used in the grout.

For prepackaged grouts, provide the manufacturer's current certified mill test reports for the product.

Do not use compressed air to aid in the pumping of grout.

Provide grout pumps of a positive displacement type, capable of providing a continuous flow of grout, and capable of maintaining an outlet pressure of at least 150 pounds per square inch and with a pressure gauge having a full-scale reading of not more than 300 pounds per square inch.

Determine the flowability of the grout according to ASTM C 939. The efflux time of a grout sample immediately after mixing shall be between 11 and 30 seconds. Do not begin grouting until this test is passed. When hot weather conditions may cause quick setting of the grout, cool the grout by approved methods, as necessary, to prevent blockages during pumping operations. When freezing weather conditions are possible during and following placement of grout, protect the grout from damage by freezing according to the *PTI Guide Specification for Grouting of Post-Tensioned Structures*.

Provide a supply of potable water and standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch and of sufficient capacity to flush out any partially-grouted ducts.

Clean all 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 all inlets and outlets for their capacity to accept injection of grout by blowing compressed, oil-free air through the system and proving each inlet and outlet in turn.

Pass all grout through a screen with 1/8 inch maximum clear openings before entering the grout pump. Open all grout vents prior to the commencement 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 all outlets in a similar manner one after the other in the direction of the flow. For outlets placed a short distance downstream from a high point, close that outlet before its associated high point outlet. Increase the grouting pressure at the injection end to at least 100 pounds per square inch and hold for at least 10 seconds. Do not remove or open valves and caps until the grout has set.

Abrasive blast clean the concrete surface of recessed anchorage assemblies. Fill anchor recesses with concrete conforming to the requirements for the structure and finish flush.

Remove ends of vents 1 inch below the roadway surface after grouting has been completed. Permanently seal all recess areas.

Do not release the falsework under the bottom slab supporting the superstructure until at least 48 hours after grouting of the post-tension prestressing steel or until the grout strength is obtained.

Table 553-1
Prestressed Concrete Member Tolerances

Description	Tolerance
Precast Girders With Cast-In-Place Deck[1]	
Length	±1/4 inch/25 feet, ±1 inch max.
Width (overall)	+3/8 inch, -1/4 inch
Depth (overall)	+1/2 inch, -1/4 inch
Depth (flanges)	-1/4 inch
Width (web)	+3/8 inch, -1/4 inch
Sweep [2]	1/8 inch/10 feet
Variation from end squareness or skew	±3/16 inch/foot, ±1inch max.
Camber variation from design camber	±1/8 inch/10 feet ±1/2 inch, max. ≤ 80 foot length ±1 inch, max. > 80 foot length
Position of strands: Individual Bundled Position from design location of deflection points for deflected strands	 ±1/4 inch ±1/2 inch ±20 inches
Position of plates other than bearing plates	±1 inch
Position of bearing plates	±5/8 inch
Tipping and flushness of plates	±1/4 inch
Tipping and flushness of bearing plates	±1/8 inch
Position of inserts for structural connections	±1/2 inch
Position of handling devices Parallel to length Transverse to length	 ±6 inches ±1 inch
Position of stirrups: Longitudinal spacing Projection above top	 ±2 inches ±3/4 inch
Local smoothness [3]	±1/4 inch in 10 feet any surface

(1) AASHTO I Beams and Bulb Tee Girders.
(2) Variation from straight line parallel to centerline of member.
(3) 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

Description	Tolerance
Precast Girders Used In Multi-Beam Decks [4]	
Length	±3/4 inch
Width (overall)	±1/4 inch
Depth (overall)	±1/4 inch
Depth (top flange)	±1/2 inch
Depth (bottom flange)	+1/2 inch, -1/8 inch
Width (web)	±3/8 inch
Sweep [5] Up to 12 m member length 12 to 18 m member length Greater than 18 m member length	 ±1/4 inch ±3/8 inch ±1/2 inch
Variation from end squareness or skew Horizontal Vertical	±1/8 inch/foot ±1/2 inch max. ±1/2 inch
Camber variation from design camber	±1/8 inch/10 feet ±1/2 inch max.
Differential camber between adjacent members of the same design	1/4 inch /10 feet 3/4 inch max.
Position of Strands: Individual Bundled Position from design location of deflection points for deflected strands	 ±1/4 inch ±1/4 inch ±20 inches
Position of plates other than bearing plates	±1 inch
Tipping and flushness of plates	±1/4 inch
Position of inserts for structural connections	±1/2 inch
Position of handling devices: Parallel to length Transverse to length	 ±6 inches ±1 inch

(4) Box beams, slabs, decked bulb tee, and multi-stem girders.
(5) Variation from straight line parallel to centerline of member.

Table 553-1 (continued)
Prestressed Concrete Member Tolerances

Description	Tolerance
Precast Girders Used In Multi-Beam Decks	
Position of stirrups: Longitudinal spacing Projection above top	 ±1 inch +1/4 inch, -3/4 inch
Tipping of beam seat bearing area	±1/8 inch
Position of dowel tubes	±5/8 inch
Position of tie rod tubes: Parallel to length Vertical	 ±1/2 inch ±3/8 inch
Position of slab void: End of void to center of tie hole Adjacent to end block	 ±1/2 inch ±1 inch
Local smoothness (6)	±1/4 inch in 10 feet any surface
Post-Tension Members	
Position of post tensioning ducts	±1/4 inch
Position of tendon anchorage bearing plates	±1/4 inch

(6) Does not apply to top surface left rough to receive a topping or to visually-concealed surfaces.

553.10 Painting Steel. Use a wire brush or abrasive blast to remove all dirt and residue not firmly bonded to the metal or concrete surfaces. Clean and paint the exposed ends of the prestress steel, post-tension anchor head assemblies, and a 1-inch strip of adjoining concrete.

Mix zinc-rich paint conforming to FSS TT-P-641. Work the paint into all voids in the prestressing tendons. Apply one thick coat to surfaces that will be covered with concrete. Apply 2 coats to surfaces not covered with concrete.

553.11 Acceptance. See Tables 552-9 and 553-2 for sampling and testing requirements.

Prestressing steel, reinforcing steel, anchor devices, elastomeric bearings, and material for concrete and grout will be evaluated under Subsection 106.03. Furnish production certifications for hydraulic cement, prestressing steel, and reinforcing steel.

Grouting will be evaluated under Subsections 106.02 and 106.04. Sampling and testing requirements will be according to the *PTI Guide Specification for Grouting of Post-Tensioned Structures.*

Concrete for precast, prestressed concrete members will be evaluated under Subsections 106.02, 106.03, and 106.04.

Concrete for post-tensioned, cast-in-place concrete members will be evaluated under Section 552.

Construction of precast, prestressed concrete members and post-tensioned, cast-in-place concrete members will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Falsework and forms will be evaluated under Section 562.

Measurement

553.12 Measure the Section 553 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Do not measure reinforcing steel or concrete for precast, prestressed concrete structural members.

Measure the concrete for post-tensioned, cast-in-place concrete structures under Section 552. Measure the reinforcing steel for post-tensioned, cast-in-place concrete structures under Section 554.

Measure prestressed piling under Section 551.

Payment

553.13 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 553-2
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods or Specifications	Sampling Frequency	Sampling Point	Split Sample	Reporting Time
Prestressed concrete	Measured and tested for conformance (106.04)	Compressive strength	—	AASHTO T 23 & T 22	1 per 30 yd^3 (2)	Discharge stream at point of placing(1)	Yes, when requested	Upon completing tests
Grout	Measured and tested for conformance (106.04)	—	—	PTI Guide Specification for Grouting of Post-Tensioned Structures	Each mixture	Each source	—	Upon completing tests

(1) Sample according to AASHTO T 141 except composite samples are not required.

(2) In addition to the test cylinders required to determine 28-day strength, cast 2 release cylinders for each concrete member. Cure the release-strength cylinders with the concrete member that they represent.

Section 554. — REINFORCING STEEL

Description

554.01 This work consists of furnishing 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 on the plans. Submit all order lists and bending diagrams for acceptance. Acceptance 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 accepted.

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.*

554.05 Bending. Fabricate reinforcing bars according to ACI SP 66. Cold bend all reinforcing bars that require bending. Limit the overall height or drop bending tolerance of deck truss bars to plus 0 inch or minus 1/4 inch. Do not bend bars partially embedded in concrete except as shown on the plans or otherwise permitted.

When the dimensions of hooks or the diameter of bends are not shown on the plans, 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 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. Pad all bundled bands. Lift with a strong back, multiple supports, or a platform bridge. Prevent bar-to-bar abrasion. Do not drop or drag bundles.

Before placement, inspect coated bars for damage to the coating. Patch all defects in the coating that are discernable to the unaided eye with a prequalified patching/repair material according to AASHTO M 284. Clean areas to be patched by removing all surface contaminants and damaged coating. Roughen the area to be patched before applying the patching material. Where rust is present, remove the rust by blast cleaning or power tool cleaning immediately before applying the patching material.

Promptly treat the bar according to the resin manufacturer's recommendations and before detrimental oxidation occurs. Overlap the patching material onto the original coating for 2 inches or as recommended by the manufacturer. Provide a minimum 8 mil dry film thickness on the patched areas.

Take necessary steps to minimize damage to the epoxy coating of installed bars. Clean and patch any damage to the coating noted after installation as described above.

Field repairs will not be allowed on bars that have severely-damaged coatings. Replace bars with severely-damaged coatings. A severely-damaged coating is defined as a coating with a total damaged area in any 1-foot length of bar that exceeds 5 percent of the surface area of that portion of the bar. Coat mechanical splices after splice installation according to AASHTO M 284 for patching damaged epoxy coatings.

554.08 Placing and Fastening. Support the bars on precast concrete blocks or metal supports according to the CRSI *Manual of Standard Practice.* 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 A 493, type 430.

Coat chairs, tie wires, and other devices used to support, position, or fasten epoxy-coated reinforcement with a dielectric material. Do not use plastic supports.

Space slab bar supports no more than 4 feet apart transversely or longitudinally. Do not use bar supports either directly or indirectly to support runways for concrete buggies or other similar construction loads.

Space parallel bars within 1½ inches of the required location. Do not cumulate spacing variations. The average of any two adjacent spaces shall not exceed the required spacing.

Provide 2 inches clear cover for all reinforcement except as otherwise shown on the plans.

Place reinforcing steel in deck slabs within 1/4 inch of the vertical plan location. Tie bridge deck reinforcing bars together at all intersections except where spacing is less than 12 inches in both directions, in which case alternate intersections may be tied. Check the clear cover over deck reinforcing steel using a template before placing deck concrete. Replace damaged supports.

Tie bundle bars together at intervals not exceeding 6 feet. Do not bundle bars unless the location and splice details are specified.

Do not place concrete in any member until the placement of the reinforcement is approved.

554.09 Splices. Splicing, except as shown on the plans, is not permitted without approval. Provide lap lengths shown on the plans. Splice reinforcing bars only where shown on the plans or accepted drawings. Do not place slab bar mechanical splices adjacent to each other.

Make lapped splices by placing the reinforcing bars in contact and wiring them together so as to maintain the alignment and position of the bars.

If welding of reinforcing steel is permitted by the contract, the welds shall conform to AWS D 1.4. Do not weld reinforcing steel if the chemical composition of the steel exceeds the percentages in Table 554-1.

Table 554-1
Reinforcing Steel Components

Chemical Composition	Percent
Carbon (C)	0.30
Manganese (MA)	1.50
Carbon Equivalent (C.E.)	0.55

Use welders that are currently certified. When required in the contract, test each weld using magnetic particle, radiography, or other nondestructive inspection techniques.

Mechanical couplers may be used in lieu of welding if approved. Use couplers with a strength that is at least 125 percent of the required yield strength of the reinforcing steel.

If welded wire fabric is shipped in rolls, straighten into flat sheets before placing. Splice sheets of mesh or bar mat reinforcement by overlapping not less than 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. Furnish 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 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure reinforcing steel excluding laps added for the Contractor's convenience. Do not measure couplers or mechanical splicers. Do not measure chairs, mortar blocks or other items used to support reinforcing steel and supports.

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. It includes furnishing, fabricating, and erecting structural steels and incidental metal construction.

Material

555.02 Conform to the following Sections and Subsections:

Bearing devices	564
Bolts and nuts	717.01(d)
Castings	717.04
Elastomeric compression joint seals	717.16
Falsework	562
Galvanized coatings	717.07
High-strength bolts, nuts, and washers	717.01(e)
Painting	563
Pins and rollers	717.03
Sheet lead	717.08
Steel forgings	717.02
Steel grid floors	717.09
Steel pipe	717.06
Structural steels	717.01
Welded stud shear connectors	717.05

Construction Requirements

555.03 General. Fabricate the structural steel in a fabricating plant that is certified under the AISC *Quality Certification Program*. Fabricate fracture critical elements according to the AASHTO *Guide Specifications for Fracture Critical Non-Redundant Steel Bridge Members.*

Perform welding and weld qualification tests according to the provisions of ANSI/AASHTO/AWS Bridge Welding Code D1.5.

555.04 Notice of Beginning of Work. Give written notice 21 days before the beginning of work at the shop. Do not manufacture any material or perform any work in the shop before notification.

555.05 Inspection. Structural steel may be inspected at the fabrication site according to Subsection 106.06.

Ultrasonically inspect all girder flanges before fabrication according to ASTM A 578M except as follows:

(a) Inspect after the flanges are stripped from the master plate.

(b) Sections 6 and 7 acceptance standards do not apply. Use supplementary requirement S2.1 for acceptance standards.

(c) Flanges may be inspected in the plant or warehouse where the flanges are stripped.

Furnish a copy of all mill orders and certified mill test reports. Show on the mill test reports the chemical analyses and physical test results for each heat of steel used in the work.

If approved, furnish production certifications in lieu of mill test reports for material that normally is not 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.

Include in the certified mill test reports for steels with specified impact values, in addition to other test results, the results of Charpy V-notch impact tests. When fine-grain practice is specified, confirm on the test report that the material was so produced. Furnish copies of mill orders at the time orders are placed with the manufacturer. Furnish certified mill test reports and production certifications before the start of fabrication using material covered by these reports. Furnish, from the manufacturer, a production certification according to Subsection 106.03.

555.06 Drawings (Shop Drawings, Erection Drawings, and Transportation Drawings). Prepare and submit drawings according to Subsection 104.03. Acceptance of the drawings covers the requirements for strength and detail only. No responsibility is assumed for errors in dimensions.

(a) Shop drawings. Show full, detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts (such as pins, nuts, bolts, drains, weld symbols, etc.) on shop drawings for steel structures.

Where specific orientation of plates is required, show the direction of rolling of plates. Cut flanges and webs of plate girders from plates so the long dimension of the girder parallels the rolling direction.

Identify on the shop drawings the type and grade of each piece that is to be made of steel other than AASHTO M 270, grade 36 steel.

Show on the shop drawings assembly marks that are cross-referenced to the original pieces of mill steel and their certified mill test reports.

The location of all shop-welded splices shown on the shop drawings are subject to approval. Locate all shop-welded splices to avoid points of maximum tensile or fatigue stress. Locate splices in webs at least 12 inches from shop splices, butt joints in flanges, or stiffeners. Additional nondestructive tests may be required on shop-welded splices.

(b) Erection drawings. Submit drawings fully illustrating the proposed method of erection. Show details of all falsework bents, bracing, guys, dead-men, lifting devices, and attachments to the bridge members. Show the sequence of erection, location of cranes and barges, crane capacities, location of lifting points, and masses of bridge members. Show complete details for all anticipated phases and conditions of erection. Calculations may be required to demonstrate that allowable stresses are not exceeded and that member capacities and final geometry are correct. See Section 562 for additional requirements.

(c) Camber diagram. Furnish a camber diagram that shows the camber at each panel point of trusses or arch ribs and at the location of field splices and fractions of span length (quarter points minimum) of continuous beams and girders or rigid frames. On the camber diagram, show calculated cambers to be used in preassembly of the structure as required in Subsection 555.15.

(d) Transportation drawings. Show all support points, tie-downs, temporary stiffening trusses or beams, and any other details needed to support and brace the member. Provide calculation sheets showing dead load plus impact stresses induced by the loading and transportation procedure. Use impact stresses of at least 200 percent of the dead load stress. Use a total load, including impact, of not less than 300 percent of the dead load.

If required, furnish transportation drawings for acceptance.

Ship and store all members, both straight and curved, with their webs vertical.

555.07 Storage of Material. Store structural material above the ground on platforms, skids, or other supports. Keep material free from dirt, grease, and other foreign matter, and provide appropriate protection from corrosion.

555.08 Fabrication.

(a) Identification of steels. Use a system of assembly-marking of individual pieces and cutting instructions to the shop (generally by cross referencing of the assembly-marks shown on the shop drawings with the corresponding item covered on the mill purchase order) that maintains the identity of the original piece.

Material may be furnished from stock, which can be identified, by heat number and mill test report.

During fabrication, up to the point of assembling members, show clearly and legibly the specification of each piece of steel (other than grade 36 steel) by writing the material specification on the piece or using the identification color code shown in Table 555-1.

Table 555-1
Identification Color Codes

Grade	Color
50	Green and Yellow
50W	Blue and Yellow
70W	Blue and Orange
100	Red
100W	Red and Orange

For other steels (except grade 36 steel) not shown in Table 555-1 or included in AASHTO M 160, provide information on color code used.

Mark for grade by steel die stamping, or by a substantial firmly-attached tag, pieces of steel (other than grade 250 steel) that, before assembling into members, will be subject to fabricating operations (such as blast cleaning, galvanizing, heating for forming, or painting) that might obliterate paint color code marking. Where the steel stamping method is used, place the impressions on the thicker tension-joint member in transition joints.

The maximum allowed depth of the impression is 0.010 inches. Use a tool that makes character sizes with corresponding face radii as shown in Table 555-2. Avoid impressions near edges of tensile-stressed plate members.

Table 555-2
Size of Steel Die Stamp Markings

Character Size	Minimum Face Radii
1/8 inch	0.007 inches
3/16 inch	0.003 inches
1/4 inch	0.010 inches

Use low-stress type steel die stamps. Do not use die stamps on fracture-critical members.

If requested, furnish an affidavit certifying that throughout the fabrication operation, the identification of steel has been maintained.

Heat curving of steel girders is not allowed.

Do not drill, cut, or weld portions of structural members unless shown in the plans or approved in writing.

(b) Plates.

(1) Direction of rolling. Unless otherwise shown on the drawings, cut and fabricate steel plates for main members and splice plates for flanges and main tension members, not secondary members, so that the primary direction of rolling is parallel to the direction of the principal tensile and compressive stresses.

(2) Plate cut edges.

(a) Edge planing. Remove sheared edges on plates thicker than 5/8 inch to a depth of 1/4 inch beyond the original sheared edge or beyond any re-entrant cut produced by shearing. Fillet re-entrant cuts before cutting.

(1) Oxygen cutting. Oxygen cut structural steel according to ANSI/AASHTO/AWS Bridge Welding Code D1.5.

(2) Visual inspection and repair of plate cut edges. Visually inspect and repair plate cut edges. The cut edges shall conform to ANSI/AASHTO/AWS Bridge Welding Code D1.5.

(b) Flange plates. Furnish flange plates with either oxygen-cut edges that have the corners chamfered at least 1/16 inch by grinding, or furnish Universal mill plates unless oxygen-cut edges are required.

(c) Web plates. Oxygen cut to the prescribed camber web plates of built-up beams and girders, box girders, and box arches. Cut sufficient extra camber into the webs to provide for all camber losses due to welding, cutting, etc.

(d) Truss members. Prepare, by oxygen cutting, all longitudinal edges of all plates in welded sections of truss web and chord members. Chamfer, by grinding the edges of the corners of plates not joined by welding, at least 1/16 inch.

(e) Stiffeners and connection plates. Stiffeners and connection plates welded transverse to girder webs and flanges may be furnished with sheared edges provided the plate thickness does not exceed 3/4 inch. Universal mill plate may be used provided its thickness does not exceed 1 inch. Furnish other stiffeners and connection plates with oxygen-cut edges.

(f) Lateral gusset plates. 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 3/8 inch. Bolted lateral gusset plates may be furnished with sheared edges provided the thickness is less than or equal to 3/4 inch.

(g) Splice plates and gusset plates. Furnish girder and stringer splice plates and truss gusset plates with oxygen-cut edges.

(h) Bent plates. Furnish unwelded, load-carrying, rolled-steel plates to be bent as follows.

Take material from the stock plates such that the bend line is at right angles to the direction of rolling, except that cold-bent ribs for orthotopic-deck bridges may be bent with bend lines in the direction of rolling.

Before bending, round the corners of the plates to a radius of 1/16 inch throughout the portion of the plate where the bending occurs.

(1) Cold bending. Cold bend so that no cracking of the plate occurs. Use the minimum bend radii shown in Table 555-3 measured to the concave face of the metal.

Allow for springback of grades 100 and 100W steels equal to about three times that for grade 36 steel. Use a lower die span of at least 16 times the plate thickness for break press forming.

(2) Hot bending. If a radius shorter than the minimum specified for cold bending is essential, hot bend the plates at a temperature not greater than 1,100 ºF, except for grades 100 and 100W. When grades 100 and 100W steel plates are heated to temperatures greater than 1,100 ºF, requench and temper according to the producing mill's standard practice.

Table 555-3
Minimum Bending Radii

Plate Thickness - (t) (inches)	Bending Radius [1] (inches)
≤ 1/2	2(t)
Over 1/2 to 1	2.5(t)
Over 1 to 1½	3(t)
Over 1½ to 2½	3.5(t)
Over 2½ to 4	4(t)

(1) Bend radii for all grades of structural steel.

(c) Fit of stiffeners. Fabricate (mill, grind, or weld as shown on the plans or as specified) end bearing stiffeners for girders and stiffeners intended as supports for concentrated loads to provide full bearing on the flanges to which they transmit load or from which they receive load. Fabricate intermediate stiffeners not intended to support concentrated loads to provide a tight fit against the compression flange.

(d) Abutting joints. Mill or saw cut abutting joints in compression members of trusses and columns to give a square joint and uniform bearing. The maximum allowed opening at other joints, not required to be faced, is 3/8 inch.

(e) Facing of bearing surfaces. Finish bearing, base plates, and other bearing surfaces that will come in contact with each other, or with concrete, to the ANSI surface roughness defined in ANSI B46.1, *Surface Roughness, Waviness and Lay, Part I,* as shown in Table 555-4.

Table 555-4
ANSI Surface Roughness Values

Bearing Surf ce	S rface Roughness Value (microinches)
Steel slabs	2,000
Heavy plates in contact in sho s to be welded	1,000
Milled ends of compression m mbers, milled or ground ends of stiffeners and llers	500
Bridge rollers and rockers	250
Pins and pin holes	125
Sliding bearings	125

Machine sliding bearings that have a surface roughness greater than 75 microinches according to ANSI 60 so the lay of the cut is parallel to the direction of movement.

Fabricate parts in bearing to provide a uniform even contact with adjacent bearing surface when assembled. Limit maximum gap between bearing surfaces to 0.04 inches. Base and sole plates that are plane and true and have a surface roughness not exceeding the above tabulated values need not be machined except machine sliding surfaces of base plates.

Do not machine surfaces of fabricated members until all fabrication on that particular assembly or subassembly is complete. Machine metal components that are to be heat treated after heat treatment.

(f) Straightening material. If approved, straighten plates, angles, other shapes, and built-up members by methods that do not produce fracture or other damage to the metal. Straighten distorted members by mechanical means or, if approved, by carefully planned procedures and supervised application of a limited amount of localized heat. Use rigidly-controlled procedures and do not exceed the temperatures specified in Table 555-5 when heat straightening grades 70W, 100, and 100W steel members.

Table 555-5
Heat Straightening Temperatures

Material to be Straightened	Maximum Temperature
Grade 70W > 6 inches from weld	1,075 ºF
Grade 70W < 6 inches from weld	900 ºF
Grade 100 or 100W > 6 inches from weld	1,125 ºF
Grade 100 or 100W < 6 inches from weld	950 ºF

In all the other steels, do not exceed 1,200 ºF in the heated area. Control the application by temperature-indicating crayons, liquids, or bimetal thermometers.

Keep parts to be heat straightened and substantially free of external forces and stress except stresses resulting from mechanical means used in conjunction with the application of heat.

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

555.09 Annealing and Stress Relieving. Machine, finish bore, and straighten annealed or normalized structural members after heat treatment. Normalize and anneal (full annealing) according to ASTM A 919. Maintain uniform temperatures throughout the furnace during the heating and cooling so that the temperature at no two points on the member differs by more than 100 ºF at any one time.

Do not anneal or normalize members of grades 100/100W or 70W steels. Stress relieve these grades only with approval.

Record each furnace charge, identify the pieces in the charge, and show the temperatures and schedule actually used. Provide proper instruments, including recording pyrometers, for determining at any time the temperatures of members in the furnace. Make records of the treatment operation available for approval. The maximum allowed holding temperature for stress relieving grades 100/100W and grade 70W steels is 1,100 ºF and 1,050 ºF, respectively.

Stress relieve 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 ANSI/AASHTO/AWS Bridge Welding Code D1.5.

555.10 Bolt Holes. Punch or drill all bolt holes. Material forming the parts of a member that is composed of not more than 5 thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the bolts where the thickness of the material is not greater than 3/4 inch for structural steel, 5/8 inch for high-strength steel, or 1/2 inch for quenched and tempered alloy steel unless subpunching and reaming is required under (h), the preparation of field connections.

Where there are more than five thicknesses or where any of the main material is thicker than 3/4 inch for structural steel, 5/8 inch for high-strength steel, or 1/2 inch for quenched and tempered alloy steel, either subdrill and ream or drill all holes full size.

If required, either subpunch or subdrill (subdrill if thickness limitation governs) 3/16 inch smaller and, after assembling, ream 1/16 inch larger or drill full size to 1/16 inch larger than the nominal diameter of the bolts.

(a) Punched holes. Use a die diameter that is not more than 1/16 inch larger than the punch diameter. Ream holes that require enlarging to admit bolts. Clean cut the holes without torn or ragged edges.

(b) Reamed or drilled holes. Ream or drill holes so they are cylindrical and perpendicular to the member. Where practical, direct reamers by mechanical means. Remove burrs on the outside surfaces. Ream and drill with twist drills, twist reamers, or roto-broach cutters. Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling.

(c) Accuracy of holes. Holes not more than 1/32 inch larger in diameter than the true decimal equivalent of the nominal diameter of the drill or reamer are acceptable. The slightly conical hole resulting from punching operations is acceptable. The width of slotted holes produced by flame cutting or a combination of drilling or punching and flame cutting shall be no more than 1/32 inch greater than the nominal width. Grind flame cut surfaces smooth.

(d) Accuracy of hole group before reaming. Accurately punch full size, subpunched, or subdrilled holes so that after assembling (before any reaming is done) a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. Punched pieces not meeting this requirement will be rejected. Holes, through which a pin 3/16 inch smaller in diameter than the nominal size of the punched hole cannot be inserted, will be rejected.

(e) Accuracy of hole group after reaming. After reaming, the maximum allowed offset of 85 percent of any contiguous group of holes through adjacent thicknesses of metal is 1/32 inch.

Use steel templates having hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. Use connection centerlines when locating templates from the milled or scribed ends of members.

(f) Numerically-controlled drilled field connections. In lieu of drilling undersized holes and reaming while assembled, or drilling holes full-size while assembled, drilling or punching bolt holes full-size in unassembled pieces and connections, including templates for use with matching undersized and reamed holes by means of suitable numerically-controlled (N/C) drilling or punching equipment is allowed.

(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. Subpunch or subdrill and ream while assembled, or drill full size to a steel template, the holes in field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames.

Holes for field splices of rolled beam stringers continuous over floor beams or cross frames may be drilled full-size unassembled to a steel template. Holes for floor beams or cross frames may be drilled full size unassembled to a steel template. Subpunch and ream while assembled, or drill full size to a steel template, all holes for floor beam and stringer field end connections.

When reaming or drilling full size field-connection holes through a steel template, carefully locate and position the template, and firmly bolt in place before drilling. Use exact duplicates of templates used for reaming matching members or the opposite faces of a single member. Accurately locate templates used for connections on like parts or members so that the parts or members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, holes drilled full size through all thicknesses or material assembled in proper position may be used.

555.11 Pins and Rollers. Accurately fabricate pins and rollers that are straight, smooth, and free from flaws. Forge and anneal pins and rollers more than 9 inches in diameter. Pins and rollers 9 inches or less in diameter may be either forged and annealed or cold-finished carbon steel shafting.

In pins larger than 9 inches in diameter, bore a hole not less than 2 inches in diameter full length along the pin axis after the forging has been allowed to cool to a temperature below the critical range (under suitable conditions to prevent damage by too rapid cooling and before being annealed).

(a) Boring pin holes. Bore pin holes true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other. Produce the final surface using a finishing cut.

Produce a pin hole diameter that does not exceed that of the pin by more than 1/50 inch for pins 5 inches or less in diameter or by 1/32 inch for larger pins.

The maximum allowed variation of the outside-to-outside distance of end holes in tension members and the inside-to-inside distance of end holes in compression members is 1/32 inch from that specified. Bore pin holes in built-up members after the member has been assembled.

(b) Threads for bolts and pins. Provide threads on all bolts and pins for structural steel construction that conform to the Unified Standard Series UNC ANSI B1.1, class 2A for external threads and class 2B for internal threads except when pin ends have a diameter of 1⅜ inches or more, provide six threads per inch.

555.12 Eyebars. Pin holes may be flame cut at least 2 inches smaller in diameter than the finished pin diameter. Securely fasten together (in the order to be placed on the pin) all eyebars that are to be placed side-by-side in the structure and bore at both ends while clamped. Pack and match-mark eyebars for shipment and erection. Stamp with steel stencils, so as to be visible when the bars are nested in place on the structure, all identifying marks on the edge of one head of each member after fabrication is completed. Use low-stress type steel die stamps.

Provide eyebars, straight and free from twists, with pin holes accurately located on the centerline of the bar. Do not allow the inclination of any bar to the plane of the truss to exceed 1/8 inch per foot.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically-operated torches abreast of each other, guided by a substantial template to prevent distortion of the plates.

555.13 Assembly — Bolting. Clean surfaces of metal in contact before assembling. Assemble parts of a member. Securely pin and firmly draw together before drilling, reaming, or bolting is commenced. Take assembled pieces apart, if necessary, for the removal of burrs and shavings produced by the operation. Assemble members to be free from twists, bends, and other deformation.

Drift during assembling only enough to bring the parts into position without enlarging holes or distorting the metal.

555.14 Welded Connections. Fabricate surfaces and edges to be welded smooth, uniform, clean, and free of defects that would adversely affect the quality of the weld. Prepare edge according to ANSI/AASHTO/AWS Bridge Welding Code D1.5.

555.15 Preassembly of Field Connections. Preassemble field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers, and rigid frames before erection to verify the geometry of the completed structure or unit and to verify or prepare field splices. Present the method and details of preassembly for approval.

Use methods and details of preassembly that are consistent with the procedure shown on the approved erection camber diagrams. Assemble all girders and beams in their cambered (no load) condition.

When members are assembled with their webs vertical, support them at intervals of 20 feet, or two-tenths of the span length, whichever is less. When the webs are horizontal, the above intervals of support 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 the secondary stresses created by assembling the truss in the fully cambered (no load) position. Support trusses during assembly at each panel point. Preassemble at least 3 contiguous panels that are accurately adjusted for line and camber. For successive assemblies, include at least one section or panel of the previous assembly (repositioned if necessary and adequately pinned to ensure accurate alignment) plus 2 or more sections or panels added at the advancing end. For structures longer than 150 feet, make each assembly not less than 150 feet long regardless of the length of individual continuous panels or sections. Assembly may start from any location in the structure and proceed in one or both directions as long as preceding requirements are satisfied.

(a) Bolted connections. Where applicable, assemble major components with milled ends of compression members in full bearing and then ream subsized holes to the specified size while the connections are assembled.

(b) Check assembly/numerically-controlled drilling. When using numerically-controlled drilling or punching, make a check assembly for each major structural type of each project. Fabricate the check assembly of at least 3 contiguous shop sections or, for a truss, all members in at least 3 contiguous panels but not less than the number of panels associated with 3 contiguous chord lengths (such as the length between field splices). Base check assemblies on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Shop assemblies other than the check assemblies are not required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required.

Receive approval of each assembly (including camber, alignment, accuracy of holes, and fit of milled joints) before reaming is commenced or before any N/C drilled check assembly is dismantled.

(c) Field-welded connections. Field-welded connections are prohibited unless specifically shown on 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 such match-marks.

555.16 Connections Using Unfinished, Turned, or Ribbed Bolts. Use unfinished, turned, or ribbed bolts, where specified, conforming to ASTM A 307 for grade A bolts. Use bolts with single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

(a) Turned bolts. Furnish turned bolts with a body surface ANSI roughness not exceeding 125 microinches. Furnish hex headed bolts and nuts of the nominal size specified. Carefully ream holes for turned bolts and furnish bolts to provide for a light driving fit. Keep bolt threads entirely outside of the holes. Provide a washer under the nut.

(b) Ribbed bolts. Use approved form of ribbed body with continuous longitudinal ribs. Provide a body diameter measured on a circle through the points of the ribs 5/64 inch greater than the nominal diameter specified for the bolts.

Furnish ribbed bolts with round heads conforming to ANSI B18.5. Furnish hexagonal nuts that are either recessed or have a washer of suitable thickness. Ribbed bolts shall have a driving fit when installed in holes. Provide sufficiently hard ribs such that the ribs do not compress or deform and allow the bolts to turn in the holes during tightening. If the bolt twists before drawing tight, ream the hole and provide an oversized replacement bolt.

555.17 Connections Using High-Strength Bolts. This subsection covers the assembly of structural joints using AASHTO M 164 or M 253 high-strength bolts, or equivalent fasteners, tightened to a high tension.

(a) Bolted parts. Use steel material within the grip of the bolt with no compressible material such as gaskets or insulation. Fabricate bolted steel parts to fit solidly together after the bolts are tightened. Limit the maximum slope of the surfaces of parts in contact with the bolt head or nut to 1:20 with respect to a plane normal to the bolt axis.

(b) Surface conditions. At the time of assembly, clean all joint surfaces (including surfaces adjacent to the bolt head and nut) of dirt or foreign material and scale except tight mill scale. Remove burrs that would prevent solid seating of the connected parts in the snug-tight condition.

Paint or other coatings are not permitted on the faying surfaces of slip-critical connections. All connections are considered to be slip-critical. Exclude paint (including any inadvertent overspray) from areas closer than one-bolt diameter, but not less than 1 inch, from the edge of any hole and all areas within the bolt pattern.

(c) Installation. Install fasteners of the same lot number together. Protect fasteners from dirt and moisture. Take from protected storage only as many fasteners as are anticipated to be installed and tightened during a work shift. Return unused fasteners to protected storage at the end of the shift. Do not clean lubricant from fasteners that is required to be present in the as-delivered condition. Clean and relubricate, before installation, fasteners for slip-critical connections that accumulate rust or dirt.

Provide a tension measuring device (a Skidmore—Wilhelm calibrator or other acceptable bolt tension indicating device) on all projects where high-strength fasteners are being installed and tightened. Use the tension measuring device to perform the rotational-capacity test and to confirm all of the following:

- Table 555-6 requirement for the complete fastener assembly
- Calibration of the wrenches, if applicable
- Understanding and proper use of the tightening method

Table 555-6
Minimum Fastener Tension(1)

Nom nal Bolt Diameter (inches)	AASHTO M 164 (pounds)	AASHTO M 253 (pounds)
1/2	12,000	15,000
5/8	19,000	24,000
3/4	28,000	35,000
7/8	39,000	49,000
1	51,000	64,000
1⅛	56,000	80,000
1¼	71,000	102,000
1⅜	85,000	121,000
1½	103,000	148,000

(1) Equal to 70 percent of the specified minimum tensile strength of bolts (as specified for tests of full size AASHTO M 164 and M 253 bolts with UNC threads loaded in axial tension) rounded to the nearest 1,000 pounds.

For short grip bolts, direct tension indicators (DTI) with solid plates may be used to perform this test. First check the DTI with a longer grip bolt in the Skidmore-Wilhelm calibrator. The frequency of confirmation testing, number of tests to be performed, and test procedure shall conform to (3) through (5) as applicable. Confirm the accuracy of the tension measuring device by an approved testing agency at least annually.

Install fasteners together with washers of size and quality specified, located as required below, in properly aligned holes and tightened by any of the methods described in (3) to (6) inclusive to at least the minimum tension specified in Table 555-6 after all the fasteners are tight.

If approved, tightening may be performed by turning the bolt while the nut is prevented from rotating when it is impractical to turn the nut. If impact wrenches are used, provide adequate capacity and sufficient air to tighten each bolt in approximately 10 seconds.

Do not reuse AASHTO M 253 fasteners and galvanized AASHTO M 164 fasteners. If approved, other AASHTO M 164 bolts may be re-used once. Touching up or retightening previously-tightened bolts that may have been loosened by the tightening of adjacent bolts will not be considered as reuse provided the snugging-up continues from the initial position and does not require greater rotation, including the tolerance, than that required by Table 555-7.

Table 555-7 (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 and Other Face Sloped Not More than 1:20 (Bevel Washer Not Used)	Both Faces Sloped Not More Than 1:20 from Normal to Bolt Axis. (Bevel Washers Not Used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameter (3)	2/3 turn	5/6 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 ±30º for bolts installed by 1/2 turn or less. The tolerance is ±45º for bolts installed by 2/3 turn or more.
(3) Determine the required rotation by actual tests in a suitable tension device simulating the actual conditions.

(1) Rotational-capacity tests. Subject high-strength fasteners, black and galvanized, to job-site rotational-capacity tests performed according to AASHTO M 164 and the following:

(a) After tightening to a snug-tight condition, as defined in (c)(3), tighten the fastener 2 times the required number of turns indicated in Table 555-7, in a Skidmore-Wilhelm Calibrator or equivalent tension measuring device, without stripping or failure.

(b) During this test, the maximum recorded tension must be equal to or greater than the turn test tension that is 1.15 times the required fastener tension indicated in Table 555-6.

(c) The measured torque at a tension "P," after exceeding the turn test tension required above in *(b)*, shall not exceed the value obtained by the following equation:

$$\text{Torque} = 0.25\ PD$$

where:

Torque	=	Measured torque in foot·pounds
P	=	Measured bolt tension in pounds
D	=	Nominal bolt diameter in feet

For rotational-capacity tests, use washers even though their use may not be required in the actual installation.

(2) Washers. Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels conforming to AASHTO M 293.

Where necessary, washers may be clipped on one side not closer than 7/8 times the bolt diameter when measured from the center of the washer.

Hardened washers are not required for connections using AASHTO M 164 and M 253 bolts except under the following conditions:

(a) Use hardened washers under the element turned in tightening when the tightening is done by the calibrated wrench method.

(b) Use hardened washers under both the head and the nut when AASHTO M 253 bolts are installed in material having a specified yield point less than 40 kips per square inch regardless of the tightening method.

(c) Use a hardened washer conforming to ASTM F 436 where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than M24 are to be installed in oversize or short-slotted holes in an outer ply.

(d) Use hardened washers conforming to ASTM F 436, except with

5/16 inch minimum thickness, under both the head and the nut in lieu of standard thickness hardened washers where AASHTO M 253 bolts over 1 inch in diameter are to be installed in an oversize or short slotted hole in an outer ply. Multiple hardened washers with a combined thickness equal to or greater than 5/16 inch do not satisfy this requirement.

(e) Where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than 1 inch in diameter are installed in a long-slotted hole in an outer ply, provide a plate washer or continuous bar of at least 5/16-inch thickness with standard holes with sufficient size to cover the slot after installation and is structural grade material that need not be hardened.

When AASHTO M 253 bolts over 1 inch in diameter are used in long-slotted holes in external plies, use a single hardened washer conforming to ASTM F 436 with a 5/16-inch minimum thickness in lieu of washers or bars of structural grade material. Multiple hardened washers with combined thickness equal to or greater than 5/16 inch do not satisfy this requirement.

Alternate design fasteners conforming to Subsection 717.01 with a geometry that provides a bearing circle on the head or nut with a diameter equal to or greater than the diameter of hardened washers conforming to ASTM F 436 satisfy the requirements for washers specified herein and may be used without washers.

(3) Turn-of-nut tightening. At the start of work, test nut tightening using a device capable of indicating bolt tension. Test not less than 3 bolt-and-nut assemblies of each diameter, length, and grade to be used in the work. Demonstrate with the test that the method for estimating snug-tight condition and controlling the turns from snug tight develops a tension not less than 5 percent greater than the tension required by Table 555-6. Perform periodic retesting when required.

Install bolts in all holes of the connection and initially tighten to a snug-tight condition. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench.

Systematically snug-tighten bolt groups from the most rigid part of the connection to the free edges. Then retighten the bolts of the connection in a similar systematic manner as necessary until all bolts are snug tight and the connection is fully compacted. Following the snug-tightening operation, tighten all bolts in the connection by the applicable amount of rotation specified in Table 555-7.

During all tightening operations, do not allow rotation of the fastener part not turned by the wrench. Tighten systematically from the most rigid part of the joint to its free edges.

(4) Calibrated wrench tightening. Calibrated wrench tightening may be used only when installation procedures are calibrated on a daily basis and when a hardened washer is used under the element turned in tightening. Standard torques taken from tables or from formulas that assume to relate torque to tension are not acceptable.

If calibrated wrenches are used for installation, set them to provide a tension not less than 5 percent in excess of the minimum tension specified in Table 555-6. Calibrate the installation procedure at least once each working day for each bolt diameter, length, and grade using fastener assemblies that are being installed in the work.

Perform the calibration with a device capable of indicating actual bolt tension by tightening 3 typical bolts of each diameter, length, and grade from the bolts and washers being installed using a job supplied washer under the element turned in tightening. Recalibrate wrenches when significant difference is noted in the surface condition of the bolts, threads, nuts or washers. Verify during use that the wrench adjustment selected by the calibration does not produce a nut or bolt head rotation from snug tight greater than permitted in Table 555-7. Turn nuts in the tightening direction when measuring the torque of manual torque wrenches.

If calibrated wrenches are used to install bolts in a connection, install bolts with hardened washers under the turned element. When tightening bolts in all holes of the connection, tighten to a snug-tight condition. Following this initial tightening operation, tighten all bolts in the connection using a calibrated wrench. Tighten systematically from the most rigid part of the joint to its free edges. Touch up previously-tightened bolts that may have been relaxed during the tightening of adjacent bolts until all bolts are properly tightened.

(5) Direct tension indicator tightening. When tightening of bolts using direct tension indicator devices is used, assemble a representative sample of not less than 3 devices for each diameter and grade of fastener to be used in the work in a calibration device capable of indicating bolt tension. Include in the test assembly flat-hardened washers, if required in the actual connection, arranged as those in the actual connections to be tensioned. The calibration test must demonstrate that the device indicates a tension not less than 5 percent greater than that required by Table 555-6.

Follow the manufacturer's installation procedures for installation of bolts in the calibration device and in all connections. Give special attention to proper installation of flat-hardened washers when direct tension indicator devices are used with bolts installed in oversize or slotted holes and where the load indicating devices are used under the turned element.

When bolts are installed using direct tension indicators conforming to ASTM F 959, install bolts in all holes of the connection and bring to a snug-tight condition. Snug tight is indicated by partial compression of the direct tension indicator protrusions. After all bolts are snug-tight, tighten all fasteners systematically from the most rigid part of the connection to the free edges in a manner that minimizes relaxation of previously-tightened fasteners. Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final tightening to deform the protrusion to the specified gap.

(6) Installation of alternate design bolts. When fasteners that incorporate a design feature intended to indirectly indicate the bolt tension or to automatically provide the tension required by Table 555-6 and conform to Subsection 717.01 are to be installed, test a representative sample of not less than 3 bolts of each diameter, length, and grade on the project with a device capable of indicating bolt tension.

Include in the test assembly flat-hardened washers, if required in the actual connection, arranged as in the actual connections to be tensioned. The calibration test must demonstrate that each bolt develops a tension not less than 5 percent greater than the tension required by Table 555-6. Follow manufacturer's installation procedure. Perform periodic re-testing when required.

When alternate design fasteners that are intended to control or indicate bolt tension of the fasteners are used, install bolts in all holes of the connection and initially tighten sufficiently to bring all plies of the joint into firm contact; but without yielding or fracturing the control or indicator element of the fasteners. Continue to tighten systematically from the most rigid part of the connection to the free edges in a manner that minimizes relaxation of previously-tightened fasteners.

Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final twist-off or pull-off of the control or indicator element of individual fasteners.

(7) Inspection. Inspect the tightened bolts in the presence of the CO. Use an inspection torque wrench to verify tightening of threaded fasteners. For non-threaded fasteners, ping each fastener with a hammer to test for soundness. Replace or retighten any loose or relaxed fastener. Cutting with a torch is not permitted for removal of bolts.

Individually place 3 bolts of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Perform this calibration operation at least once each inspection day.

Use a washer under the part turned in tightening each bolt if washers are used on the structure. If washers are not used on the structure, use the same specification material that abuts the part turned in the tension measuring device as used on the structure. In the calibrated device, tighten each bolt by any convenient means 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 3 bolts as the job-inspection torque.

Select at random in each connection 10 percent (at least two) of the tightened bolts on the structure represented by the test bolts, and apply the job-inspection torque to each selected bolt with the inspecting wrench turned in the tightening direction. If this torque turns no bolt head or nut, the bolts in the connection will be considered to be properly tightened. If the torque turns one or more bolt heads or nuts, apply the job-inspection torque to all bolts in the connection. Tighten and reinspect any bolt whose head or nut turns at this stage. As an option, retighten all bolts in the connection and resubmit for inspection.

555.18 Welding. Welding, welder qualifications, prequalification of weld details, and inspection of welds shall conform to ANSI/AASHTO/AWS Bridge Welding Code D1.5. Delete the provisions of 9.25.1.7. Do not underrun the nominal fillet weld size.

Do not weld or tack brackets, clips, shipping devices, or other material not required to any member unless shown on the accepted drawings.

555.19 Erection. Falsework and forms shall conform to Section 562. Use steel erectors certified under the AISC Quality Certification Program.

(a) Handling and storing material. Place material stored on the project 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 near enough together to prevent damage due to deflection.

(b) Bearings and anchorages. Furnish and install bridge bearings according to Section 564. If the steel superstructure is to be placed on a substructure that was built under a separate contract, verify that the masonry has been correctly constructed before ordering material.

(c) Erection procedures.

(1) Conformance to drawings. Erect according to accepted erection drawings. Modifications to or deviations from the approved erection procedure require revised drawings and verification of stresses and geometry.

(2) Erection stresses. Allow for erection stresses induced in the structure as a result of the use of a method of erection or equipment that differs from that previously approved and that will remain in the finished structure as locked-in stresses. Provide additional material, as needed, 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 of the structure during erection.

(3) Maintaining alignment and camber. During erection, support segments of the structure in a manner that produces the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing as necessary during erection to provide stability and ensure correct geometry. As necessary, provide temporary bracing at any stage of erection.

(d) Field assembly. Accurately assemble as shown on the erection drawings and required by match-marks. Carefully handle the material. Do not hammer, damage, or distort the members. Clean bearing surfaces and permanent contact surfaces before assembly.

Assemble splices and field connections with at least 2 cylindrical erection pins per part (4 minimum per splice or connection). A plate girder splice requires for example, at least 4 cylindrical erection pins for the top flange splice, 4 pins for the web splice, and 4 pins for the bottom flange splice. These provide 2 pins for each part. Place the pins in the corner holes of the splice plates.

Install more cylindrical erection pins, if necessary, to accurately align the parts. Fill the remaining holes in the connection with bolts, and tighten systematically from the most rigid part of connection to the free edges. Remove cylindrical erection pins and replace with tightened bolts.

Release temporary erection supports at a splice or connection only after all bolts are installed and tightened. Show special assembly and support situations on the erection drawings.

Fitting-up bolts may be the same high-strength bolts used in the installation. If other fitting-up bolts are required, use the same nominal diameter as the high-strength bolts. Use cylindrical erection pins 1/32 inch larger than the bolts.

(e) Pin connections. Use pilot and driving nuts in driving pins. Drive the 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. Correction of minor misfits involving minor amounts of reaming, cutting, and chipping may be done, if approved. Any error in the shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

555.20 Acceptance. Material (except bearing devices and painting) for steel structures will be evaluated under Subsections 106.02 and 106.03. Furnish production certifications for each shipment of structural steel, steel forgings, and high-strength bolts, nuts, and washers.

Construction of steel structures will be evaluated under Subsections 106.02 and 106.04.

Bearing devices will be evaluated under Section 564.

Painting will be evaluated under Section 563.

Measurement

555.21 Measure the Section 555 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure structural steel computed according to the AASHTO *Standard Specifications for Highway Bridges.* Include all metal items incidental to the structure and required by the contract such as castings, steel plates, anchor bolts and nuts, bearings, rockers, rollers, pins and nuts, expansion dams, roadway drains and scuppers, weld metal, bolts embedded in concrete, cradles and brackets, posts, conduits and ducts, and structural shapes.

When measurement is by 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 109.05.

Payment

555.22 The accepted quantities will be paid at the contract price per unit of measurement for the Section 555 pay item 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 furnishing, erecting, removing, and resetting bridge railing.

Bridge railing is designated as concrete, steel, aluminum, or timber according to the predominant material contained in the railing.

Material

556.02 Conform to the following Sections and Subsections:

Aluminum bolt heads and nuts	717.14
Aluminum alloy for bridge rail	717.13
Aluminum-impregnated caulking compound	725.28
Aluminum welding wire	717.15
Box beam rail	710.07
Concrete	552
Painting	563
Reinforcing steel	709.01
Structural steel	555
Timber	557

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 not more than 3/8 inch beyond the nut when tightened. Chamfer or round by grinding or filing all 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 any unevenness in the curb, sidewalk, or wall that supports the railing. The railing shall present a smooth, uniform appearance in its final position. Set all posts vertical.

556.04 Concrete Railing. Construct according to Section 552.

556.05 Steel Railing. Construct according to Section 555.

556.06 Aluminum Railing. Construct according to Section 555 except as amended by the following:

(a) Cutting. Material that is 1/2 inch thick or less may be cut by shearing, sawing, or milling. Saw or mill material that is over 1/2 inch thick. Do not flame cut. Make cut edges true, smooth, and free from excessive burrs or ragged breaks. Fillet reentrant cuts by drilling before cutting.

(b) Bending. Material may be heated to a maximum 400 ºF for a period not to exceed 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 not 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, not to exceed 1/2 inch larger than the nominal bolt diameter.

(d) Welding. Weld according to AWS Structural Aluminum Welding Code D1.2.

(e) Contact with other material. Do not place aluminum alloys in contact with copper, copper base alloys, lead, or nickel. Where aluminum alloys come in contact with other metals, coat the contacting surfaces thoroughly with an aluminum-impregnated caulking compound or place a neoprene gasket between the surfaces.

Where aluminum alloys come in contact with concrete or stone, coat the contacting surfaces with an aluminum-impregnated caulking compound. When bond between aluminum and concrete is required, coat the aluminum with zinc-chromate paint and allow to dry before installation.

Where aluminum alloys come in contact with wood, coat the contacting wood surface with 3 coats of paint according to Section 563 and coat the contacting aluminum surface with an aluminum caulking compound.

556.07 Timber Railing. Construct according to Section 557.

556.08 Remove and Reset Bridge Railing. Remove and store the existing bridge railings and appurtenances. Replace all railings, supports, and hardware damaged during removal, storage, or resetting.

556.09 Painting. Where required by the contract, paint according to Section 563.

556.10 Acceptance. Material (except concrete, painting, reinforcing steel, structural steel, and timber) for bridge railings will be evaluated under Section 106.03. Furnish a production certification with each shipment of bridge railing.

Concrete will be evaluated under Section 552 except compressive strength will be evaluated under Subsection 106.04.

Painting will be evaluated under Section 563.

Reinforcing steel will be evaluated under Section 554.

Structural steel will be evaluated under Section 555.

Timber will be evaluated under Section 557.

Construction of bridge railings will be evaluated under Subsections 106.02 and 106.04.

Measurement

556.11 Measure the Section 556 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 furnishing, preparing, erecting, and painting structural timber. It also includes all required yard lumber and hardware.

Material

557.02 Conform to the following Section and Subsections:

Hardware	716.02
Painting	563
Structural glued laminated timber	716.04
Treated structural timber and lumber	716.03
Untreated structural timber and lumber	716.01

Construction Requirements

557.03 General. Excavate and backfill according to Section 209.

Furnish structural lumber and timber of the required stress grade.

Clear the ground under and in the vicinity of all stored material of stacks of weeds, rubbish, or other objectionable material. Place the bottom layer of material at least 8 inches above the ground level. Provide sufficient support to prevent sagging.

Open-stack untreated material to shed water. Stack material in layers on spacers (stickers) that extend across the full width of the stack to allow for free air circulation. Align all stickers vertically and space them at regular intervals.

Close-stack treated material to shed water.

Protect material from the weather. If covered, use sheet material such as water-resistant paper or opaque polyethylene film. Do not cover with impervious membranes such as polyethylene film during dry weather. Slit individual wrappings full length or puncture on the lower side to permit drainage of water.

Store and protect glued laminated timber according to the recommendations for unloading and handling, job site storage, and erection in "Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage, and Erection," AITC 111.

Use slings or other devices to protect corners of heavy construction timbers and banded packages of lighter construction timber.

Cut and form all lumber and construction timber so all joints will have even bearing over the entire contact surface. Do not use shims in making joints. Construct all joints to be closed. Drive nails and spikes to set the heads flush with the wood surface.

Use the same end, face, and edge of the timber member for all layout dimensions. Bore all holes from mating faces.

557.04 Treated Timber. Fabricate timbers before treatment. Handle treated timber according to the Consumer Information Sheet published by the AWPA. Handle treated timbers carefully and do not drop, damage outer fibers, or penetrate the surface with tools. Do not use cant dogs, hooks, or pike poles. In coastal waters, do not cut or bore timber below the high-water mark.

Carefully trim all field cuts or abrasions made in fabricated timber after treatment. Dip, soak, spray or apply three brush coats of a copper naphthenate solution prepared in accordance with AWPA M4. Apply the preservative in such a manner that it does not drip or spill into the aquatic environment or onto the soil.

Impregnate all holes bored after treatment with the same preservative using equipment suitable for proper application of the preservative. Plug all unused holes with preservative treated plugs.

557.05 Holes for Bolts, Dowels, Rods, and Lag Screws. Bore all holes before preservative treating the wood. Bore holes for round drift pins and dowels to the same diameter as the dowel or pin. 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 1/8 inch larger than the diameter of the bolt.

Bore holes for lag screws according to Subsection 7.3.1. of the AITC *Timber Construction Manual.*

557.06 Bolts and Washers. Galvanize hardware and fasteners including nails, spikes, bolts, washers, and timber connectors. Do not galvanize malleable iron or cast-iron hardware or fasteners.

Use washers under all bolt heads and nuts in contact with wood. Use malleable iron washers with a diameter approximately three times the bolt diameter. Use cast-iron washers when the timber is in contact with the ground. Use square washers only when indicated on the contract plans.

Cut off excess bolt lengths of more than an inch. After final tightening, check or burr all bolts with a pointing tool to prevent loosening of the nuts.

557.07 Countersinking. Countersink nuts and bolt heads where required by the contract. Paint recesses formed for countersinking, except in railings, with an approved preservative. After bolts or screws are in place, fill the holes with hot pitch or other approved filler.

557.08 Framing. Do not slab or trim treated piles for fitting sway or sash braces. Fill all gaps that occur between braces and piles with treated blocks so that the bracing is securely fastened to the piles.

557.09 Framing Bents. Bed mud sills firmly and evenly to solid bearing and tamp in place.

When concrete is cast, set dowels for anchoring sills and posts to project at least 6 inches above the tops of the pedestals. Carefully finish concrete pedestals supporting framed bents so that sills or posts bear evenly on the pedestals.

Provide firm, even bedding for mud sills. Make sills bear true and even on mud sills, piles, or pedestals. Drift bolt sills with bolts that extend into the mud sills or piles for at least 6 inches. Where possible, remove all earth in contact with sills for circulation of air around the sills.

557.10 Caps for All Bents. Make timber caps bear evenly and uniformly over the tops of the supporting posts or piles with their ends in alignment. Secure all caps with driftbolts and set approximately at the center of and extending into the posts or piles at least 9 inches.

557.11 Bracing. Bolt the ends of bracing through the pile, post, cap, or sill. Brace intermediate intersections with posts or piles with bolts or spikes with wire or boat spikes, as required. In all cases use galvanized spikes in addition to bolts.

Make all bracing bear firmly against the pile or cap to which it is bolted. Provide and place shims as necessary to prevent bending the bracing more than 1 inch out of line when bracing bolts are tightened.

Where the space between the bracing and cap or pile is less than 1 inch, shims need not be used. Where the space between the bracing and the cap or pile is 1½±1/2 inches, place 2 ogee washers with their narrow faces together or other approved washers on each bolt that passes through the space.

Where the space between the bracing and the cap or pile is over 2 inches, use wooden shims of the proper thickness. Fabricate the wooden shims from white oak or 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 not less than 4 inches and the length not less than the width of the bracing measured along the cap or pile. Do not adze, trim, or cut any treated member to avoid the use of shims.

557.12 Stringers. Size stringers at bearings and place in position so that knots near edges are in the top portions of the stringers.

Outside stringers may have butt joints with the ends cut on a taper. Lap interior stringers to take bearing over the full width of the floor beam or cap at each end. Separate the lapped ends of untreated stringers by at least 1/2 inch for air circulation. Securely fasten the lapped ends with drift bolts as required. Stagger the joints where stringers are 2 panels in length.

Securely toenail cross-bridging between stringers with at least 2 nails in each end. Cut all cross-bridging members for a full bearing at each end against the sides of the stringers. Place cross-bridging at the center of each span. If blocking is used, make it fit snugly and hold in place as required.

557.13 Plank Floors. Use plank that is surfaced on four sides (S4S).

Single-ply timber floors consist of a single thickness of planks supported on stringers. Lay the planks heart side down with 1/4 inch space between them for seasoned material and with tight joints for unseasoned material. Spike each plank securely to each stringer. Carefully grade the planks as to thickness and lay so that no 2 adjacent planks vary in thickness by more than 1/16 inch.

Two-ply timber floors consist of 2 layers of flooring supported on stringers. Treat the lower layer according to Subsection 557.04. Lay the top layer either diagonally or parallel to the centerline of roadway as required. Securely fasten each floor piece to the lower layer. Stagger joints at least 3 feet. 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.

557.14 Transversely Nail-Laminated Decks. Use 2-inch nominal thickness laminations, surface one edge hit or miss 1/8 inch scant (SIE-H or M 1/8-inch scant), and one side hit or miss 1/8 inches scant (SIS-H or M 1/8-inch scant).

Place the laminations on edge and at right angles to the centerline of roadway. Spike each piece to the preceding piece at each end and at approximately 18-inch intervals with the galvanized spikes driven alternately near the top and bottom edges. Use spikes of sufficient length to pass through 2 pieces and at least halfway through the third piece.

Where timber stringers are used, use spikes to toenail every other piece to every other stringer. When steel stringers are used, securely attach the pieces using approved galvanized metal clips.

Use pieces of sufficient length to bear on at least 4 stringers. Do not splice pieces between stringers. Space end joints on any one stringer no closer than every third piece. Space end joints in adjoining pieces no closer than every second stringer.

557.15 Wheel Guards and Railings. Surface (S4S) wheel guards, rails, and posts. Place wheel guards in sections not less than 12 feet in length. Squarely butt-joint all rails at posts.

557.16 Trusses. Fabricate trusses to show no irregularities of line when completed. Fabricate chords straight and true from end-to-end in horizontal projection. In vertical projection, fabricate chords to a smooth, corded curve through panel points conforming to the correct camber. Do not make uneven or rough cuts at the points of bearing.

557.17 Drains. Hot-dip galvanize drains, including anchorages, after fabrication.

557.18 Painting. When paint is specified in the contract, paint according to Section 563.

557.19 Acceptance. Material (except paint) for timber structures will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each shipment of structural timber and lumber.

Construction of timber structures will be evaluated under Subsections 106.02 and 106.04.

Painting will be evaluated under Section 563.

Measurement

557.20 Measure the Section 557 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure untreated and treated structural timber and lumber by the thousand feet board measure (MFBM) in the structure.

Compute the quantities from nominal dimensions and actual lengths except for transversely nail-laminated decks. Measure transversely nail-laminated decks in place after dressing.

Measure timber piles under Section 551.

Measure timber bridge rail under Section 556.

Payment

557.21 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 or masonry surfaces.

Material

558.02 Conform to the following Subsections:

Asphalt	702.05(b)
Primer	702.05(a)

Construction Requirements

558.03 Dampproofing. Cure the concrete or masonry surface according to Subsection 552.15 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, reasonably smooth surface that is free of dust and loose material. Apply dampproofing in dry weather when the air and surface temperatures are 45 ºF or higher.

Apply primer to the surface and allow it to dry. Apply 2 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, fully covering the surface, and thoroughly work them into the surface. Make the total of the final 2 asphalt coats approximately 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 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

Description

559.01 This work consists of waterproofing concrete surfaces with a firmly-bonded membrane and, when specified, protecting with a mortar or asphalt plank overlay.

Protection types are designated as follows:

Type 1— Mortar overlay.

Type 2— Asphalt plank overlay.

Material

559.02 Conform to the following Subsections:

Asphalt	702.05(b)
Asphalt plank	702.05(e)
Asphalt roll roofing	702.05(f)
Joint filler	712.01
Mortar	702.05(d)
Primer	702.05(a)
Waterproofing fabric	702.05(c)
Welded wire fabric	709.01

Construction Requirements

559.03 Membrane Waterproofing. Make the concrete surface smooth and free of projections or depressions that might cause puncture of the membrane. Allow concrete surfaces to dry at least 10 days after completion of curing. Make the surface dry and free of dust and loose material. Apply waterproofing in dry weather when the temperature is above freezing. Apply primer and allow to dry.

Begin at the lowest point of the concrete surface and apply a mop coat of asphalt slightly wider than half the width of fabric. Apply asphalt at a temperature between 300 and 350 ºF. Apply so no uncoated areas of concrete remain.

Lay fabric so that drainage is over and not against or along the laps. Lay a half width of fabric on the asphalt and press into place expelling all entrapped air and obtaining close contact with the surface.

Mop coat the top of the first strip so as to completely conceal the weave and an adjoining section of concrete surface slightly wider than half the fabric width. On this mopping, lay a full-width strip of fabric and press into place completely covering the first strip. Mop this second strip and an adjoining section of concrete surface slightly wider than half the fabric width. Place a third strip of fabric so as to lap the first strip by not less than 4 inches. Continue this process of lapping each strip of fabric at least 4 inches over the strip placed before the last strip until the entire surface is covered with 2 layers of fabric. Lap the ends at least 12 inches. Do not allow the fabric to touch an unmopped surface.

Mop the entire surface with hot asphalt after all fabric is placed. Apply asphalt at a rate not less than 12 gallons per 100 square feet of finished horizontal surface and not less than 15 gallons per 100 square feet of vertical surface. Regulate work so, at the close of a day's work, all fabric in place is mopped. Take special care to ensure that all laps are sealed.

At the edges of the membrane and at places where it is punctured by openings such as for drains or pipes, prevent water from getting between the waterproofing and the waterproofed surface.

Provide flashing at curbs and against girders, spandrel walls, etc. with separate sheets that lap the main membrane at least 12 inches. Seal flashing with either a metal counterflashing or by embedding the upper edges of the flashing in a groove joint filler.

Repair or replace any membrane waterproofing that is found to leak. Sampling frequency and location where samples are to be taken will be specified in the contract.

Apply protective covering or backfill to prevent damage.

559.04 Membrane Waterproofing with Mortar Protection. Construct waterproofing membrane to be protected with mortar according to Subsection 559.03.

Completely cover the membrane, except on undercut surfaces, with a course of reinforced mortar.

Use a 2-inch thick mortar course reinforced with welded wire reinforcement (W5.5 by W5.5) or its equivalent placed midway between the top and bottom surfaces of the mortar. Trowel the top surface of the mortar course to a smooth, hard finish. Cure the protective mortar with wet burlap held in close surface contact for 72 hours.

Protect undercut membrane surfaces with a layer of asphalt roll roofing laid in hot asphalt in place of the mortar covering. Use the same bituminous material as used for mopping the membrane.

559.05 Membrane Waterproofing with Asphalt Plank Protection. Construct waterproofing membrane with asphalt plank protection according to Subsection 559.03.

Cover the membrane with asphalt plank. Lay the plank in regular, straight courses as required. Use whole planks in all cases except as required for closures and for fitting around openings and obstructions. Carefully cut to size closing and trimming pieces. Before the planks are laid, remove all surplus talc or other powder from the planks with a stiff brush or broom. Lay each piece in a mopping of hot asphalt, and coat the edges and ends of pieces in place with hot asphalt before placing an adjacent piece in contact. Press each individual piece tightly against the piece next to it. Make the completed surface uniform and smooth without open joints.

559.06 Acceptance. Material for waterproofing will be evaluated under Subsections 106.02 and 106.03.

Applying waterproofing will be evaluated under Subsections 106.02 and 106.04.

Measurement

559.07 Measure the Section 559 items listed in the bid schedule according to Subsection 109.02.

Payment

559.08 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	725.01(c)

Construction Requirements

560.03 General. Submit a proposed sequence and schedule to the CO for acceptance. Include the proposed removal method, list of removal equipment, and equipment operator certifications.

Submit the proposed method for filtering wastewater. Use methods such as filters and sediment traps to ensure that wastewater released into the environment is free of concrete particles and sediment. Dispose of all debris off the project according to Subsection 203.05.

Construct structurally-adequate debris shields to prevent debris and wastewater from entering waterways, travel lanes open to public traffic, or areas designated not to be disturbed.

Furnish all water required to operate the hydrodemolition equipment.

560.04 Equipment. Furnish a self-propelled and completely programmable hydrodemolition system designed for concrete removal to precise depths. Provide qualified equipment operators certified by the equipment manufacturer.

Demonstrate and calibrate the hydrodemolition equipment in a 60-square yard test area identified by the CO. Establish the operating parameters to achieve the required depth of removal. Submit the complete list of operating parameters to be used for production work to the CO for approval.

560.05 Concrete Removal. In the presence of the CO, use a hammer, chain, or other acceptable means to test the concrete surface and determine the soundness of the concrete. Identify and mark all concrete to be removed at least one day in advance of the hydrodemolition operation.

Using hydrodemolition equipment, remove the designated concrete to a minimum depth of 1 inch below the bottom of the top mat of reinforcing steel. If needed, recalibrate the equipment during production to obtain satisfactory concrete removal. Also remove all loose and unsound concrete below the minimum depth.

In areas inaccessible to the hydrodemolition equipment, use acceptable hand-held water blasting equipment or power-driven hand tools such as jack hammers, mechanical chipping tools, or chipping hammers to remove the designated concrete.

Do not damage remaining sound concrete or reinforcing steel. When the bond between existing concrete and reinforcing steel is destroyed, remove the concrete adjacent to the reinforcing steel to a depth that permits new concrete to bond to the entire periphery of the reinforcing steel.

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. Remove debris immediately after the demolition operation to prevent it from rebonding to the surface or reinforcing steel.

560.06 Reinforcing Steel. Do not cut or damage reinforcing steel designated to remain. Use methods acceptable to the CO to repair or replace all reinforcing steel damaged by the concrete removal operation.

560.07 Surface Preparation. Before placing new concrete, clean the concrete surface and all exposed reinforcing steel of all rust, loose and rebounded material, and other contaminants that may inhibit a bond with new concrete. If compressed air is used, provide a filter in the air line to ensure that the air delivered is oil-free. Protect the steel and surface from contamination until the new concrete is placed.

560.08 Acceptance. Removal of concrete by hydrodemolition will be evaluated under Subsection 106.02.

Measurement

560.09 Measure the Section 560 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure hydrodemolition by the cubic foot in its original position.

Payment

560.10 The accepted quantity measured as provided in Subsection 109.02, will be paid at the contract price per unit of measurement for the Section 560 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 561. — Reserved

Section 562. — TEMPORARY WORKS

Description

562.01 This work consists of the design, construction, inspection, and removal of temporary works for the construction and repair of permanent structures. Temporary works includes all temporary facilities used in construction that do not become part of the permanent structure. Such temporary works include, but are not limited to, falsework, formwork, cofferdams, and excavation supports.

Material

562.02 Select material consistent with the safety and quality required by the design assumptions. Furnish manufactured devices complying with the *Certification Program for Bridge Temporary Works* (FHWA-RD-93-033).

Design Requirements

562.03 Design. Design and construct safe and adequate temporary works that will support all loads imposed and provide the necessary rigidity to produce in the final structure, the lines and grades shown on the plans. Design temporary works according to the *AASHTO Guide Design Specification for Bridge Temporary Works*. When a manufactured device is to be employed, ensure that the design load on the device is within the load rating recommended by the manufacturer. Design falsework and forms supporting deck slabs and overhangs on girder bridges so that there will be no differential settlement between the girders and the deck forms during placement of deck concrete.

For cast-in-place concrete structures, limit the calculated deflections of falsework and formwork members as follows:

(a) Falsework members vertical deflection: 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): 1/360 of the span under the dead load of the concrete only or the lateral pressure of fluid concrete only.

(c) Formwork (sheathing): 1/8 inch or 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 so that loads are applied to girder webs within 6 inches of a flange or stiffener. Distribute the loads in a manner that does not produce 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 forms that require holes to be drilled into the girder webs.

Do not use deck overhang form brackets for steel girder bridges that require holes to be cast or drilled into the girder webs.

Do not apply loads to existing, new, or partially completed structures that exceed the load carrying capacity of any part of the structure according to the load factor design methods of the AASHTO Bridge Design Specifications using load group IB.

Do not use permanent or stay-in-place deck forms unless specified in the contract.

562.04 Drawings. Prepare and submit drawings according to Subsection 104.03. Furnish design calculations and supporting data in sufficient detail to permit a structural and safety review of the proposed design. Show all information necessary to allow the design of all components to be checked independently. When manufactured devices are used as part of the temporary works, provide catalog or equivalent data indicating the device's recommended safe load capacity.

When concrete placement is involved, indicate on the drawings the proposed sequence, rate of placement, direction of placement, and location of all construction joints. Show anticipated total settlements and deflections of the falsework and forms on the drawings. Include falsework footing settlements, joint take-up, and deflection of beams or girders.

For steel girder erection, submit the erection procedure and temporary support system. Include calculations in sufficient detail to substantiate that the girder geometry is correct. Design supporting falsework to accommodate the erection procedure without over stressing the structural steel and to produce the required final structural geometry, intended continuity, and structural action.

Do not start construction of any temporary work for which drawings are required until the CO has accepted the drawings.

Construction Requirements

562.05 Foundations. Determine the allowable bearing capacity of the foundation material on which the supports for temporary works will rest. Perform load tests to verify proposed bearing capacity values that are in doubt, marginal or in other high risk situations.

Foundation support values shown in the contract for the permanent structure may be used in the design of falsework foundations provided 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.

Do not locate the edge of footings closer than 12 inches from the intersection of the bench and the top of the slope. Unless shoring adequately supports the excavation for footings, do not locate the edge of the footings closer than 48 inches or the depth of excavation; whichever is greater, from the edge of the excavation.

Provide adequate site drainage and soil protection to ensure the integrity of the foundation material for the temporary works supports.

If piles are used, capacities may be estimated and later confirmed during construction using standard procedures based on the driving characteristics of the pile. In the absence of more sophisticated methods of determining pile capacity, use the dynamic formula according to Section 551 to determine ultimate pile capacity. The Contractor may elect to use load tests to confirm the estimated capacities. Perform load tests to verify bearing capacity values that are in doubt, marginal or in other high risk situations.

Submit all foundation design calculations and other relevant foundation design data to the CO for acceptance.

562.06 Construction. Construct temporary works according to the accepted drawings. Use material and workmanship consistent with that assumed in the design of the temporary works.

Do not weld temporary works or use driven devices to fasten temporary works to any portion of the permanent structure unless it is shown on the accepted drawings.

Furnish and place form panels for exposed surfaces in uniform widths of not less than 3 feet and in uniform lengths of not less than 6 feet except where the width of the member formed is less than 3 feet. 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. For walls with sloping footings, which do not abut other walls, panels may be placed with the long dimension parallel to the footing. Precisely align form panels on each side of the panel joint by means of 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.

When architectural treatment is required, make the angle points for chords in wall stems fall at vertical rustication joints. 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 all of the following apply:

(a) Chords within the panel are the same length;

(b) Chords do not vary from a true curve by more than 1/2 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. During concrete placement, record settlement to the nearest 1/8 inch.

Discontinue concrete placement and take corrective action if settlement or deflections occur that deviate more than 3/8 inch from those shown on the falsework drawings.

If satisfactory corrective action is not taken before initial set, remove all unacceptable concrete.

562.07 Maintenance and Inspection. Inspect and maintain temporary works in an acceptable condition throughout the period of use. Clearly mark the capacity of each manufactured device according to the *Certification Program for Bridge Temporary Works* (FHWA-RD-93-033).

In the presence of the CO, perform an in-depth inspection of the temporary works not more than 24 hours before beginning each concrete placement or before allowing people to enter a cofferdam or excavation support structure. Inspect other temporary works at least once a month to ensure they are functioning properly. Use a registered professional engineer to inspect cofferdams, shoring, support of excavation structures, and support systems for load tests before loading.

Make inspections and certifications according to the *Certification Program for Bridge Temporary Works* (FHWA-RD-93-033). Furnish written results of the inspections to the CO before placing concrete, allowing people to enter a cofferdam or excavation support structure, or loading temporary works. Include a certification that the system meets the requirements of the contract and drawings.

562.08 Removal. Remove all temporary works except as follows:

(a) Portions of driven falsework piles that are more than 12 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 any navigation channel;

(b) Footing forms where their removal would endanger the safety of cofferdams or other work; and

(c) Forms from enclosed cells where access is not provided.

Remove temporary works in such a manner as to permit the structure to uniformly and gradually take the stresses due to its own mass.

Unless otherwise permitted, remove all temporary works upon completion of the work. Do not disturb or damage the finished work. Restore the area to its original or planned condition. Clean up all debris. The removed temporary works remain the property of the Contractor.

Forms that do not support the dead load of concrete members and forms for railings and barriers may be removed 24 hours after the concrete is placed, excluding forms for cold weather concrete, and provided that the concrete has sufficient strength to prevent damage to the surface. Remove cold weather concrete forms only after the strength of the concrete has reached at least 500 pounds per square inch. When forms are removed at less than 7 days after concrete placement cure concrete according to Subsection 552.15.

Forms supporting the dead load of concrete members may be removed only after the concrete has reached 90% of the design compressive strength and has been in place for at least 7 days.

Falsework supporting any span of a simple span bridge may be removed only after the concrete, excluding concrete above the bridge deck, has reached 90% of the design compressive strength and has been in place for at least 10 days.

Falsework supporting any span of a continuous or rigid frame bridge may be removed only after the concrete in that span and the concrete in the adjacent portions of each adjoining span for a length equal to at least one-half 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 after the prestressing steel has been tensioned.

Remove falsework for arch bridges uniformly and gradually. Begin 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 all 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.

Measurement and Payment

562.10 See Subsection 109.05.

Do not measure temporary works for payment.

Section 563. — PAINTING

Description

563.01 This work consists of removing coatings and applying protective coatings to metal, timber, or concrete surfaces to control corrosion and deterioration.

Material

563.02 Conform to the following Section and Subsections:

Linseed oil	725.14
Mineral spirits	725.14
Paint	708
Water	725.01

Construction Requirements

563.03 Protection of Public, Property, and Workers. Comply with the Steel Structures Painting Council's (SSPC) *SSPC-PA Guide 3 — A Guide to Safety in Paint Application* and OSHA requirements. If the paint being removed is a hazardous material containing lead or chromium, comply with all the following:

• SSPC Guide 6I(CON) — Guide for Containing Debris Generated During Paint Removal Operations;

• SSPC Guide 7I(DIS) — Guide for the Disposal of Lead-Contaminated Surface Preparation Debris;

• 29 CFR 1926.62 — OSHA Construction Industry Standards for Lead;

• 40 CFR 50.6 — EPA National Primary and Secondary Ambient Air Quality Standards for Particulate Matter;

• 40 CFR 50.12 — EPA National Primary and Secondary Ambient Air Quality Standards for Lead; and

• 40 CFR Parts 260-268 — Resource Conservation and Recovery Act (RCRA).

At least 28 days before beginning surface preparation, submit a written plan for acceptance that details the measures to be used for protecting the environment, public, adjacent property, and workers. Include in the plan the following:

(a) Manufacturer's material safety data sheets and product data sheets for all cleaning and painting products.

(b) A detailed containment plan for removed material, cleaning products, and paint debris. Include details of attachment that do not require welding or drilling holes in the existing structure. Make connections with clamps or other approved devices.

(c) A detailed disposal plan for removed material, cleaning products, and paint debris.

(d) Specific safety measures to protect workers from site hazards including falls, fumes, fires, or explosions.

(e) If paint being removed is a hazardous material, include specific safety measures to comply with 29 CFR 1926.62, 40 CFR 50.6, 40 CFR 50.12, and 40 CFR Parts 260-268. Document compliance upon request.

(f) Emergency spill procedures.

(g) To perform quality control functions, provide a competent person as defined in SSPC-QP 2 with the following:

(1) An SSPC Competent Person Certificate;

(2) A certificate of completion of 29 CFR 1926.62 Lead in Construction training;

(3) Minimum of 2 years industrial field painting experience;

(4) Minimum of 90 days of field supervisory or management experience in paint removal projects; and

(5) Documentation of the individual’s qualifications including records of training and experience.

Perform work according to the accepted plan. If the measures fail to perform as intended, immediately stop work and take corrective action. Collect and properly dispose of all material including waste water that is used in preparing, cleaning, or painting.

563.04 Protection of the Work. Protect adjacent surfaces that are not to be painted by using tarps, screens, paper, cloth, or other suitable means. Prevent contamination of freshly-painted surfaces by dust, oil, grease, or other harmful or deleterious material.

563.05 Surface Preparation, General. Notify the CO in writing at least 7 days before beginning operations. Immediately before painting, prepare the surface according to the following:

(a) Clean the surface to the specified cleanliness level.

(b) Remove dirt, dust, and other contaminants from the surface using methods recommended by the paint manufacturer.

(c) Thoroughly dry the surface.

(d) Determine that the surface temperature is between 50 and 100 ºF.

(e) Determine that the surface temperature is 5 ºF or more above the dew point according to ASTM E 337.

(f) Determine that the humidity is 85 percent or less, unless specified otherwise on the manufacturer's product data sheet.

Suitable engineering controls such as enclosures and dehumidification may be used to provide the conditions required above.

563.06 Paint Application, General. Use safe handling practices that conform to the manufacturer's safety data sheet and instructions. Mix and apply paint according to the product instructions. Mix paint with mechanical mixers for a sufficient length of time to thoroughly blend the pigment and vehicle together. Continue the mixing during application. Do not thin paint that is formulated ready for application.

Paint in a neat and workmanlike manner that does not produce excessive paint build-up, runs, sags, skips, holidays, or thin areas in the paint film. Measure the wet film thickness during application and adjust the application rate such that, after curing, the desired dry film thickness is obtained. Apply paint by brush, spray, roller, or any combination thereof if permitted by the manufacturer's product data sheet.

Use brushes that have sufficient bristle body and length to spread the paint in a uniform film. Use round, oval shaped brushes, or flat brushes no wider than 4½ inches. Evenly spread and thoroughly brush out the paint as it is applied.

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 D 4285. Use the spray gun tip sizes and pressures recommended by the manufacturer.

Use rollers only on flat, even surfaces. Do not use rollers that leave a stippled texture in the paint film.

Use sheepskin daubers, bottle brushes, or other acceptable methods to paint surfaces that are inaccessible for painting by regular means.

Cure each coat of paint according to the manufacturer's recommendations. Correct all thin areas, skips, holidays, and other deficiencies before the next application of paint. Tint succeeding applications of paint to contrast with the paint being covered. The CO will approve the color 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, thoroughly clean all areas where the undercoating is damaged or deteriorated, and spot coat these with the specified undercoats to the required thickness before applying the final coat.

563.07 Structural Iron and Steel.

(a) Paint systems.

(1) New surfaces or surfaces with all existing paint removed. Furnish a paint system shown in Table 563-1.

(2) Surfaces with existing sound paint. Furnish a paint system compatible with the existing paint. Furnish a system shown in Table 563-2 or a system approved for use on steel structures by the State highway agency in the State in which the structure is located.

At least 14 days before ordering paint, verify compatibility of the proposed system with the existing system as follows:

(a) Select a test area of at least 30 square feet in a condition representative of the condition of the structure. Perform the specified level of surface preparation, and apply the proposed system to the existing topcoat and to the existing primer. Observe for lifting, bleeding, blistering, wrinkling, cracking, flaking, or other evidence of incompatibility.

(b) Verify that no indication of incompatibility exists at least 14 days after the application of each product. Perform adhesion tests according to ASTM D 3359, method A. Notify the CO immediately if adhesion testing fails at the interface of the existing system and substrate or between the existing finish coat and primer. An adhesion failure indicates incompatibility. Choose a more compatible paint system.

(b) Surface preparation. Do not remove sound paint unless specifically required by the contract.

(1) New surfaces or surfaces with all existing paint removed. Remove all dirt, mill scale, rust, paint, and other foreign material from exposed surfaces by blast cleaning to near white metal according to SSPC-SP 10.

Use compressed air that is free from oil or moisture and does not show black or wet spots when tested according to ASTM D 4285. Do not use unwashed sand or abrasives that contain salts, dirt, oil, or other foreign matter. Before blast cleaning near machinery, seal bearings, journals, motors, and moving parts against entry of abrasive dust.

Blast clean with clean dry slag, mineral grit, steel shot, or steel grit. Use a suitable gradation to produce a dense, uniform anchor pattern. Produce an anchor profile height of 1 to 2 mils, but not less than that recommended by the paint system manufacturer's product data sheet. Measure anchor profile height using the tape method according to ASTM D 4417.

Table 563-1
Structural Iron and Steel Coating Systems for
New Surfaces and Surfaces with All Existing Paint Removed

Coat	Paint System [(1)]				
	1	**2**	**3**	**4**	**5**
	Aggressive Environments (Salt)	**Aggressive Environments (Salt)**	**Aggressive Environments (Salt)**	**Less Aggressive Environments (No Salt)**	**Less Aggressive Environments (No Salt)**
Primer	Inorganic zinc type I 3-4 mils dry	Zinc-rich epoxy 3-4 mils dry	Moisture-cured urethane 2-3 mils dry	Acrylic latex 2-3 mils dry	Low VOC alkyd 2-3 mils dry
Intermediate	Epoxy 2-3 mils dry	Epoxy 3-4 mils dry	Moisture-cured urethane 2-3 mils dry	Acrylic latex 2-3 mils dry	Low VOC alkyd 2-3 mils dry
Top	Aliphatic urethane 2-3 mils dry	Aliphatic urethane 2-3 mils dry	Moisture-cured urethane 2-3 mils dry	Acrylic latex 2-3 mils dry	Low VOC alkyd 2-3 mils dry
Total Thickness	8-11 mils dry	8-11 mils dry	6-9 mils dry	6-9 mils dry	6-9 mils dry

(1) System 1, 2, or 3 is for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments such as marine, industrial, high humidity, or structures exposed to deicing salts. System 4 or 5 is for use in those environments free from high concentrations of salts or pollutants that cause aggressive corrosion environments.

Table 563 - 2
Structural Iron and Steel Coating Systems for Surfaces with Existing Sound Paint

Coat	Paint System (1)		
	6	7	8
	Aggressive Environments (Salt)	Less Aggressive Environments (No Salt)	Less Aggressive Environments (No Salt)
Primer	Moisture-cured urethane 2-3 mils dry	Low VOC alkyd 2-3 mils dry	Low viscosity epoxy sealer 1-2 mils dry
Intermediate	Moisture-cured urethane 2-3 mils dry	Low VOC alkyd 2-3 mils dry	Epoxy 3-4 mils dry
Top	Moisture-cured urethane or aliphatic urethane 2-3 mils dry	Low VOC silicone-alkyd 2-3 mils dry	Aliphatic urethane 2-3 mils dry
Total Thickness	6-9 mils dry	6-9 mils dry	6-9 mils dry

(1) System 6 is for the corrosion protection of iron and steel in aggressively corrosive atmospheric environments such as marine, industrial, high humidity, or structures exposed to deicing salts. System 7 or 8 is for use in those environments free from high concentrations of salts or pollutants that cause aggressive corrosion environments.

The same day cleaning is performed, remove dirt, dust, and other debris from the surface by brushing, blowing with clean dry air, or vacuuming and apply the first coat of paint to the blast cleaned surfaces. If the cleaned surfaces rust or become contaminated before painting, repeat the blast cleaning.

(2) Surfaces with existing sound paint. Wash all areas to be painted with pressurized water to remove dirt, surface chalking, loose rust, and contaminants such as chlorides. Maintain a wash water pressure of at least 500 pounds per square inch. Capture all wash water and removed waste according to appropriate regulations.

Clean according to SSPC-SP 2 — Hand Tool Cleaning, SSPC-SP 3 — Power Tool Cleaning, or SSPC-SP 6 — Commercial Blast Cleaning to remove dirt, loose mill scale, loose rust, or paint that is not firmly bonded to the underlying surface. Clean small areas that show pinhole corrosion, stone damage from traffic, or minor scratches. Clean at least 2 inches beyond the damaged areas. Feather edges of remaining old paint to achieve a reasonably smooth surface.

The same day hand- or power-tool cleaning is performed, remove dirt, dust, and other contaminants from the surface with solvent-cleaning methods according to SSPC-SP 1, and spot paint all bare steel areas with the first coat of paint. If the cleaned surfaces rust or become contaminated before painting, repeat solvent cleaning. Repair all damage to sound paint by applying the entire system.

(c) Application of paints. Apply each coat to the wet film thickness as recommended by the paint manufacturer to obtain the specified dry film thickness. Verify the application rate of each coat with a wet film paint thickness gauge immediately after applying paint to the surface. Confirm the application rate by measuring the dry film thickness after the solvent has evaporated from the surface.

563.08 Painting Galvanized Surfaces. Remove all oil, grease, or other contaminants on the surface by washing with a mineral spirit solvent according to SSPC-SP 1.

Apply the coating system shown in Table 563-3 for other metals.

Table 563-3
Coating Systems for Other Structures

Substrate	Paint Coatings			
	Primer	Intermediate	Finish	Total
Smooth Wood	Exterior wood primer (1) 2-3 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	5-7 mils dry
Rough Lumber	Exterior latex or alkyd (1) 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	3-6 mils dry
Concrete	Epoxy single coat 3-4 mils dry. For gloss finish, finish with aliphatic-polyurethane (2 mils dry).			3-6 mils dry
Masonry Block	Masonry block filler 2-3 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	5-7 mils dry
Aluminum	Metal primer 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	4-6 mils dry
Other Metals	Metal primer (2) 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	Exterior latex or alkyd 1-2 mils dry	4-6 mils dry

(1) For untreated wood, thin the primer with up to 0.1 gallon of turpentine and 0.1 gallon of linseed oil per gallon of paint.
(2) For galvanized surfaces, use an epoxy primer (1-2 mils dry thickness) or a vinyl wash primer (1 mil dry thickness).

563.09 Painting Timber Structures. Dry timber to a moisture content of 20 percent or less. On previously painted timber, remove all cracked or peeled paint, loose chalky paint, dirt, and other foreign material by wire brushing, scraping, or other approved methods. On timber treated with creosote or oilborne pentachlorophenol preservative, wash and brush away visible salt crystals on the wood surface and allow to dry. Remove all dust or other foreign material from the surface to be painted.

Apply the coating system shown in Table 563-3. The primer may be applied before erection. After the primer dries and the timber is in place, fill all cracks, checks, nail holes, or other depressions flush with the surface using approved putty. Evenly spread and thoroughly work the paint into all corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the next coat.

563.10 Painting Concrete Structures. Remove all laitance, dust, foreign material, curing compound, form oil, grease or other deleterious material from the concrete surface. Remove form oil, grease, or curing compound by washing with a 5 percent solution of trisodium phosphate and rinsing with clean water. Allow the surface to dry completely.

Give the cleaned surface a light abrasive sweep to remove mortar wash or other contaminants. Remove all residue and dust by hand, broom, compressed air or other approved methods.

Apply the coating system coatings shown in Table 563-3. Evenly spread and thoroughly work the paint into all corners and recesses. Allow the full thickness of the applied coat of paint to dry before applying the next coat.

563.11 Acceptance. Paint material will be evaluated under Subsections 106.02 and 106.03. If sampling and testing of paint components is required, sampling will be according to FSS 141 method 1021 and the testing of the paint properties will be according to the procedures and methods listed in FSS 141.

Painting application will be evaluated under Subsection 106.02 and 106.04. The dry paint thickness on steel structures will be determined using a type I magnetic film thickness gauge according to SSPC-PA 2 or by using destructive methods according to ASTM D 4138. If destructive methods are used, repair test locations in an approved manner.

Measurement

563.12 Measure the Section 563 items listed in the bid schedule according to Subsection 109.02.

Payment

563.13 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 furnishing and installing bridge bearings.

Bearing devices are designated as elastomeric, rocker, roller, sliding plate, pot, spherical and disk bearings.

Material

564.02 Conform to the following Subsections:

Elastomeric bearing pads	717.10
Galvanized coatings	717.07
Non-shrink grout	725.22(c)
Tetrafluoroethylene (TFE) surfaces for bearings	717.11

Construction Requirements

564.03 General.

(a) Drawings. Prepare and submit drawings for the bearings according to Subsection 104.03 and Section 18 of the AASHTO *Standard Specifications for Highway Bridges* Division II, Volume II. Show all details of the bearings including the material proposed for use. Obtain approval before beginning fabrication.

(b) Fabrication. Fabricate bearings according to Section 18 of the AASHTO *Standard Specifications for Highway Bridges* Division II, Volume II. The surface finish of bearing components in contact with each other or with concrete, but not embedded in concrete, shall conform to Subsection 555.08(e).

Preassemble bearing assemblies in the shop and check for proper completeness and geometry. Galvanize steel bearing components and anchor bolts. Do not galvanize stainless steel bearing components or anchor bolts.

(c) Packaging, handling, and storage. Before shipping from the manufacturer, clearly identify each bearing component and mark on its top the location and orientation in the structure. Securely bolt, strap, or otherwise fasten the bearings to prevent any relative movement.

Package bearings so they are protected from damage due to shipping, handling, weather, or other hazards. Do not dismantle bearing assemblies at the site except for inspection or installation.

Store all bearing devices and components at the work site in a location that provides protection from environmental and physical damage.

(d) Construction and installation. Clean the bearings of all deleterious substances. Install the bearings to the positions shown on the drawings. Set bearings and bearing components to the dimensions shown on the drawings or as prescribed by the manufacturer. Adjust according to the manufacturer's instructions to compensate for installation temperature and future movements of the bridge.

Set bridge bearings level at the exact elevation and position. Provide full and even bearing on all external bearing contact surfaces. If bearing surfaces are at improper elevations, not level, or if bearings cannot otherwise be set properly, notify the CO and submit a written proposal to modify the installation for approval.

Bed metallic bearing assemblies, not embedded in concrete, on concrete with an approved filler or fabric material.

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 surface upon which to place the bearing.

564.04 Elastomeric Bearings. The bearings include nonreinforced pads (consisting of elastomer only) and reinforced bearings with steel or fabric laminates.

Reinforce elastomeric bearings more than 1/2 inch thick with laminates every 1/2 inch through the entire thickness.

Fabricate elastomeric bearings according to AASHTO M 251. Use material that meets the flash tolerance, finish, and appearance requirements of the *Rubber Handbook* as published by the Rubber Manufacturer's Association Incorporated, RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings. Determine compliance with AASHTO M 251, level I acceptance criteria.

Mark each reinforced bearing with indelible ink or flexible paint. The marking information shall include the order number, lot number, bearing identification number, and elastomer type and grade number. Unless otherwise specified, mark on a face that is visible after erection of the bridge. Furnish a list of all individual bearing numbers.

Place bearings on a level surface. Correct any misalignment 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 ºF.

564.05 Rocker, Roller, and Sliding Bearings. When TFE coatings are required, use coatings conforming to Subsection 564.07.

Fabricate rocker, roller, and sliding bearings according to the details shown on the plans and to Section 555. Perform fabrication according to the standard practice in modern commercial shops. 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 finished machining.

Thoroughly coat all contact surfaces with oil and graphite just before placing roller bearings. Install rocker, roller, and sliding bearings so they are vertical at the specified mean temperature after release of falsework and after any shortening due to prestressing forces. Take into account any variation from mean temperature of the supported span at time of installation and any other anticipated changes in length of the supported span.

Make sure the superstructure has full and free movement at movable bearings. Carefully position cylindrical bearings so that their axes of rotation align and coincide with the axis of rotation of the superstructure.

564.06 Masonry, Sole, and Shim Plates for Bearings. Provide metal plates used in masonry, sole, and shim plates, conforming to AASHTO M 270, grade 36.

Fabricate and finish steel according to Section 555. Form holes in bearing plates by drilling, punching, or accurately controlled oxygen cutting. Remove all burrs by grinding.

Accurately set bearing plates in level position as shown on the drawings and provide a uniform bearing over the bearing contact area. When plates are embedded in concrete, make provision to keep them in correct position as the concrete is placed.

564.07 Tetrafluoroethylene (TFE) Surfaces for Bearings. Furnish TFE material that is factory-bonded, mechanically connected, or recessed into the backup material as shown on the plans.

Bond or mechanically attach the fabric containing TFE fibers to a rigid substrate. Use a fabric capable of carrying unit loads of 10,000 pounds per square inch without cold flow. Use a fabric-substrate bond capable of withstanding, without delamination, a shear force equal to 10 percent of the perpendicular or normal application loading plus any other bearing shear forces.

Determine compliance using approved test methods and procedures according to Section 18, Subsection 18.8.3, AASHTO *Standard Specifications for Highway Bridges* Division II, Volume II. If the test facility does not permit testing completed bearings, manufacture extra bearings and prepare samples of at least 100-kip capacity at normal working stresses.

Determine static and dynamic coefficient of friction at first movement of the test bearing at a sliding speed of less than 1 inch per minute. The coefficient of friction shall not exceed the coefficient of friction as specified in Table 564-1 or by the manufacturer.

Furnish a listing of all individual bearing numbers.

Table 564-1
Coefficient of Friction

Material	Bearing Pressure (pounds per square inch)	Friction Coefficient
Unfilled TFE, fabric containing TFE fibers, or TFE-perforated metal composite	500	0.08
	2,000	0.06
	3,500	0.04
Filled TFE	500	0.12
	2,000	0.10
	3,500	0.08
Interlocked bronze and filled TFE structures	500	0.10
	2,000	0.07
	3,500	0.05

564.08 Anchor Bolts. Furnish swedge or thread anchor bolts conforming to ASTM A 307 or as shown on the plans or specified in the contract.

Preset anchor bolts before placement of the concrete or install anchor bolts in drilled holes after placement of the concrete. If installed after concrete placement, secure the bolts in the drilled holes with non-shrink cement grout or an approved chemical adhesive. If non-shrink cement grout is used, drill holes 1 inch in diameter greater than the bolt. If chemical adhesives are used, follow adhesive manufacturer's recommendations for hole-diameter.

Adjust bolt locations for superstructure temperature as required. Do not restrict free movement of the superstructure at movable bearings by anchor bolts or nuts.

564.09 Bedding of Masonry Plates. Place filler or fabric as bedding material under masonry plates if required by the contract. Use the type of filler or fabric specified and install to provide full bearing on contact areas. Thoroughly clean the contact surfaces of the concrete and steel immediately before placing the bedding material and installing bearings or masonry plates. If bedding materials are not specified, comply with AASHTO 18.4.10 as directed by the CO.

564.10 Acceptance. Bearing devices will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification with each shipment of bearing devices.

Bearing device installation will be evaluated under Subsections 106.02 and 106.04.

Measurement

564.11 Measure the Section 564 items listed in the bid schedule according to Subsection 109.02.

Payment

564.12 The accepted quantities will be paid at the contract price per unit of measurement for the Section 564 pay item 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 constructing drilled shafts.

Material

565.02 Conform to the following Section and Subsections:

Casings	717.01(a)
Neat cement grout	725.22(f)
Mineral slurry	725.26
Reinforcing steel	709.01
Structural concrete	552

Construction Requirements

565.03 Qualifications and Submittals. Submit the following for acceptance at least 30 days before constructing drilled shafts. Acceptance of the Contractor's personnel, installation plan, and trial shafts does not relieve the Contractor of the responsibility for obtaining the required results in the completed work.

(a) Personnel

(1) Construction personnel. Use personnel with at least 3 years experience in the construction of drilled shafts. Provide resumes of job experience, project description, the owning agency's name and current phone number, and the Contractor's name and current phone number that the individual worked for while constructing the drilled shafts.

(2) Testing personnel. Use an engineer with at least two years experience with the nondestructive crosshole sonic logging method for concrete drilled shafts to perform field-testing and interpretation of the recorded measurements. Provide a resume of job experience, project description, owning agency's name and current phone number. Provide experienced labor support as needed to adequately perform the required tests.

(b) Installation Plan. Furnish the following:

(1) A description, including capacities, of the proposed equipment to be used including cranes, drills, drilling unit, augers, bailing buckets, and final cleaning equipment. Include an explanation of why the equipment was selected and a description of the equipment's suitability to the anticipated site and subsurface conditions. Include a project history of the drilling equipment that demonstrates its successful use on shafts of equal or greater size in similar subsurface conditions.

(2) Demonstrate an understanding of the subsurface conditions at the site. Reference the available subsurface data provided in the contract test hole boring logs and in the geotechnical report prepared for this project.

(3) Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.

(4) Details of shaft excavation methods including proposed drilling methods; methods for removing materials from the shafts; procedures for maintaining correct horizontal and vertical alignment of the excavation; and a disposal plan for excavated material.

(5) When a mineral slurry is required, details of the methods to mix, circulate, use, maintain, and dispose of the slurry. Provide a detailed slurry mix design and discuss its suitability to the subsurface conditions.

(6) Details of methods used to ensure shaft stability during excavation and concrete placement. Include a review of the method's suitability to the anticipated site and subsurface conditions. If casings are proposed or required, provide casing dimensions and detailed procedures for permanent casing installation and temporary casing installation and removal.

(7) Details of reinforcement placement including bracing, centering, centralizers, and lifting and support methods.

(8) Details of concrete placement including proposed operational procedures for free fall, tremie, or pumping methods.

(9) The method used to form an emergency horizontal construction joint during concrete placement.

565.04 Trial Drilled Shafts. When trial drilled shafts are required by the contract, perform the work according to the applicable requirements of Subsection 565.05 and the following.

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 3 shaft diameters or 2 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 on the plans. When bells are specified for production shafts, include a bell in the final shaft to verify the feasibility of belling in the specified bearing stratum.

If material caves into the drilled hole or the hole deforms excessively, case the hole. When casings are used, seat the casing as necessary to prevent caving and to allow dewatering of the hole. Remove all material inside the hole. Keep the casing in place a minimum of 4 hours while attempting to remove all 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.

If the trial drilled shaft is determined to be unsatisfactory, modify the methods and equipment. Submit a new installation plan and drill a new trial drilled shaft at the Contractors' expense.

Once approval is given to construct the production drilled shafts, no changes are permitted in the installation plan without prior approval.

565.05 Drilled Shafts.

(a) Excavation. Do not excavate additional shafts, allow excessive wheel loads, or allow excessive vibrations within 15 feet or 3 shaft diameters, whichever is greater, of a newly constructed shaft for at least 20 hours. Excavate for structure footings supported on drilled shafts and construct fills before drilling. Position the drilled shaft within 3 inches of the required position in a horizontal plane at the top of shaft elevation.

Excavate holes according to the accepted installation plan. Do not allow the alignment of a vertical shaft to vary from the required alignment by more than 1/4 inch per foot of depth. Do not allow the alignment of a battered shaft to vary by more than 1/2 inch per foot of depth from the required batter alignment.

Provide equipment with the capability to excavate shafts 20 percent longer than and the same diameter as those shown on the plans.

Maintain a log of material excavated from the drilled shaft that includes the following information:

- 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.
- Elevation and approximate rate of any seepage or groundwater encountered.

- Equipment used, time required to drill shaft, bit changes, breakdowns, and all other difficulties encountered.
- Remarks.

When it is determined that the hole sidewall has softened due to excavation methods, swelled due to delays in concreting, or degraded because of slurry cake buildup, overream sidewall a minimum of 1/2 inch or a maximum of 3 inches to sound material.

At the time of concrete placement, clean the hole so no more than 50 percent of the bottom of each hole has more than 1/2 inch of sediment and the maximum depth of sediment at any place on the bottom of the hole does not exceed 1½ inches. For dry holes, reduce the depth of water to 3 inches or less before placing concrete.

(1) Dry method. Use the dry construction method at sites where the groundwater level and soil conditions are suitable to permit construction of the shaft in a relatively dry excavation and where the sides and bottom of the shaft may be visually inspected before placing concrete. The dry method consists of drilling the shaft, removing accumulated water, removing loose material from the excavation, placing the reinforcing cage, and concreting the shaft in a relatively dry excavation.

The dry construction method can only be used when the trial shaft excavation demonstrates all the following:

(a) Less than 12 inches of water accumulates above the base of the hole during a 1-hour period when no pumping is permitted;

(b) The sides and bottom of the hole remain stable without detrimental caving, sloughing, or swelling over a 4-hour period immediately following completion of excavation; and

(c) Loose material and water can be satisfactorily removed before inspection and before concrete placement.

(2) Wet method. Use the wet construction method or the casing construction method for shafts that do not meet the above requirements for the dry construction method. This method consists of using water or mineral slurry to maintain stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft.

The wet method involves the following work:

(a) Desanding and cleaning the slurry;

(b) Final cleaning of the excavation using a bailing bucket, air lift, submersible pump, or other approved devices;

(c) Placing the shaft concrete with a tremie or concrete pump beginning at the shaft bottom;

(d) Providing, as needed, temporary surface casings to aid shaft alignment and positioning; and

(e) Providing temporary surface casings to prevent sloughing of the top of the shaft excavation unless it can be satisfactorily demonstrated that the surface casing is not required.

Where drilled shafts are located in open water areas, extend exterior casings from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. Install the exterior casing in a manner that will produce a positive seal at the bottom of the casing to prevent piping of water or entry of other material from the shaft excavation.

(b) Mineral slurry. Premix the mineral slurry with clean fresh water according to the mineral 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 mineral component directly into the shaft excavation.

Provide desanding equipment to limit slurry sand content to less than 4 percent by volume at any point in bore hole. Desanding is not required for setting temporary casings, sign posts, or lighting mast foundations.

During drilling, maintain slurry surface in the shaft at least 4 feet above the highest expected adjacent piezometric water pressure head and at a level sufficient to prevent caving of the hole.

When there is a sudden significant loss of slurry from the hole, stop drilling and take corrective measures to prevent slurry loss. Prevent the slurry from setting up in the shaft. If at any time the slurry construction method fails to produce the desired final results, discontinue and use an approved alternative method.

Maintain density, viscosity, and pH of the mineral slurry during shaft excavation and until concrete placement within the acceptable ranges shown in Table 565-1. 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 first 8 hours of slurry use. When results are acceptable and consistent, the testing frequency may be decreased to one test set for every 4 hours of slurry use.

Table 565-1
Acceptable Range of Values for Mineral Slurry

Property	At Time of Slurry Introduction	In Hole at Time of Test Concreting	Method
Density, pounds per cubic foot	64.3 – 69.1	64.3 – 75.0	Density balance
Viscosity, seconds per quart	28 – 45	28 – 45	Marsh cone
pH	8 – 11	8 – 11	pH paper or meter

Note: 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. If desanding is required, sand content shall not exceed 4 percent by volume at any point in the bore hole according to the American Petroleum Institute sand content test.

When a slurry sample is unacceptable, make necessary corrections to bring the slurry within specifications. Do not place concrete until the results of the resampling and retesting indicate acceptable values.

Dispose of slurry in an environmentally acceptable manner at an approved location.

(c) Casings. Use smooth, clean, watertight, steel casings of sufficient strength to withstand handling and installation stresses and the concrete and surrounding earth pressures. All casing diameters shown on the plans are outside diameters.

The diameter of a permanent casing is subject to American Pipe Institute tolerances applicable to regular steel pipe. Make the outside diameter of the casing no less than the specified size of the shaft.

Install casings to produce a positive seal at the bottom that prevents piping of water or other material into or out of the hole. If it becomes necessary to remove a casing and substitute a longer or larger diameter casing through caving soils, stabilize the excavation with slurry or backfill before the new casing is installed. Other approved methods may be used to control the stability of the excavation and protect the integrity of the foundation soils.

All subsurface casings are to be considered temporary unless designated in the contract as permanent casing. Remove temporary casing before completing placement of concrete in any shaft excavation requiring casing. During casing extraction, maintain a level of fresh concrete in the casing that is a minimum of 5 feet above the surrounding level of water or drilling fluid. Exercise care during casing removal to maintain an adequate level of 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; and

(3) Providing a replacement shaft.

When a casing is designated as permanent, cut the casing off at the required elevation and leave in place.

565.06 Reinforcing Steel for Drilled Shafts and Placement of Crosshole Sonic Logging Access Tubes. Perform the 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 not to exceed 10 feet along the length of the cage. Use spacers of approved material at least equal in quality and durability to the shaft concrete.

Provide standard weight black steel pipe per ASTM A 53 with nominal inside diameter of 2 inches for crosshole sonic logging access tubes. Install the access tubes for each drilled shaft as shown in FLH T 521. Use pipes and pipe joints that have a round, regular internal diameter, free of defects or obstructions, and that will result in watertight access tubes that permit the free, unobstructed passage of source and receiver probes. Use access tubes that are free of corrosion, that have clean internal and external faces to ensure probe passage, and that have a good bond between the concrete and tubes. Do not use duct tape or similar materials to seal joints. Do not use stiffening devices such as mandrels in the access tubes during concrete placement. Fit the access tubes with a water-tight shoe on the bottom and a removable cap on top.

Secure tubes firmly to the interior of the reinforcement cage. Install the tubes in a regular, symmetric pattern according to FLH T 521 such that each tube is spaced the maximum possible distance from each adjacent tube. Tubes shall be as near to parallel as possible. The tubes shall be installed from 1/2 foot above the shaft bottoms to at least 10 feet above the shaft tops, and at least 2 feet above the ground surface. Do not bend or damage the tubes during reinforcement installation operations.

Inspect the shaft by drilling test hole, standard penetration test, or visual inspection. Place the reinforcing steel cage as a unit immediately after the shaft excavation is inspected and accepted and before concrete placement. If the concrete is not placed immediately after the cage is installed, the cage may have to be removed before placing the concrete to verify the integrity of the excavated area and to ensure loose material is removed from the bottom of the hole. Handle reinforcing cages to avoid distortion or racking of the steel.

During concrete placement, provide positive support from the top for the reinforcing steel cage. Maintain the top of the reinforcing steel cage no more than 6 inches above and no more than 3 inches below the required position. If the reinforcing steel cage is not maintained within tolerances, make acceptable corrections and do not construct additional shafts until the method of reinforcing steel cage support has been approved.

565.07 Concrete for Drilled Shafts. When the top of shaft is above ground, use a removable form or other approved means to form the shaft to at least 2 feet below finished ground. Forms may be removed provided the requirements in Subsection 562.08 are complied with and 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 effected by underwater placement.

Place concrete immediately after all excavation is complete and the reinforcing steel cage is in place.

Fill the crosshole sonic logging access tubes with clean water within 1 hour after concrete placement and replace the tube cap. Do not apply excess torque, hammering, or other stress to the access tubes at any time that could affect the concrete-tube bond.

Prepare ten 6-inch by 12-inch concrete cylinders for pulse velocity testing from the same concrete mix used in the drilled shaft.

Furnish concrete conforming to Section 552 except as otherwise indicated herein. For shafts constructed without drilling fluid, use class A structural concrete having a slump of 7 ± 1 inches. For shafts constructed with drilling fluid, use class A structural concrete having a slump of 8 ± 1 inches. Use seal concrete for under water placement. Do not use seal concrete above the freeze/thaw or wet/dry zone of the hole. Place underwater concrete according to Subsection 552.11(e) except as modified herein. The method of underwater placement is subject to approval.

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 permitted 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. Before initial concrete set, consolidate the top 10 feet of the shaft concrete using acceptable vibratory equipment. Finish the top of the shaft to +1 inch or -3 inches from the required elevation. For wet holes, do not consolidate until all water or slurry above the concrete surface has been removed. Place concrete either by free fall, tremie, or concrete pump.

(a) Free-fall concrete placement. Use free-fall placement only in dry holes with an 25-foot maximum height of free-fall. The concrete shall fall directly to the shaft base without contacting either the rebar cage or hole 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. Place concrete through a hopper at the top of the tube or through side openings as the drop chute is removed from the shaft during concrete placement. 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. If concrete placement causes the shaft excavation to cave or slough or if the concrete strikes the rebar cage or sidewall, reduce the height of free-fall and reduce the rate of concrete flow into the excavation. If placement cannot be satisfactorily accomplished by free-fall, use tremie or pumping to place the concrete.

(b) Tremies. Use tremies for concrete placement in either wet or dry holes. A tremie consists of a 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. Make the tremie inside diameter at least 6 times the maximum size of aggregate used in the concrete mix and not less than 10 inches. Make the inside and outside surfaces of the tremie clean and smooth. Make the wall thick enough to prevent crimping or sharp bends.

Use a watertight tremie in accordance with Subsection 552.11(e) for wet holes. Construct the discharge end of the tremie to permit 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 5 feet below the surface of the fluid concrete. Maintain a positive head of concrete in the tremie at all times. If at any time during the concrete placement, 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 any necessary sidewall removal as directed, and reconstruct the shaft.

(c) Pumped concrete. Use pumped concrete placement in either wet or dry holes. Use 4-inch minimum diameter discharge tubes with watertight joints. Place the discharge tube at the shaft base elevation.

Use a sealed discharge tube according to Subsection 552.11(e) 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 pump discharge tube immersed at least 5 feet below the surface of the fluid concrete. If at any time during the concrete placement, the discharge tube 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 any necessary sidewall removal as directed by the CO, and reconstruct the shaft.

565.08 Integrity Testing.

(a) Testing. Perform integrity testing on all production drilled shafts using FLH T 521, Standard Method for Determining Pulse Velocity Through Concrete in Drilled Shafts. Test drilled shafts no earlier than 2 days and no later than 45 days after concrete placement. Before testing, provide precise information as to drilled shaft bottom and tip elevations, access tube lengths, surveyed tube positions, and date of concrete placement.

Provide portable crosshole sonic logging testing equipment according to FLH T 521 and provide the following:

(1) An ultrasonic source probe and one or more receiver probes able to descend freely through a 2-inch inside diameter steel, water-filled access tube.

(2) Capability to amplify/filter data and print ultrasonic logs on site.

(3) An independent stable 110-volt, 60-hertz, alternating current power supply if needed.

If access tubes are not acceptable for testing (e.g., tubes are not plumb, tube does not retain water, tube-concrete debonding has occurred, tube obstructions exist), provide replacement access tubes by core drilling or propose an alternative test method that is acceptable to the CO. After integrity testing, inspection and data analysis are completed and accepted by the CO, fill access tubes with approved neat cement slurry or grout from the bottom using a tremie.

Perform pulse velocity testing along the diametric axis of the concrete cylinders according to ASTM C 597, Standard Test Method for Pulse Velocity Through Concrete. Perform pulse velocity testing on two concrete cylinders for each of the following cure times: 2 days, 7 days, 14 days, 21 days, and 28 days. After testing, break the two cylinders according to AASHTO T 22. Report test results and prepare a graph of pulse velocity and compressive strength versus times. Crosshole sonic logging test results will be compared to pulse velocity results of the same concrete age.

(b) Test results and reporting. Provide preliminary results to the CO for each shaft tested before crosshole sonic logging personnel leave the site. Within 5 days of testing, submit a detailed crosshole sonic logging report and all test data in ASCII format with a header (identifying shaft tested, tube coordinates, and each data column) to the CO on a compact disk. Allow 5 days for the CO to conduct a review of the data before any further construction on the tested shaft and before issuing the final, written report.

Include the following in the crosshole sonic logging report: (1) project identification and dates of testing; (2) table and a schematic showing shafts tested with identification of tube coordinates and collar elevation; (3) names of personnel that performed the tests/interpretation and their affiliation; (4) equipment used; (5) data logs; (6) XY plots of first arrival times, amplitude, and velocity versus depth; and (7) interpretation, analysis, and results. Determine the velocity reduction by comparing the velocities achieved in the drilled shaft to the pulse velocity testing on the cylinders constructed from the same concrete and of the same age as the drilled shaft.

Where velocity reductions are greater than 20 percent, process the data and construct easy-to-understand two-dimensional cross-sections between tubes and three-dimensional volumetric images for the entire shaft. The cross-sections shall be color-coded tomographic images indications velocity variations along the shaft. Identify the location and geometry of defective zones (those with velocity reductions of greater than 20 percent) in three-dimensional color images and provide a detailed discussion of each.

565.09 Acceptance. Material for mineral slurry will be evaluated under Subsections 106.02 and 106.03.

Concrete will be evaluated under Section 552. Concrete, tremie placed or pumped, will be sampled at point of discharge into the tremie or concrete pump hopper.

Reinforcing steel will be evaluated under Section 554.

Construction of drilled shafts will be evaluated under Subsections 106.02, 106.03, and 106.04 as follows:

(a) Drilled shafts with velocity reductions not exceeding 20 percent are acceptable.

(b) Where velocity reductions exceed 20 percent, furnish additional imaging and other data required in Subsection 565.08(b) to enable further evaluation of the shaft. When required by the CO, drill a minimum of two cores to intercept the imaged defect and obtain core samples from these suspect area. The CO will evaluate the cross-hole sonic logging data, the imaging data, and the core data and make a determination as to the presence of substantive defects.

If a shaft is determined to have substantive defects, submit a plan according to Subsection 106.01 to remove and replace, correct, or modify the work. Proposed modifications to the drilled shaft or load transfer mechanisms shall be designed and stamped by a professional engineer. Include drawings stamped by a professional engineer for all foundation elements affected. Do not begin remedial work until the CO has approved the plan.

Measurement

565.10 Measure the Section 565 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure drilled shafts from the plan top elevation to the approved tip. Do not measure portions of shafts extending deeper than approved.

Do not measure concrete or reinforcing steel.

Measure trial drilled shafts, determined to be satisfactory, from the approved tip elevation to the ground surface at the center of the shaft.

Payment

565.11 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 unit bid 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 unit bid price by the compressive strength pay factor.

Section 566. — SHOTCRETE

Description

566.01 This work consists of constructing one or more courses of shotcrete on a prepared surface.

Shotcrete aggregate grading is designated as shown in Table 703-15.

Material

566.02 Conform to the following Subsections:

Air-entraining admixture (wet mix only)	711.02
Chemical admixtures (wet mix only)	711.03
Concrete coloring agents	711.05
Curing material	711.01
Hydraulic cement	701.01
Penetrating stain	708.05
Pozzolans	725.04
Reinforcing fibers	725.29
Reinforcing steel	709.01
Shotcrete aggregate	703.18
Water	725.01(a)

Construction Requirements

566.03 Composition (Shotcrete Mix Design). Design and produce shotcrete mixtures that conform to Table 566-1. Shotcrete mixtures shall also conform to the following ACI specifications.

- ACI 506R Guide to Shotcrete;
- ACI 506.1 State of the Art Report on Fiber Reinforced Shotcrete; and
- ACI 506.2 Specifications for Proportioning Application of Shotcrete.

Verify mix design with trial mixes prepared from the same source proposed for use. Submit the following for acceptance at least 36 days before placing shotcrete:

(a) Proposed shotcrete mix design with mix proportions. Include the dosage and type of any admixture with proposed mix design.

Table 566-1
Composition of Shotcrete

Type of Shotcrete Process	Minimum Cement Content (pounds per cubic yard)	Maximum W/C Ratio	Air Content Range %	Minimum 28-Day Strength (pounds per square inch)
Wet	546	0.55	NA	4000
Dry	546	0.50	NA	4000
Wet (AE)	546	0.45	5 min.	4000
Dry (AE)	546	0.45	5 min.	4000

(b) Representative samples of shotcrete material, if requested by the CO. Results of shotcrete preconstruction testing.

(c) Proposed method for applying shotcrete.

(d) Other information necessary to verify compliance with ACI 506.2.

(e) Shotcrete materials certifications.

(f) Fiber samples, if used.

(g) Description of proposed equipment for mixing and applying shotcrete. Include the manufacturer's instructions, recommendations, literature, performance, and test data. In addition to meeting equipment requirements in ACI 506, provide the following:

(1) Water supply system. For dry mix, provide a job site water storage tank. Provide a positive displacement pump with a regulating valve that is accurately controlled to provide water at the required pressure and volume.

(2) Mixing. Use equipment capable of handling and applying shotcrete containing the specified maximum size aggregate and admixtures. Provide an air hose and blow pipe to clear dust and rebound during shotcrete application.

(h) Qualifications. Demonstrate satisfactory completion of at least 3 comparable projects. Provide Foremen experienced in shotcrete construction on at least 5 comparable projects. At least 30 days before starting shotcrete work, identify foremen and nozzlemen assigned to the project and submit a summary of each individual's experience.

566.04 Hydration Stabilizing Admixtures. When hydration stabilizing admixtures are used to extend the allowable delivery time for shotcrete, include the admixtures in the shotcrete mix design. Base dosage on the time needed to delay the initial set of the shotcrete for delivery and discharge on the job. Include the design discharge time limit in the dosage submittal. The maximum allowable design discharge time is 3.5 hours.

Use an approved and compatible hydration activator at the discharge site to ensure proper placement and testing.

Determine dosage required to stabilize shotcrete using job site material and field trial mixtures. The extended-set admixture shall control the hydration of all cement minerals and gypsum.

When requested, the admixture manufacturer shall provide the service of a qualified person to assist in establishing the proper dose of extended-set admixture and to make dosage adjustments required to meet changing job site conditions.

566.05 Preconstruction Testing. Conduct preconstruction shotcrete field trials before starting shotcrete production.

(a) Field trials. Construct test panels from 24-inch by 24-inch by 6 inches wood forms. Have each proposed nozzleman produce shotcrete panels on two vertical wood forms. Cure the test panels according to AASHTO T 23 except do not immerse the panels.

(b) Coring. Take six 3-inch diameter cores from each test panel according to AASHTO T 24. Trim the ends of the cores according to AASHTO T 24 to make cores at least 3 inches long.

(c) Compressive strength testing. Soak the cores in water for 40 hours immediately before testing. Test three cores from each test panel four days after the field trial and test the remaining three cores 28 days after the field trial. Perform tests according to AASHTO T 23.

(d) Mix design acceptance. Submit the test data and a visual description of each core to the CO. Include details concerning presence of voids, sand pockets, lamination, and other inadequacies. Acceptance of the nozzlemen and mix design will be based on preconstruction field trials and test results. The visual quality of the cores shall not be lower than grade 2 according to shotcrete grading requirements of ACI 506.2.

Submit field quality control test reports within two working days of performing the tests. Include the following information in the reports:

- Sample identification including mix design and test panel number and orientation;
- Date and time of sample preparation including curing conditions and sample dimensions;
- Date, time, and type of test;
- Complete test results including load and deformation data during testing, sketch of sample before and after testing, and any unusual occurrences observed;

- Name and signature of person performing the test;
- Location of steel reinforcement, if used, covered by shotcrete; and
- Name of nozzleman.

566.06 Shotcrete Construction. Apply shotcrete according to ACI 506R and the following.

(a) Surface preparation. Remove curing compound on previously-placed shotcrete surfaces by sandblasting. Install approved depth gauges to indicate the thickness of the shotcrete layers. Install depth gauges on 6-foot centers longitudinally and transversely with no less than two gauges per increment of surface area to receive the shotcrete. Moisten all surfaces.

(b) Temperature and Weather Conditions. Maintain the temperature of the shotcrete mix between 50 °F and 90 °F. Place shotcrete when the surface and ambient temperature is at least 40 °F and rising. Do not perform shotcrete operations during high winds and heavy rains.

(c) Shotcrete application. Use the same nozzlemen that created acceptable test panels.

(1) Apply shotcrete within 45 minutes of adding cement to the mixture.

(2) Limit the layer thickness of each shotcrete application to 2 inches. Thicker applications may be approved if the Contractor can demonstrate that no sloughing or sagging is occurring. If additional thickness is required, broom or scarify the applied surface and allow the layer to harden. Dampen the surface before applying an additional layer.

(3) Remove laitance, loose material, and rebound. Promptly remove rebound from the work area.

(4) 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.

(5) Finish shotcrete as specified.

566.07 Curing Shotcrete. Cure the surface according to Subsection 552.15. For intermediate shotcrete surfaces or if a stained or finished final surface is required, cure the shotcrete according to Subsection 552.15(b). If no stained or finished surface is required, apply curing compound to the final exposed shotcrete surface according to Subsection 552.15(c). Maintain shotcrete at a temperature above 40 °F until shotcrete has achieved a minimum compressive strength of 750 pounds per square inch.

566.08 Production Report. Prepare and submit a written report within 24 hours of shotcrete production and application for each shift. Include the following information in the report:

(a) Quantity and location of shotcrete applied including sketches of areas where shotcrete was placed.

(b) Observations of success or problems of equipment operation, application, final product condition, and any other relevant issues during production and application.

(c) Batch number(s) if applicable.

(d) Name of nozzleman.

(e) Names and signature of person performing the observation.

566.09 Acceptance. See Table 566-2 for sampling and testing requirements and the acceptance quality characteristic category.

Material for shotcrete will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification for the hydraulic cement.

The shotcrete placement system will be evaluated under Subsections 106.02 and 106.04.

The shotcrete mixtures air content and unit mass will be evaluated under Subsections 106.02 and 106.04. Compressive strength will be evaluated under Subsection 106.05. See Table 566-1 for specification limits.

Measurement

566.10 Measure the Section 566 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure shotcrete by the cubic yard in place.

Payment

566.11 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 unit bid 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 unit bid price by the compressive strength pay factor.

Table 566-2
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods or Specifications	Sample Frequency	Point of Sampling	Split Sample	Reporting Time
Aggregate source quality (703.18)	Measured and tested for conformance (106.04 & 105)	Quality	—	AASHTO M 80	1 per material type	Source of material	Yes	Before producing
Shotcrete composition (mix design)	Measured and tested for conformance (106.04)	All	—	Subsection 566.03	1 per mix design	Source of material	Yes	Before producing
Production aggregate (fine & course)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per material type	Flowing aggregate stream (bin, belt, discharge conveyor belt, or stockpile)	Yes, when requested	Before batching
		Fineness modulus	—	"	—	"	"	"
Shotcrete	Measured and tested for conformance (106.04)	Unit mass	—	AASHTO T 121	1 per load [1]	Truck mixer or agitator[2]	—	Upon completing tests
		Air content	—	AASHTO T 152 or T 196	"	"	—	"
	Statistical (106.05)	Compressive strength	II	AASHTO T 24	1 set per 30 yd^3 but not less than 1 per day	Production test panels	Note 4	Note 3

(1) See Subsection 552.09(b)(3).

(2) Sample according to AASHTO T 141.

(3) Prepare production test panels according to Subsection 566.07(a). Obtain two 3-inch diameter core specimens from each panel according to AASHTO T 24. A single compressive strength test result is the average result from two 3-inch diameter core specimens from the same test panel tested according to AASHTO T 23 at 28 days.

(4) Deliver cores to designated laboratory for testing.

DIVISION 600

INCIDENTAL CONSTRUCTION

Section 601. — MINOR CONCRETE STRUCTURES

Description

601.01 This work consists of constructing minor concrete structures.

Material

601.02 Conform to the following Subsections:

Air-entraining admixtures	711.02
Chemical admixtures	711.03
Coarse aggregate	703.02
Concrete coloring agents	711.05
Curing material	711.01
Fine aggregate	703.01
Fly ash	725.04
Hydraulic cement	701.01
Joint fillers	712.01
Precast concrete curbing	725.06
Precast concrete units	725.11
Reinforcing steel	709.01
Structural steel	717.01
Water	725.01

601.03 Concrete Composition. Conform to Table 601-1. Before batching concrete, submit the proposed concrete proportions for approval on Form FHWA 1606 *Minor Concrete Mix Design Trial Batch Summary* or other approved form. As a minimum, submit the following:

(a) Type and source(s) of all material proposed for use.

(b) Material certification for all material proposed for use.

(c) Saturated surface dry mass of the fine and coarse aggregate per cubic yard of concrete.

(d) Gradation of fine and coarse aggregate.

(e) Mass of mixing water per cubic yard of concrete.

(f) Mass of cement per cubic yard of concrete. Fly ash, ground iron blast-furnace slag, or silica fume may be substituted for cement according to Subsection 552.03(g).

(g) Entrained air content of plastic concrete in percent by volume.

(h) Maximum slump of plastic concrete in inches.

(i) When colored concrete is required, submit preliminary samples of the colored concrete. Prepare a 3-foot by 3-foot by 4-inch panel for each acceptable mix that is to be colored. Finish and cure the panels in the same manner as the concrete will be finished and cured on the project.

Table 601-1
Composition of Minor Structure Concrete

Property	Specification
Cement content	611 pounds per cubic yard minimum
Water/cement ratio	0.49 maximum
Slump	5 inches maximum
Air content	4 % minimum
Size of coarse aggregate	AASHTO M 43 with 100% passing the 1½-inch sieve
28-day compressive strength	3,000 pounds per square inch minimum

Construction Requirements

601.04 General. Excavate and backfill according to Section 209. When concrete is cracked, spalling, or scaling, remove concrete to the nearest joint.

Design and construct forms that are free of bulge and warp and allow for removal without injuring the concrete. When concrete contains a retarding admixture, fly ash, or other pozzolan replacement for cement, 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 552.10. Moisten the forms and foundation immediately before placing concrete. Discharge concrete within the time limit shown in Table 552-4.

Place concrete to avoid segregation of material. Consolidate with vibrators according to Subsection 552.11(d). Do not use aluminum pipe for transporting or placing concrete. The intervals between deliveries of batches for a single pour on a structure shall not exceed 30 minutes.

Do not apply water to plastic concrete surfaces during finishing operations.

601.06 Curing Concrete. Cure concrete a minimum of 7 days. If high early strength cement is used, cure concrete a minimum of 3 days. Cure according to Subsection 552.15. Finish exposed concrete surfaces according to Subsection 552.16(a) or (b), as applicable.

601.07 Acceptance. See Table 601-2 for sampling and testing requirements.

Material for minor concrete structures including reinforcing steel, and structural steel for minor structures will be evaluated under Subsections 106.02 and 106.03.

The concrete mixture's slump, air content, compressive strength, unit mass, and temperature will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Construction of minor concrete structures will be evaluated under Subsections 106.02 and 106.04.

Measurement

601.08 Measure the Section 601 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure concrete by the cubic yard 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.

The concrete lump sum item will be prorated based on the progress of the work under this Section.

Table 601-2
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Concrete	Measured and tested for conformance (106.04)	Unit mass	—	AASHTO T 121	1 set per 30 yd^3 but not less than 1 per day	Point of discharge	—	Upon completing tests
		Air content	—	AASHTO T 152 or T 196	“	“	—	“
		Slump	—	AASHTO T 119	“	“	—	“
		Temperature	—	Field measured	“	“	—	“
		Compressive strength	—	AASHTO T 23 & T 22	“	Discharge stream at point of placing	—	“

Section 602. — CULVERTS AND DRAINS

Description

602.01 This work consists of constructing culverts, drains, and precast concrete box culverts.

Material

602.02 Conform to the following Section and Subsections:

Aluminum-alloy corrugated pipe	707.03
Aluminum-alloy spiral rib pipe	707.12
Asphalt-coated pipe	707.04
Asphalt mastic	702.07
Concrete-lined corrugated steel pipe	707.13
Fiber-bonded asphalt coated steel pipe	707.09
Invert-paved corrugated steel pipe	707.14
Joint fillers, sealants, and preformed joint seals	712.01
Joint mortar	712.02
Metallic-coated corrugated steel pipe	707.02
Metallic-coated spiral rib pipe	707.11
Non-reinforced concrete pipe	706.01
Plastic pipe	706.08
Polymer-coated steel pipe	707.08
Precast reinforced concrete box sections	706.07
Reinforced arch-shaped concrete pipe	706.04
Reinforced concrete pipe	706.02
Reinforced D-load concrete pipe	706.06
Reinforced elliptically-shaped concrete pipe	706.05
Slotted drain pipe	707.10
Lean concrete backfill	614
Watertight gaskets	712.03

Construction Requirements

602.03 General. Furnish culvert pipe with a wall thickness not less than that shown on the plans or determined from the fill-height tables included in the plans. Use the same material and coating on all contiguous pipe sections and special sections such as elbows and branch connections. For culvert extensions, furnish the same material as the existing culvert.

The plans show the size, approximate location, and length of culverts. Determine final location, skew, length, elevations, and grade according to Subsection 152.03(g). Do not order culvert material until the CO has accepted the final structure size, length, and alignment.

Excavate and backfill according to Section 209.

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 all sections. Place circular pipe with elliptical reinforcement with the minor axis of the reinforcement in a vertical position. Construct the joints by 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 permits. Fill and seal joints with mortar inside and out. 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. Protect the joint ends from mud, silt, gravel, or other unwanted material. Lay the pipe sections with gaskets attached. Remove, clean, relubricate, and reseat gaskets disturbed or contaminated.

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.

602.05 Laying Metal Pipe. Lay pipe with outside laps of circumferential joints upgrade and longitudinal laps positioned other than in the invert. Place elongated pipes with major axis within 5 degrees of vertical.

Join pipe sections together with soil tight bell and spigot joints or coupling bands according to AASHTO M 36 or M 196. Limit the use of bell and spigot joints to slopes of 10 percent or less. Limit the use of coupling bands with projections (dimples) to attaching prefabricated flared end sections.

When 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 recommendation.

Provide soil-tight and spigot joints for plastic pipe culverts.

If plastic end sections are used, reinforce and stiffen them such that inward buckling during construction is less than 3/8 inch with a 100 pounds of force.

602.07 Laying Slotted Drain Pipe. Join the sections together with coupling bands. Cover the slots with roofing paper or other approved covering during backfilling and paving to keep material out of the pipe. Backfill with a lean concrete backfill.

602.08 Acceptance. Material for culverts, drains, and precast concrete box culverts furnished will be evaluated under Subsections 106.02 and 106.03.

Installation of culverts, drains and precast concrete box culverts will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Measurement

602.09 Measure the Section 602 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure pipe and box culverts by the linear foot 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 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. Furnish steel, aluminum alloy, asphalt coated steel, or asphalt-coated aluminum alloy structural plate structures.

Provide a copy of manufacturer's assembly instructions before assembly. The instructions shall show the position of each plate and assembly order.

Assemble the structural plates according to the manufacturer's instructions. Exercise care in the use of drift pins and pry bars to prevent damage to the structural plate and its coating. The plates shall 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 steel bolts on steel plates to a minimum of 100 foot·pounds and a maximum of 300 foot·pounds.

Torque steel bolts and aluminum bolts on 0.1-inch thick aluminum plates to a minimum of 90 foot·pounds and a maximum of 115 foot·pounds.

Torque steel bolts and aluminum bolts on 0.1-inch thick and heavier aluminum plates to a minimum of 90 foot·pounds and a maximum of 115 foot·pounds.

For long-span structures:

(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 suitable survey control on the structure to check structure movement.

(d) Check and control the deflection movements of the structure during the entire backfilling operation. Do not exceed the manufacturer's recommended limits.

(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 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 or adjusting manholes, inlets, catch basins, junction boxes, and spring boxes.

Material

604.02 Conform to the following Section and Subsections:

Concrete	601
Concrete brick	725.08
Concrete masonry blocks	725.09
Corrugated metal units	725.13
Frames, grates, covers, and ladder rungs	725.12
Grout	725.22
Joint fillers, sealants, and preformed joint seals	712.01
Joint mortar	712.02
Precast concrete units	725.11(a)
Reinforcing steel	709.01
Watertight gaskets	712.03

Construction Requirements

604.03 General. Excavate and backfill according to Section 209.

604.04 Concrete Construction. Construct concrete manholes, inlets, and catch basins according to Section 601. Concrete units may be cast-in-place or precast. Finish the surface according to Subsection 552.16(a) or (b) as applicable.

Where a pipe enters through an existing concrete wall, cut the concrete and steel reinforcement in a manner that does not loosen the reinforcement in the wall. Cut the steel reinforcement flush with the opening wall face. Grout all joints and openings cut in the wall.

Finish the channel flow line in manholes, inlets, and catch basins accurately to match the pipe flow line.

Assemble precast concrete manhole sections with flexible watertight gaskets or mastic joint fillers in the tongue and groove joints. If gaskets are used, handle the precast units carefully after the gasket has been attached to avoid damaging the gasket or contaminating the joint. Attain the proper alignment before the joints are forced home. Maintain partial support during the insertion of the tongue or spigot to minimize the unequal lateral pressure on the gasket and to maintain concentricity until the gasket is properly positioned. If mastic is used, apply mastic joint filler according to the manufacturer's recommendations.

Set metal frames in a full joint mortar bed.

Grout or use a preformed joint seal to make all joints and openings watertight. Finish mortar joints with a bead on the outside and a smooth finish on the inside.

Space ladder rungs uniformly on 12-inch centers and align vertically. Grout ladder rungs into precast concrete walls.

604.05 Masonry Block Construction. Construct concrete footings according to Section 601. Construct block masonry plumb. Stagger vertical joints and set block with the cells vertical. Dampen block to reduce the rate of absorption. Butter bearing members and vertical joints full of mortar. Bond block with mortar on all sides. Construct joints straight, level, plumb, flush, and 1/4 to 1/2 inch thick. Backfill the structure after the masonry block has cured according to Subsection 552.15 for 7 days.

604.06 Metal Construction. Fabricate metal drop inlets from the same material as adjoining metal pipes.

604.07 Grade Adjustment of Existing 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.

When 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 without reconstructing the walls or resetting the frame.

When catch basins and inlets are adjusted to grade and abut existing concrete construction, separate the castings from the adjacent concrete with a preformed expansion joint no less than 1/2 inch thick.

Clean each structure of all accumulated silt, debris, or foreign matter.

When an existing structure is abandoned, seal all pipes entering the structure with a tight fitting plug of concrete not less than 6 inches thick or water tight masonry not less than 8 inches thick. Fracture the base of concrete structure to prevent entrapment of water. Obliterate the top of the structure to an elevation at least 3 feet below finished grade and backfill according to Section 209.

604.08 Acceptance. Precast concrete units (including manholes, inlets, catch basins, junction boxes, and spring boxes) furnished will be evaluated under Subsections 106.02 and 106.03.

Material (except concrete) for cast-in-place concrete units (including manholes, inlets, catch basins, junction boxes, and spring boxes) will be evaluated under Subsections 106.02 and 106.03. Construction of cast-in-place concrete units will be evaluated under Subsections 106.02 and 106.04.

Concrete for cast-in-place units will be evaluated under Section 601.

Excavation and backfill will be evaluated under Section 209.

Installation and adjustment of concrete units (including manholes, inlets, catch basins, junction boxes, and spring boxes) will be evaluated under Subsections 106.02 and 106.04.

Measurement

604.09 Measure the Section 604 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure manholes from finished grade to the flow line surface of the manhole.

Measure metal frames and grates and removing and resetting metal frames and grates unless included as part of the original inlet, manhole, or catch basin construction.

Payment

604.10 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 furnishing and installing underdrains, sheet drains, and pavement edge drains.

Material

605.02 Conform to the following Subsections:

Aluminum-alloy corrugated pipe	707.03
Asphalt-coated pipe	707.04
Geocomposite drains	714.02
Geotextile type I	714.01
Granular backfill	703.03
Metallic coated corrugated steel pipe	707.02
Perforated concrete pipe	706.03
Plastic pipe	706.08
Sand	703.15
Structural backfill	704.04

Construction Requirements

605.03 General. Use the same material and coating on all contiguous drain sections, extensions, elbows, branch connections, and other special sections.

Drain material, size, and approximate location are shown on 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 or geocomposite is used, smooth the trench surfaces by removing all projections that may damage the geotextile or geocomposite. Replace geotextile or geocomposite damaged during installation. Make repairs to geocomposites according to the manufacturer's recommendations.

Do not permit soil or other foreign material to enter the drain systems. Plug the upgrade end of installations.

Furnish nonperforated pipe for outlet pipe. Install outlet pipe according to Section 602. Immediately place and secure a screen made of 17 gage diameter galvanized wire having approximately 1/2 by 1/2-inch mesh openings over the outlet ends of all exposed pipes and weep holes.

605.04 Placing Underdrain. Join pipe sections securely with coupling fittings or bands. Join polyvinyl chloride (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 as recommended by the manufacturer.

Backfill and compact all trenches within the limits of the roadbed according to Section 209 except use granular backfill material. Trenches for geocomposite underdrains within the limits of the roadbed may also be backfilled with clean sand and compacted.

When underdrain is placed in ditch lines, prevent infiltration of surface water by placing material conforming to AASHTO M 145, A-4, A-5, A-6, or A-7 in the top 12 inches of the trench.

(a) Standard underdrain. When geotextile is required, place the long dimension of the geotextile parallel to the centerline of the trench. Position the geotextile, without stretching, in contact with the trench surface. Overlap the joints a minimum of 24 inches with the upstream geotextile placed over the downstream geotextile.

Place collector pipe with the perforations facing downward.

Place granular 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 granular backfill material according to Section 209.

Fold the geotextile over the top of the granular backfill with a minimum overlap of 12 inches.

(b) Geocomposite underdrain. Extend the geotextile 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 layer of granular backfill between the geocomposite and the trench wall. Temporarily support the drain against the trench wall while backfilling.

When the trench is less than 18 inches wide, backfill the trench using clean sand. Backfilling and compacting in layers is not required. Compact the sand by vibrating, tamping with a mechanical tamper, or flooding with water.

When the trench is 18 inches wide or more, place granular backfill or clean sand to a height of 12 inches above the top of the collector pipe and compact. Place and compact the remainder of the granular backfill material or clean sand according to Section 209.

605.05 Placing Geocomposite Sheet Drain. Do not place sheet drain against a mortar course less than 4 days old.

When a geocomposite is used in conjunction with a waterproof membrane, install drainage panels compatible with the membrane using methods recommended by the membrane manufacturer. 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 a minimum of 3 inches in the direction of water flow. For vertical splices, overlap the geotextile 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 from the bottom of the drainage core around the collector pipe.

Backfill with structural backfill and compact according to Subsections 208.10 and 208.11.

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 layer of clean sand between the geocomposite and the trench wall. Temporarily support the drain against the trench wall while backfilling.

When the trench is less than 18 inches wide, backfill the trench using clean sand. Backfilling and compacting in layers is not required. Compact the sand by vibrating, tamping with a mechanical tamper, or flooding with water.

When the trench is 18 inches wide or more, place and compact granular backfill or clean sand according to Section 209.

605.07 Acceptance. See Table 605-1 for sampling and testing requirements.

Material (except granular backfill) for underdrains, sheet drains, and edge drains will be evaluated under Subsections 106.02 and 106.03.

Granular backfill will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Sections 208 and 209.

Geotextile will be evaluated under Section 207.

Outlet pipes will be evaluated under Section 602.

Installation of underdrains, sheet drains, and edge drains will be evaluated under Subsections 106.02 and 106.04.

Measurement

605.08 Measure the Section 605 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

When measurement is for a system, do not measure geotextiles, collector pipes, backfill, and outlet pipes that are part of the system.

Measure granular backfill and sand by the cubic yard 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Granular backfill	Measured and 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 furnishing and installing corrugated metal spillways.

Material

606.02 Conform to the following Section:

Culverts and drains	602

Construction Requirements

606.03 Placing Corrugated Metal Spillways. Spillway, inlet, outlet, and connector dimensions and proportions may vary to permit the use of manufacturer's standard jigs and templates.

Install spillway inlet assemblies as shown on the plans and consolidate the earth backfill by tamping.

Lay spillway outlet pipe according to Section 602. Anchor the spillway as shown on the plans.

606.04 Acceptance. Pipes, anchor assemblies, hardware, and other material furnished to fabricate metal spillways will be evaluated under Subsections 106.02 and 106.03.

Excavation and backfill will be evaluated under Section 209.

Construction of spillways will be evaluated under Subsections 106.02 and 106.04.

Measurement

606.05 Measure the Section 606 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure downdrain and outlet pipes under Section 602.

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, RECONDITIONING, AND REPAIRING EXISTING DRAINAGE STRUCTURES

Description

607.01 This work consists of cleaning, reconditioning, and repairing existing culverts and appurtenant structures.

Construction Requirements

607.02 General. Dispose of material according to Subsection 203.05.

607.03 Removing and Cleaning Culverts. Carefully remove the culvert and clean all foreign material from within the barrel and at the jointed ends.

607.04 Cleaning Culverts in Place. Remove and dispose of all foreign material within the barrel and appurtenances of the culvert by any method that does not damage the culvert.

All or part of a culvert designated to be cleaned in place may be removed, cleaned, and relayed according to Section 602.

607.05 Relaying or Stockpiling Salvaged Pipe. Relay removed and cleaned pipe according to Section 602. Furnish all jointing material and replace damaged pipe according to Section 602.

Place salvaged pipe at a designated stockpile location. Dispose of pipe that is damaged.

607.06 Reconditioning Drainage Structures. Remove all debris from structures designated to be reconditioned. Repair all leaks and structural damage and replace missing or broken metalwork according to Section 602.

607.07 Acceptance. Cleaning, reconditioning, and repairing existing drainage structures will be evaluated under Subsection 106.02.

Relaying culverts will be evaluated under Section 602.

Measurement

607.08 Measure the Section 607 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure removing, cleaning, and stockpiling culvert in the stockpile.

Payment

607.09 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 ditches, gutters, spillways, and similar 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

Type 6 — Placed riprap

Material

608.02 Conform to the following Sections and Subsections:

Asphalt mixtures	404
Bed course	704.09
Concrete	601
Granular backfill	703.03(b)
Grout	725.22(e)
Mortar	712.05
Reinforcing steel	709.01
Riprap rock	705.02
Rubble	620

Construction Requirements

608.03 General. Excavate and backfill according to Section 209. Place and compact bed course material. Compact the bed course with at least three passes of a lightweight mechanical tamper, roller, or vibratory system. Form the bed parallel to the finished surface of the waterway.

608.04 Grouted Rubble Paved Waterway (Type 1). Embed pavement stones on the bed 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. Place the stones with the flat faces up and the longest dimension at right angles to the centerline of the waterway.

Ram each stone until it is firm and reasonably true to the surface in grade, alignment, and cross-section. Remove and relay stone having an irregular or uneven surface.

Fill the joints with granular backfill to within 4 inches of the surface. Pour and broom grout into the joints until the grout is 1/2 inch below the surface. Clean the excess grout from the surface.

608.05 Mortared Rubble Paved Waterway (Type 2). Embed each pavement stone with its flat face up and its longest dimension parallel to the gutter line. Place stones alternately so that there is not a continuous joint across the waterway or parallel to the flow line. Limit joint widths from 1 inch minimum to 2 inches maximum.

Ram the stone until it is firm and reasonably true to the surface in grade, alignment, and cross-section.

Apply mortar to the exposed stone sides in such quantities that when the adjacent stone is placed and rammed into position, the mortar is within 1/2 inch of the surface but not protruding above the surface. Clean the excess mortar from the surface.

608.06 Concrete and Rubble Paved Waterway (Type 3). Place the concrete foundation, reinforcing steel, and pavement stone in a progressive operation. Secure the reinforcing steel within the middle third of the depth of the concrete foundation. Clean and wet the pavement stone to near saturation.

Embed the stone in the concrete foundation before it hardens. Place stones alternately so there is not a continuous joint across the waterway or parallel to the flow line. Limit joint widths from 1 inch minimum to 2 inches maximum. Fill the joints between stones with mortar to 1 inch below the top of the stone.

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 404. Before overlaying existing asphalt paved waterway, clean and seal the cracks according to Section 414.

608.09 Placed Riprap Waterway (Type 6). Use class I riprap. Perform the work according to Subsections 251.03 and 251.04.

608.10 Acceptance. See Table 608-1 for sampling and testing requirements.

Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsection 106.04.

Bed course and granular backfill will be evaluated under Subsections 106.02 and 106.04.

Construction of paved waterways will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Riprap will be evaluated under Section 251.

Asphalt mixture will be evaluated under Section 404.

Concrete will be evaluated under Section 601.

Rubble will be evaluated under Section 620.

Measurement

608.11 Measure the Section 608 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure the square yard width horizontally to include the total width. Measure the length parallel to the flow line.

Payment

608.12 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Bed course	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes, when requested	24 hours
	“	Liquid limit	—	AASHTO T 89	“	“	“	“
Granular backfill	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes, when requested	24 hours
Mortar	Measured and tested for conformance (106.04)	Making test specimens Compressive strength (2)	—	AASHTO T 23 & T 22	1 per installation (1)	Job site	Yes, when requested	24 hours

(1) Sample consists of 2 test specimens.

(2) The compressive strength will be the average of two test specimens.

Section 609. — CURB AND GUTTER

Description

609.01 This work consists of constructing or resetting of curb, combination curb and gutter, or wheelstops.

Stone curb is designated as type I or II according to Subsection 705.06.

Material

609.02 Conform to the following Sections and Subsections:

Asphalt mixtures	404
Bed course	704.09
Concrete	601
Joint filler	712.01
Mortar	712.05
Precast concrete curbing and wheelstops	725.06
Reinforcing steel	709.01
Stone curbing	705.06

Construction Requirements

609.03 General. Excavate and backfill according to Section 209. Place and compact the bed course material. Compact the bed course with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

609.04 Stone and Precast Concrete Curb. Clean the curb material thoroughly and wet it just before setting. Set the curb in bed course so the face and top lines are to line and grade. Make the joints 1/2 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 meeting 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 3/4 inch wide and fill it with expansion joint filler of the same nominal thickness as the pavement joint. Fill all voids between the joint filler and the curb with mortar.

609.05 Concrete Curb or Curb and Gutter. Perform work according to Section 601. 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 curb in sections of uniform 10-foot lengths. Construct contraction joints 1/8 inch wide. Use metal divider plates. When 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 3/4-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 552.14(c)(2). When an exposed aggregate finish is required, finish according to Subsection 552.14(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 permitted.

After the concrete has hardened sufficiently to permit sawing without damage, saw contraction joints according to (a)(1) above. Construct expansion joints according to (a)(2) above.

609.06 Asphalt Concrete Curb. Where curb is constructed on a pavement, place a tack coat according to Section 412 on the area under the curb.

Construct asphalt concrete curb according to Section 404. 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.

609.07 Resetting Stone or Precast Concrete Curb. Carefully remove, clean, and store the curb. Cut or fit the curb as necessary for installation. Replace all lost, damaged, or destroyed curb. Reset the curb according to Subsection 609.04.

609.08 Wheelstops. Pin the wheelstops in place with two 3.5-foot sections of No. 6 reinforcing steel or 3/4-inch steel rods. Reset wheelstops in the same manner.

609.09 Acceptance. See Table 609-1 for sampling and testing requirements.

Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsection 106.04.

Precast units (curb and wheel stops) will be evaluated under Subsections 106.02 and 106.03.

Bed course material will be evaluated under Subsections 106.02 and 106.04.

Stone for stone curbing will be evaluated under Subsections 106.02 and 106.04.

Construction of curb and gutter, and wheelstops will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Asphalt mixture will be evaluated under Section 404.

Concrete will be evaluated under Section 601.

Measurement

609.10 Measure the Section 609 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Make no deduction in length for drainage structures installed in the curb section or for driveway and handicap access ramp openings where the gutter is continuous across the opening.

Measure bed course material by the cubic yard in place.

Payment

609.11 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 and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Bed course	Measured and 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 T 89	"	"	"	"
Mortar	Measured and tested for conformance (106.04)	Making test specimens Compressive strength (2)	—	AASHTO T 23 & T 22	1 per installation (1)	Job site	—	—

(1) Sample consists of two test specimens.

(2) The compressive strength will be the average of two test specimens.

Section 610. — HORIZONTAL DRAINS

Description

610.01 This work consists of constructing horizontal drains including collector systems when specified.

Material

610.02 Conform to the following Subsections:

Metallic-coated corrugated steel pipe	707.02
Polyethylene (PE) pipe	725.16
Polyvinyl chloride (PVC) pipe	725.15
Steel pipe	717.06

Construction Requirements

610.03 General. Furnish pipe and fittings of one material shown in Subsection 610.02. Furnish slotted pipe with 2 rows of slots cut circumferentially in the pipe on 2 of the third points that are 120 degrees apart. Make the width of the slots 0.02 inches with the total slot opening equal to 2.3 square inches per linear foot of pipe.

Excavate and backfill according to Section 209.

610.04 Drilling Holes. The locations for installing horizontal drains as shown on the plans are approximate. The exact locations will be determined in the field.

Drill holes with rotary equipment capable of drilling 3 to 6-inch diameter holes through soil and rock. Determine the elevation at the upper end of the completed horizontal drain hole by inserting tubes or pipes and measuring liquid levels, or by other satisfactory means. Dispose of drilling water in a manner that does not contaminate surface watercourses.

610.05 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 with the slots up. Retract the drill rod so the drilled hole is fully cased with the slotted pipe. Connect additional pipe as necessary to form a continuous tube.

Use unslotted pipe for the last 10 to 20 feet of the outlet end. Seal the space between the drilled hole and the unslotted 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.

610.06 Installing Outlet Drains and Collector Systems. Attach outlet drain pipe to the ends of all horizontal drains by means of a tee or street ell. Install a collector system of the type, kind, and size detailed in the contract.

610.07 Acceptance. Material furnished 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

610.08 Measure the Section 610 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.

Section 611. — WATER SYSTEMS

Description

611.01 This work consists of constructing or reconstructing water systems.

Material

611.02 Conform to the following Section and Subsections:

Bedding material	704.02
Cast iron soil pipe and fittings	725.17
Concrete	601
Polyvinyl chloride (PVC) pipe and fittings	725.15
Seamless copper water tube and fittings	725.18
Steel pipe and fittings	717.06

Construction Requirements

611.03 General. Furnish material and workmanship conforming to the standards of APWA, the AWWA, *National Building Code,* and local plumbing and safety codes.

At the preconstruction conference, submit a certified cost breakdown of the individual items involved in the lump sum item for use in making progress payments and price adjustments.

Obtain permits, arrange for inspections, and pay all fees necessary to obtain water service.

Excavate and backfill according to Section 209. Bed the pipe according to Subsection 209.09(b).

611.04 Laying Waterline. Where it is necessary to cross a waterline over a sewer line, construct the waterline a minimum vertical distance of 18 inches above the sewer line.

Inspect each joint or fixture and clean the interior of the pipe before placing in the trench. Do not allow dirt, water, rodents, or other contaminants to enter the pipe during installation. Center and push each joint completely together, and fasten the joint according to the manufacturer's recommendations.

Brace major fixtures or fixtures that could blow off the line under pressure with a cast-in-place concrete wedge block. Cast the block between the fixture and the undisturbed vertical trench wall with a minimum bearing surface of 2 square feet against the vertical wall. Do not pressure test lines until concrete has established its required strength.

611.05 Testing and Disinfecting Lines. Test all joints under pressure before backfilling. Repair all leaks.

Disinfect all lines that are to carry water for human consumption. Fill the lines with a water solution containing a residual chlorine level of at least 50 parts per million for at least 24 hours. Drain and flush the line after the disinfecting period. Do not dispose of disinfectant water in live streams.

611.06 Backfilling. Backfill according to Subsection 209.10 except hand-place the backfill to 12 inches over the top of the pipe. Remove all rocks and hard lumps from the hand-placed layer.

During backfilling, place a plastic locator strip approximately 12 inches above the pipe. If nonmetallic waterline is installed, use a locator strip containing metal that allows detection with a metal detector. Hold hydrants, valve boxes, and other vertical fixtures vertical with the tops adjusted to the required elevation.

611.07 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

611.08 Measure the Section 611 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure waterlines and encasement pipes with no deduction for the length through tees, bends, valves, or other fixtures.

Payment

611.09 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.

Payment for lump sum items will be prorated based on the total work completed.

Section 612. — SANITARY SEWER SYSTEMS

Description

612.01 This work consists of constructing sanitary sewer systems.

Material

612.02 Conform to the following Section and Subsections.

Bedding material	704.02
Cast iron soil pipe	725.17
Concrete	601
Plastic Pipe	706.08
Precast concrete units	725.11(e)
Watertight gaskets	712.03

Construction Requirements

612.03 General. Furnish either cast iron or plastic sanitary sewer lines. Furnish material and workmanship conforming to the standards of the AWWA, *National Building Code,* and local plumbing and safety codes. At the preconstruction conference, submit a certified cost breakdown of items involved in the lump sum item for use in making progress payments and price adjustments.

Obtain permits, arrange for inspections, and pay all fees necessary to obtain sewerage service.

Excavate and backfill according to Section 209. Bed the pipe according to Subsection 209.09(b).

612.04 Laying Sewer Lines. Separate waterlines and sewer lines according to Subsection 611.04.

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.

Where premolded watertight gaskets are used, check the gasket for proper positioning and shove sewer pipe into proper position. When poured joints are used, position the pipe and fill the joint completely with joint sealer. Allow the sealer to cool completely before removing the runner.

612.05 Backfilling. Backfill according to Subsection 611.06. After backfilling, flush the lines with water to ensure that they are unobstructed.

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 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure sewer lines with no deduction for 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.

Payment for lump sum items will be prorated based on the total work completed.

Section 613. — SIMULATED STONE MASONRY SURFACE

Description

613.01 This work consists of using concrete, color/stain, and grout to simulate the texture and color of native stone masonry in the stone pattern shown on the plans. It consists of the following:

(a) Designing and furnishing textured form liners.

(b) Installing form liners.

(c) Applying a surface finish (color/stain application) that duplicates the unique coloring and mottled appearance of stone masonry.

(d) Preparing a simulated stone masonry test wall and demonstrating the surface finish before beginning production work.

Material

613.02 Conform to the following Subsections:

Form liner	725.27
Joint filler	712.01(b)
Penetrating stain	708.05
Grout	725.22(e)

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 on the plans. Submit detailed drawings of the form liner for approval according to Subsection 104.03.

613.04 Form Liner Installation. Attach the form liners to the form. Attach adjacent form liners to each other with less than a 1/8-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 on 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.

613.05 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. Immediately after the free surface water evaporates and the finish embossing is complete, cure the concrete for 7 days according to Subsection 552.15(b). Do not use liquid membrane curing compounds.

613.06 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 all form tie material to a depth of at least 1 inch below the concrete face without spalling and damaging the concrete.

Cure the concrete for 7 days according to Subsection 552.15(b). Do not use liquid membrane curing compounds.

613.07 Preparation of Concrete Surface. Finish all exposed formed concrete surfaces according to Subsection 552.16(a). 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.

613.08 Color/Stain Application. Age concrete, including patches, a minimum of 30 days. Clean the surface of all latency, dirt, dust, grease, and any foreign material by approved methods.

Remove efflorescence with a pressure water wash. Use a fan nozzle held perpendicular to the surface at a distance between 2 and 3 feet. Use a minimum 3,000 pounds per square inch pressure at a rate of 3 to 4 gallons per minute. Do not sand blast surfaces that receive color/stain.

Correct all surface irregularities created by the surface cleaning.

Maintain the concrete temperature between 40 and 85 ºF when applying color/stain and for 48 hours after applying color/stain.

Color/stain all exposed concrete surfaces. Use a color/stain application suitable to obtain the appearance of the native stone masonry. Use a minimum of 3 colors/stains.

When required at boundaries between two color tones or between surfaces receiving color at different times, take care and provide protection to avoid over-spray and color overlap.

Apply grout of a natural cement color to each form joint. Use sufficient grout so the over-spray of the color/stain is not visible. Give the form pattern grout joint the appearance of mortared joints in completed masonry.

Recoat all areas inconsistent with the approved test wall.

Treat expansion joints with caulk/grout to blend with the appearance of the adjacent stone or mortar joint.

613.09 Test Wall. Before production work on the simulated stone masonry, construct a 3-foot high, by 2-foot wide, by 10-foot-long test wall according to Section 552 and these specifications.

Cast the test wall on site, using the same forming methods, procedures, form liner, texture configuration, expansion joint, concrete mixture, and color/stain application proposed for the production work. Demonstrate the quality and consistency of joint treatment, end treatment, top embossing methods, back treatment, and color/stain application on the test wall. If a test wall is unacceptable, construct a new test wall.

Begin production structural concrete work only after the test wall is approved. Begin production color/stain application only after the color/stain application on the test wall is approved. Dispose of the test wall after use.

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 color/stain to all 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.

Measurement

613.11 Measure the Section 613 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Do not measure form liners.

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. — LEAN CONCRETE BACKFILL

Description

614.01 This work consists of constructing lean concrete backfill.

Material

614.02 Conform to the following Subsections:

Aggregate	703.16
Hydraulic cement	701.01
Water	725.01(a)

Construction Requirements

614.03 Composition of Mix. Design a well-graded, flowable, self-leveling, mix conforming to Table 614-1. 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(s) of aggregates;

(b) Type and source of cement;

(c) Mix proportions;

(d) Type of cement and fly ash (if used in the mix);

(e) Commercial certifications for cement, fly ash, admixtures, and aggregate;

(f) Target values for water/cement ratio and slump; and

(g) Compressive strength at 7 and 28 days.

Table 614-1
Composition of Lean Concrete Backfill

Property	Specification
Cement content	50 pounds per cubic yard min.
Slump	6 – 8 inches
Aggregate particle size	1 inch max.
Aggregate passing No. 200 sieve	10 % max.
7-day compressive strength	220 pounds per square inch max.

614.04 General. Perform the work described under Section 209.

Do not place lean concrete backfill in contact with aluminum or aluminum-coated structures.

Do not use lean concrete backfill above the top of subgrade.

614.05 Mixing and Placing Lean Concrete Backfill. Mix lean concrete backfill by pugmill, rotary drum, or other approved mixer to obtain a uniform mix.

Place lean concrete backfill in a uniform manner that prevents voids in, or segregation of, the backfill.

When backfilling around culverts and other structures, place lean concrete backfill in a manner that does not float or shift the structure. Bring the backfill up evenly on all sides of the structure.

When placing lean concrete backfill at or below an atmospheric temperature of 35 ºF, perform the work under Subsection 552.10(a).

Wait at least 4 hours before backfilling over lean concrete backfill.

614.06 Acceptance. Material for lean concrete backfill will be evaluated under Subsections 106.02 and 106.03.

Lean concrete backfilling will be evaluated under Subsection 106.02.

Measurement

614.07 Measure the Section 614 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure lean concrete backfill by the cubic yard 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 item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 615. — SIDEWALKS, DRIVE PADS, AND PAVED MEDIANS

Description

615.01 This work consists of constructing sidewalks, drive pads, and paved medians.

Sidewalks, drive pads, and paved medians are designated as concrete, asphalt, concrete brick, or clay brick.

Material

615.02 Conform to the following Sections and Subsections:

Asphalt mixtures	404
Bed course	704.09
Clay or shale brick	725.07
Concrete	601
Concrete brick	725.08
Curing material	711.01
Masonry and mortar cement	701.02
Sealants, fillers, seals, and sleeves	712.01
Reinforcing steel	709.01

Construction Requirements

615.03 General. Excavate and backfill according to Section 209. Place bed course material in layers not exceeding 4 inches in compacted thickness. Compact each layer with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

615.04 Concrete Sidewalks, Drive Pads, and Medians. Perform the work according to Section 601. Use forms that extend for the full depth of the concrete.

(a) Joints. Construct joints perpendicular to the outside slab edges and other joints. Match the joints in adjacent curb or pavements. Tool and remove all free mortar and concrete from joints.

(1) Expansion joints. Construct at intervals not exceeding 20 feet. Use 3/4-inch thick preformed expansion joint filler for the full depth of the joints. When joints are to be sealed, use multi-component joint sealant.

(2) Contraction joints. Construct at intervals not exceeding 10 feet. Form the joint with a jointing tool or saw the joints to a depth of 1/4 to 1/3 of the thickness of the concrete and about 1/8 inch wide.

(3) Construction joints. Form construction joints around all appurtenances such as manholes, utility poles, buildings, and bridges. Use 1/2-inch, thick preformed expansion joint filler for the full depth of the joints.

When joints are to be sealed, use multi-component joint sealant.

(b) Finishes. Provide a sidewalk finish unless otherwise required. Edge outside edges of slab and all joints with a 1/4-inch radius edging tool.

(1) Sidewalk finish. See Subsection 552.14(c)(2).

(2) Exposed aggregate finish. See Subsection 552.14(c)(4).

Cure the concrete for at least 72 hours according to Subsection 552.15(b) or (c). Protect the work from pedestrian traffic for 72 hours and from vehicular traffic for 7 days.

615.05 Asphalt Concrete Sidewalks, Drive Pads, and Medians. Perform the work according to Section 404.

615.06 Brick Sidewalks, Drive Pads, and Medians. Lay brick in successive courses on a prepared surface. Lay each course of brick to grade. Relay any course that deviates from a straight line by more than 2 inches in 30 feet.

Sweep and inspect the brick surface before the bed sets. Remove each imperfect brick and replace.

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.

615.07 Acceptance. See Table 615-1 for sampling and testing requirements.

Clay or shale brick, concrete brick, curing material, joint fillers, and reinforcing steel will be evaluated under Subsections 106.02 and 106.03.

Bed course material will be evaluated under Subsections 106.02 and 106.04.

Construction of sidewalks, drive pads, and medians will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Asphalt mixture will be evaluated under Section 404.

Concrete will be evaluated under Section 601.

Measurement

615.08 Measure the Section 615 items listed in the bid schedule according to Subsection 109.02.

Payment

615.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 615 pay items listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 615-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Bed course (704.09)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes, when requested	—
		Liquid limit	—	AASHTO T 89	“	“	“	—

Section 616. — SLOPE PAVING

Description

616.01 This work consists of constructing concrete, brick, masonry block, rubble, or cellular concrete block slope paving.

Material

616.02 Conform to the following Sections and Subsections:

Bed course	704.09
Cellular concrete blocks	725.10
Concrete	601
Concrete brick	725.08
Concrete masonry blocks	725.09
Geotextile type IV	714.01
Grout	725.22(c)
Mortar	712.05
Precast concrete units	725.11(f)
Rubble	620
Topsoil	713.01(a) or (b)
Welded steel wire fabric	709.01(h)

Construction Requirements

616.03 General. Excavate and backfill according to Section 209. Place and compact bed course material with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

616.04 Geotextile. When required by the contract, place geotextile according to Subsection 207.05. Bury the ends of the geotextile for anchorage. Pin the strips at 5-foot intervals to hold the geotextile lap in place until slope paving is placed. Replace or repair all geotextile that is torn or punctured.

616.05 Concrete Slope Paving. Construct toe walls. Place welded wire fabric at the center of slab. Run the welded steel wire fabric continuously through the joints. Lap adjacent runs of fabric by at least 6 inches.

Perform concrete work 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 with a sidewalk finish according to Subsection 552.14(c)(2). Edge the outside edges of the slab and all joints with a 1/4-inch radius edging tool.

616.06 Brick, Masonry Block, or Rubble Slope Paving. Place bricks, masonry blocks, or rubble starting at the bottom of the slope. Place them on the foundation bed with flat faces up and the longest dimension parallel to the bottom of the slope.

Ram each brick, masonry block, or stone into place. Apply mortar on the exposed side in such quantities that when the adjacent brick, masonry block, or stone is placed and rammed into position, the mortar is within 1/2 inch of the surface and not protruding above the top. Make the brick and masonry block joints 1/2 inch wide or less and rubble joints 1 inch or less. Clean all mortar stain from the surface.

616.07 Cellular Concrete Block Slope Paving. Place the blocks starting in a trench or against a suitable anchorage at the bottom of the slope. Lay each block perpendicular to the slope and bed firmly against adjoining blocks. Grout to fill misaligned joints or breaks at slope changes. Do not grout individual blocks to each other.

Spread topsoil loosely over the cellular block slope paving, partially filling the cell openings. When required by the contract, establish turf according to Section 625.

616.08 Acceptance. See Table 616-1 for sampling and testing requirements.

Cellular concrete blocks, concrete brick, concrete masonry blocks, material for mortar, and welded steel wire fabric will be evaluated under Subsections 106.02 and 106.03.

Mortar will be evaluated under Subsections 106.02 and 106.04.

Bed course material will be evaluated under Subsections 106.02 and 106.04.

Slope paving construction will be evaluated under Subsections 106.02 and 106.04.

Geotextile will be evaluated under Section 207.

Excavation and backfill will be evaluated under Section 209.

Concrete will be evaluated under Section 601.

Rubble will be evaluated under Section 620.

Topsoil will be evaluated under Section 624.

Turf will be evaluated under Section 625.

Measurement

616.09 Measure the Section 616 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure topsoil under Section 624.

Measure turf establishment under Section 625.

Payment

616.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 616 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Table 616-1
Sampling and Testing Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Bed course (704.09)	Measured and tested for conformance (106.04)	Gradation	—	AASHTO T 27 & T 11	1 per 600 yd^3	Production output or stockpile	Yes, when requested	—
		Liquid limit	—	AASHTO T 89	"	"	"	—
Mortar (712.05)	Measured and tested for conformance (106.04)	Making test specimens Compressive strength	—	AASHTO T 23 & T 22	1 per installation	Job site	—	—

Section 617. — GUARDRAIL

Description

617.01 This work consists of constructing guardrail systems and modifying, removing, resetting, and raising existing guardrail systems.

(a) Guardrail systems are designated as follows:

G1 — Cable guardrail

G2 — W-beam (weak post)

G3 — Box beam

G4 — Blocked-out W beam standard barrier

G9 — Blocked-out thrie beam standard barrier

MB4 — Blocked-out W beam median barrier

SBTA — Steel-backed timber guardrail/timber posts and block-out

SBTB — Steel-backed timber guardrail/timber posts and no block-out

CRT — W-beam guardrail and no blockout

SBLG — Steel-backed log rail

(b) Steel guardrail types are designated as follows:

I — Zinc-coated, 1.80 ounces per square foot

II — Zinc-coated, 3.60 ounces per square foot

III — Painted rails

IV — Corrosion resistant steel

(c) Steel guardrail classes are designated as follows:

A — Metal thickness — 0.105 inches

B — Metal thickness — 0.135 inches

(d) Terminal section types are designated as follows:

G4-CRT — Cable releasing terminal

G4-BAT — Back slope anchor terminal

SBT-FAT-30— Flared anchor terminal, 30 feet long

SBT-FAT-20— Flared anchor terminal, 20 feet long

SBT-BAT — Back slope anchor terminal

Flared — Straight or parabolic flared W beam terminal

Tangent — Tangent W beam terminal

Material

617.02 Conform to the following Section and Subsections:

Box beam rail	710.07
Concrete	601
Corrosion resistant steel rail	710.06(b)
Galvanized steel rail	710.06(a)
Guardrail hardware	710.10
Guardrail posts	710.09
Precast concrete anchors	725.11
Reflector tabs	710.10
Retroreflective sheeting, type III	718.01
Steel-backed timber rail	710.08
Welding	555.03
Wire rope or wire cable	709.02
Wood preservative treatment	716.03

Construction Requirements

617.03 Posts. Treat field cuts for wood posts with two coats of preservative applied with a brush or sprayer. Do not place field cuts in contact with the ground.

Where the pavement surface is within 3 feet of the guardrail face, install posts before placing the pavement surface.

Punch or drill pilot holes no more than 1/2 inch larger than the post dimensions. Drive the posts into the pilot holes and set the posts plumb. Backfill and compact around the posts with acceptable material.

Where it is not possible to maintain a 24-inch minimum distance between the back of the guardrail post and the top of a 1V:2H or steeper slope, increase the standard post length by 12 inches. Where an impenetrable object is encountered, use a short post with a concrete anchor, decrease the post spacing, or nest two rail elements as approved by the CO. Do not change the post lengths and spacings in terminal sections.

617.04 Rail Elements. Install the rail elements after the pavement adjacent to the guardrail is complete. Do not modify specified hole diameters or slot dimensions.

(a) Steel rail. Shop bend all curved guardrail with a radius of 150 feet or less.

Erect rail elements in a smooth continuous line with the laps in the direction of traffic flow. Use bolts that extend at least 1/4 inch but not more than 1 inch beyond the nuts. Tighten all bolts.

Paint all scrapes on galvanized surfaces that are through to the base metal with 2 coats of zinc-oxide paint.

(b) Steel-backed timber rail. Equally space bolts along the front face of the timber rail to match the holes in the steel backing. Align timber guardrail along the top and front of the timber rail.

Field cut timber rails to produce a close fit at joints. Treat field cuts with 2 coats of chromated copper arsenate.

When required, field drill holes in the steel backing on curved sections to correspond to the field cut wood rails at the joints. Do not use a torch to cut holes.

(c) Log rail. Construct log rail according to the plans.

617.05 Terminal Sections. Construct terminal sections at the locations shown. Terminal sections consist of posts, railing, hardware, and anchorage assembly necessary to construct the type of terminal section specified.

Where concrete anchors are installed, construct either cast-in-place or precast units. Do not connect the guardrail to cast-in-place anchors until the concrete has cured 7 days. Install end anchor cables tightly without slack.

When flared or tangent terminals are required, submit drawings from the manufacturer for the terminals according to Subsection 104.03.

When required by the contract, construct earth berms according to Section 204.

617.06 Connection to Structure. Construct connection to structure and, where required by the contract, reinforced concrete transition according to the plans.

617.07 Removing and Resetting Guardrail. Remove and store the existing guardrail, posts, and appurtenances. Remove and dispose of posts that are set in concrete. Replace all guardrail, posts, and hardware damaged during removal, storage, or resetting. Backfill all holes resulting from the removal of guardrail posts and anchors with granular material according to Section 209.

617.08 Raising Guardrail. Remove the existing guardrail and appurtenances. Replace and reset posts as needed. Replace all guardrail, posts, and hardware damaged during the removal and raising.

617.09 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.

Earth berm construction will be evaluated under Section 204.

Structural excavation will be evaluated under Section 209.

Welding will be evaluated under Section 555.

Concrete will be evaluated under Section 601.

Measurement

617.10 Measure the Section 617 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure guardrail, excluding terminal sections. Measure transition sections from G9 rail to G4 rail as G9 rail.

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 the removing, resetting, or raising guardrail.

Measure earth berms under Section 204.

Payment

617.11 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 AND PRECAST GUARDWALLS

Description

618.01 This work consists of constructing and resetting concrete barrier and precast concrete guardwall systems.

Material

618.02 Conform to the following Section and Subsections:

Concrete class A(AE)	552
Guardrail hardware	710.10
Hydraulic cement	701.01
Precast concrete barrier	725.11(b)
Preformed joint filler	712.01(b)
Reinforcing steel	709.01

Construction Requirements

618.03 General. Excavate and backfill according to Section 209. Construct barriers and guardwalls that meet crash test requirements of NCHRP Report 350, *Recommended Procedures for Safety Performance and Evaluation of the Highway Features*.

618.04 Concrete Barriers. Concrete barriers may be cast-in-place, slip-formed, or precast according to Section 552. Finish the sides and top according to Subsection 552.16(a).

(a) Cast-in-place. Hand form or saw contraction joints 1/4 inch wide and 2 inches deep at 20-foot intervals. Saw as soon as possible after the concrete has set sufficiently to preclude raveling during sawing, but before shrinkage cracking occurs. Decrease the depth of the saw cut at the edge adjacent to the pavement to prevent pavement damage.

Place 3/4-inch preformed joint filler in all 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 touch the barrier extruded concrete surface as it leaves the slip-form machine except to immediately remove offsets and fins by light troweling.

Make adjustments in the operation to correct any condition causing surface blemishes larger than 1/2 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 1/4 inch when a 10-foot 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 Precast Concrete Guardwall.

(a) Fabrication. A full-size sample of the guardwall will be provided at a specified location. Fabricate the guardwall to match the sample's shape, color, and texture. The guardwall shall also conform to the following:

(1) Fabricate in a precast concrete production facility certified by the National Precast Concrete Association and according to the Association's *Manual of Quality Control.*

(2) Formulate the facing mixes, backing mixes, and structural concrete backup to produce concrete mix designs of similar aggregate-cement ratios to minimize differences in shrinkage factors and coefficients of thermal expansion and contraction. Formulate using hydraulic cement, limestone, quartz, mica, and silicious stones in such proportions as to match the sample.

(3) Use epoxy coated reinforcing steel at locations where the reinforcing steel is less than 2 inches from the exposed surface.

(4) Cast the segments straight and true to a line in strong permanent composite molds of steel, plastic resins, concrete, or rubber.

(5) Cast the facing mixes a minimum of 1 inch thick. Ensure a good bond between facing and backup mixes.

(6) Provide 4 lifting inserts in unexposed areas. Provide removable caps for the lifting inserts to allow for future segment replacement.

(b) Test section. Demonstrate the ability to match the sample by fabricating a 10-foot, full-scale guardwall test section and delivering it to the location of the sample for comparison. If the test section is not in reasonably close conformity to the sample, fabricate another test section according to (a) above. Test sections that do not match the sample may not be used in the wall installation.

(c) Installation. After the test section is approved, produce the guardwall sections to match the approved test section. Prevent damage to the segments during fabrication, handling, delivery, and installation. Repair or replace all damaged sections. Prepare the foundation and place the sections. Use backer rods and joint sealant in the section joints to match the false joints.

At 100-foot intervals and at low points in the guardwall, dig outlet ditches and fill them with 6 inches of aggregate conforming to AASHTO M 43, number 57.

618.06 Terminal Sections. Where barrier is being constructed next to roadway lanes open to traffic, connect an approved temporary terminal section to the barrier at the end of each day.

Construct permanent graded berms according to Section 204.

618.07 Resetting Barrier. Reset barrier and terminal sections according to Subsections 618.03 and 618.06. Store barrier sections in an approved location when resetting cannot immediately follow removal.

618.08 Acceptance. Material for concrete barrier and precast guardwall (except concrete and reinforcing steel) will be evaluated under Subsections 106.02 and 106.03.

Construction of concrete barriers and precast concrete guardwalls will be evaluated under Subsections 106.02 and 106.04.

Concrete barrier and precast concrete guardwall appearance will be evaluated under Subsection 106.02.

Precast concrete guardwall test sections will be evaluated under Subsection 106.02.

Concrete will be evaluated under Section 552.

Reinforcing steel will be evaluated under Section 554.

Measurement

618.09 Measure the Section 618 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure concrete barrier and precast concrete guardwall excluding terminal sections.

Measure reset barrier in the relocated position including terminal sections.

Measure earth berms under Section 204.

Payment

618.10 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, AND CATTLE GUARDS

Description

619.01 This work consists of constructing fences, gates, cattle guards, and bollard posts and removing and resetting fence.

Material

619.02 Conform to the following Section and Subsections:

Barbed wire	710.01
Chain link fence	710.03
Concrete	601
Fence gates	710.05
Fence posts and bollards	710.04
Cement grout	725.22(e)
Precast concrete units	725.11
Reinforcing steel	709.01
Temporary plastic fence	710.11
Woven wire	710.02

Construction Requirements

619.03 Fences and Gates.

(a) General. Clear along the fence line. Remove and dispose of trees, brush, logs, upturned stumps, roots of downed trees, rubbish, and debris according to Subsection 201.06. Clear a 10-foot width for chain link fence and a 3-foot width for wire fence.

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 close cut stumps within the clearing limits.

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 livestock from entering the project right-of-way, easements, or adjoining properties.

At bridges, cattle underpasses, and culverts, connect new fence to structure to permit free passage of livestock under or through the structure.

(b) Chain link fence and gates.

(1) Posts. Space posts at not more than 10-foot intervals. Measure the post spacing interval horizontally. Set posts vertically.

Set posts in concrete according to Section 601.

Where solid rock is encountered without overburden, drill line post holes at least 14 inches deep and 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 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. When 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 on 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 ornamental tops 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 appropriate means.

(3) Tension wire. Attach tension wire to end, gate, corner, or pull posts by bands and clamps. Either thread the top tension wire through the line post loop caps or hold in open slots in a manner to limit vertical movement. Tie or attach the bottom tension wire to the bottom of the line posts by ties or clamps in a manner that prevents 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.

(5) 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. Paint the cleaned areas with two coats of zinc-oxide paint.

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. 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. When 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. When 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, as necessary, and attach in a manner satisfactory to the CO.

(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 and set in concrete as shown.

(b) Wood braces. Tap the posts to receive the braces. Anchor the brace to the post with three 16d nails or a 3/8 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 and woven wire. Place barbed wire and woven wire on the side of the post facing away from the highway. On curved alignment, place the barbed wire and the woven wire on the post face on the outside of the curve. Tightly stretch and fasten barbed 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 not 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 and woven wire between posts is permitted provided not more than two splices, spaced a minimum of 50 feet apart, occur in any one run of fence. Use wrap or telephone type splices for the longitudinal woven wire and barbed wire with each end wrapped around the other wire for not less than six complete turns.

(4) Fastening barbed wire and woven wire. Terminate the woven wire and barbed wire at each end, corner, gate, and pull post. Wrap each line of barbed 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 not exceeding 12 inches apart. Fasten each strand of barbed 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 permit 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 to the top and bottom wires of woven wire in a manner to maintain the entire fence in its normal shape. Attach the guy wire to a deadman anchor buried not less 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. Twist the wire to permit weaving into the horizontal fence wires to provide rigid spacing. Weave barbed 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 materials or, splice in kind, new material as necessary, and fasten each longitudinal wire of the woven wire and each strand of the barbed wire to a new end post in line with or immediately adjacent to the new fence line.

(5) Gate installation.

(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, capable of being 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 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 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.

619.04 Grounding Fences. Where an electric line crosses the fence line, ground the fence. Drive an 8-foot long, 1/2-inch minimum diameter galvanized or copper coated 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 1/4-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 not exceeding 1,600 feet.

Where vertical penetration of the grounding rod cannot be accomplished, use an equivalent horizontal grounding system.

619.05 Remove and Reset Fence. Remove existing fence and reset to approximately the same condition as the original fence. Salvage material in the existing fence and incorporate the material into the reset fence. When posts are set in concrete, remove concrete from old post and reset in concrete. Replace fence material damaged beyond reuse. Firmly reset posts on new alignment. Space posts and attach the horizontal members or wires to posts the same as the original fence. Furnish and use new material to fasten members or wires to posts.

619.06 Temporary Fence. When necessary, construct temporary fence to keep livestock and traffic off the road being constructed. Temporary fence is intended to remain in place only during the construction of the project or until the fence is directed to be removed.

Construct a temporary fence of a type that provides an adequate enclosure for the type of livestock to be confined.

619.07 Cattle Guards.

(a) Excavating and backfilling. Perform the work described under Section 209. Excavate foundation to depth with sufficient space for proper installation of formwork.

When the cattle guard is to be installed on new embankment, complete and compact the embankment according to Section 204 before excavating for footing.

(b) Concrete foundation. Construct cast-in-place concrete foundations according to Section 601. Concrete cattleguard units may be cast-in-place or precast. Set precast units in the foundation concrete before it hardens..

Finish stringer bearings to allow full bearing under each stringer. The cattle guard shall rest on the concrete without rocking.

(c) Cattle guard. Fabricate cattle guard according to Section 555. Assemble and place guards as shown on the plans. Securely fasten the cattle guard to the foundation. Fasten the metal wings to the cattle guard as shown on the plans. Connect fences and gates according to the plans. Weld according to ANSI/AASHTO/AWS D1.5.

Standard manufactured cattle guards may be used if approved. Designs shall provide for AASHTO loading M-18. Provide suitable cleanouts. Prepare and submit drawings according to Subsection 104.03. Acceptance of the drawings covers the requirements for strength and detail only. No responsibility is assumed for errors in dimensions.

(d) Painting. All metal parts shall receive one shop coat. Two additional coats are required and may be applied in the shop or in the field. Paint according to Section 563.

619.08 Bollards. Drill holes for bollards. Set posts plumb, backfill with approved material, and compact.

619.09 Acceptance. Material for fences, gates, cattle guards, and bollards will be evaluated under Subsections 106.02 and 106.03.

Construction and erection of fences, gates, cattle guards, and bollards will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill for cattle guards will be evaluated under Section 209.

Structural steel work for cattle guards will be evaluated under Section 555.

Painting of cattle guards will be evaluated under Section 563.

Concrete work for cattle guards will be evaluated under Section 601.

Measurement

619.10 Measure the Section 619 items listed in the bid schedule according to Subsection 109.02.

Payment

619.11 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.

Masonry class is designated according to Subsection 705.03 and as follows:

(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 1/4 inch of true line, and laid in mortar.

(c) Class B masonry. Stones are shaped, dressed to within 3/4 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.

Finish for exposed faces is designated according to Subsection 705.03(f).

Material

620.02 Conform to the following Section and Subsections:

Concrete	601
Grout	725.22(f)
Mortar	712.05(a)
Rock for masonry structures	705.03

Construction Requirements

620.03 General. Furnish stone that matches the native stone on the project. Submit stone samples representing the range of colors and sizes to be used on the project to the CO 14 days before beginning work.

Keep an adequate inventory of the stone on the site to provide an ample variety of stones for the masons. When additional stone is added, mix the new stone with the existing stone in a uniform pattern and color.

Excavate and backfill according to Section 209. Prepare the foundation bed normal to, or in steps normal to, the face of the masonry. Where foundation masonry is used, clean the bearing surface thoroughly and wet immediately before spreading the mortar bed.

620.04 Placing Stone. Place stone to provide a uniform pattern and color. Do not place stone masonry when the ambient temperature is below 32 °F. Maintain completed masonry at a temperature above 40 °F for 24 hours after construction. Clean all stones thoroughly and moisten immediately before placing. Clean and moisten the bed.

When removing and resetting stone masonry, use hand tools to clean the exposed faces of the stones of all mortar before resetting.

Spread the mortar. The thicknesses of beds and joints for face stones are as shown in Table 620–1. Ring stone joints on the faces and soffits are not less than 1/4 inch or more than 1½ inches thick. However, make the bed of each course of uniform thickness throughout.

Construct joints in dimensioned masonry vertical. In all other masonry, joints may be at angles with the vertical from 0 to 45 degrees.

Level the cross beds for vertical walls. Beds for battered walls may vary from level to normal to the batter line of the face of the wall.

Lay the stones with the longest face horizontal and the exposed face parallel to the masonry face. Flush the joints with mortar.

Do not jar or displace the stones already set. If a stone is loosened after the mortar has taken initial set, remove it, clean off the mortar, and relay the stone with fresh mortar.

Table 620-1
Masonry Bed and Joint Thicknesses

Class	Beds (inches)	Joints (inches)
Rubble	1/2 – 2½	1/2 – 2½
Class B	1/2 – 2	1/2 – 2
Class A	1/2 – 2	1/2 – 1½
Dimensioned	3/8 – 1	3/4 – 1

620.05 Pointing. Conform to the following:

(a) Pointing new joints. Crown the mortar in the joints on top surfaces slightly at the center of the masonry to provide drainage.

Where raked joints are required, squarely rake all mortar in exposed face joints and beds to the required depth. Where weather joints are required, slightly rake the joints. Do not leave the mortar flush with the stone faces.

Clean all face stone of mortar stains while the mortar is fresh. After the mortar sets, clean again using wire brushes and acid. Protect the masonry during hot or dry weather and keep it wet 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 raking tool approved by the CO. Do not use power saws or grinders. Demonstrate proficiency if power equipment is used before removing mortar from the structure. Remove mortar to a depth of 2 ½ times the width of the joint. Remove any dirt or vegetation with a wire brush or other tools approved by CO. Clean joint of all loose fragments and dust with pressurized air or water.

Before filling the joint dampen adjacent stone. Do not place mortar to a depth greater than 2½ times the joint width. Place mortar in layers of approximately 1/4 inch for joints deeper than 1/8 inch. Add successive layers, once mortar has reached thumb-print hardness. Tool the final layer to match the approved joint appearance. Construct a 3-foot test section of joint along the structure to be approval by the CO before continuing with work. Approved test section maybe incorporated into the work.

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 unless approved by the CO. Protect joints during hot or dry weather by keeping damp for 3 days after work has been completed.

620.06 Constructing Walls. Construct an L–shaped sample section of wall not less than 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 sample is approved.

Set face stones in random bond to produce the effect shown on the plans and to correspond with the approved sample section. Do not extend beds in an unbroken line through more than 5 stones and joints through more than 2 stones. Bond each face stone with all contiguous face stones at least 6 inches longitudinally and 2 inches vertically. Do not construct so that the corners of four stones are adjacent to each other.

Do not bunch small stones or stones of the same size, color, or texture. In general, the stones decrease in size from the bottom to the top of work. Use large stones for the bottom courses and large, selected stones in the corners.

(a) Headers. Where required, 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 all openings and interstices in the backing completely with mortar or with spalls surrounded completely by mortar.

(c) Coping. Construct copings as shown on the plans. Where copings are not called for, finish the top of the wall with stones wide enough to cover the top of the wall from 1½ to 5 feet in length, and of random heights, with a minimum height of 6 inches. Lay stones in a manner that the top course is an integral part of the wall. Pitch the tops of the top courses of stone to line in both vertical and horizontal planes.

(d) Parapet walls. Use selected stones, squared and pitched to line and with heads dressed in the ends of parapet walls and in all exposed angles and corners. Interlock headers with as many headers as possible extending entirely through the wall. Interlock both the headers and stretchers in the 2 faces of the wall. The headers and stretchers shall comprise practically the whole volume of the wall. Completely fill all interstices and spalls with mortar.

(e) Weep holes. Provide weep holes for all walls and abutments. Place weep holes at the lowest points where free outlets can be obtained and space them no more than 10 feet center to center.

620.07 Facing for Concrete.

(a) Stone placed before concrete. Make the back of the masonry uneven to improve the bond to the concrete backing.

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 ±10 inches into the concrete backing. Space the anchors 18 inches apart both horizontally and vertically.

After the mortar has attained sufficient strength, clean the back masonry surface of all dirt, loose material, and mortar drippings. Wash surfaces just before placing the concrete using a high-pressure water jet.

When placing the concrete, carry a neat cement grout of the consistency of cream on top of the concrete and against the masonry at all times. Coat all interstices in the back of the masonry with grout.

(b) Concrete placed before stone. Allow a facing thickness as shown on the plans. Set galvanized metal slots with anchors in the concrete face. Set the anchors vertically at a horizontal spacing not exceeding 24 inches. Place a temporary filling of felt or other material in the slots to prevent filling with concrete.

Where setting the stone facing, fit the metal anchors tightly in the slots at an average vertical spacing of 24 inches. Bend at least 25 percent of the anchors at a short right angle to engage a recess cut in the stone. Extend the anchors to within 3 inches of the exposed face of the stone work.

Where the shape of the concrete face is unsuitable for the use of metal slots, use 9 gage galvanized iron wire ties at a rate of 6 ties for each square yard of exposed surface. Install ties after the concrete has cured using a gun.

Keep the concrete face continuously wet for 2 hours preceding the placing of the stone and fill spaces between the stones and concrete with mortar.

620.08 Constructing Arches. Prepare and 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 near the quarry site showing face dimensions of each ring stone and thickness of joints. Receive approval before the shaping of any ring stone is started and place no ring stone in the structure until all ring stones have been shaped and dressed.

Construct arch centering according to the approved drawings. Provide suitable wedges for adjusting the elevation of the forms.

Set arch ring stones to the exact position and hold in place with hardwood wedges until the joints are packed with mortar. When required, support centering with approved jacks to correct settlement after masonry placement begins. Lower the centering gradually and symmetrically to avoid overstresses in the arch. Make the arch self-supporting before the railing or coping is placed.

For filled spandrel arches, strike the centers before constructing the spandrel walls to avoid jamming of the expansion joints. Place the backfill so the ring is uniformly and symmetrically loaded.

620.09 Guardwall. Use rubble masonry. Concrete corewalls for guardwall may be cast-in-place or precast units according to Section 601. Concrete will have a minimum 28-day compressive strength of 3,500 pounds per square inch.

Construct an 25-foot sample section of guardwall. Do not construct additional guardwall before the sample is approved.

Construct the guardwall true and uniform along its length with no stone projecting more than 1½ inches. Make mortar beds and joints according to Table 620-1. Rake the joints and beds to a depth of 2 inches on the front and top sides and to 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 all 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.

620.10 Acceptance. See Table 620-2 for sampling and testing requirements.

Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsections 106.02 and 106.04.

Rock for masonry structures will be evaluated under Subsections 106.02 and 106.04.

Construction or rehabilitation stone masonry structures will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Concrete will be evaluated under Section 601.

Measurement

620.11 Measure the Section 620 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure stone masonry by the cubic yard in the structure.

Do not measure sample wall sections not incorporated in the work.

Measure stone masonry guardwall including terminal sections.

Measure remove and reset stone masonry by the cubic yard in the structure after resetting.

Measure repoint stone masonry along the centerline of joint.

Payment

620.12 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 all work prescribed in this Section. See Subsection 109.05.

Table 620-2
Sampling and Testing and Requirements

Material or Product	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time
Mortar (712.05)	Measured and tested for conformance (106.04)	Making test specimens Compressive strength	—	AASHTO T 23 & T 22	1 per installation	Job site	—	—

Section 621. — MONUMENTS AND MARKERS

Description

621.01 This work consists of constructing right-of-way monuments, maintenance markers, and similar monuments or posts.

Material

621.02 Conform to the following Section and Subsections:

Concrete	601
Reinforcing steel	709.01
Treated structural timber and lumber	716.03
Untreated structural timber and lumber	716.01

Construction Requirements

621.03 Monuments and Markers. Locate permanent points according to Section 152. Excavate and backfill according to Section 209. Set each monument and marker vertically at the required location and elevation. Monuments may be cast-in-place or precast according to Section 601. Backfill and compact around the monument or marker to ensure that it is held firmly in place.

621.04 Acceptance. Material (except concrete and paint) 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.

Location of permanent points will be evaluated under Section 152.

Structural excavation and backfill will be evaluated under Section 209.

Concrete will be evaluated under Section 601.

Paint will be evaluated under Section 563.

Measurement

621.05 Measure the Section 621 items listed in the bid schedule according to Subsection 109.02.

Payment

621.06 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 furnishing and operating equipment for construction work ordered by the CO 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.

Furnish and operate equipment with such auxiliary attachments, oilers, etc., as are usually needed for efficient operation of the equipment. Keep the equipment in good repair and capable of operating 90 percent of the working time.

Obtain approval of the length of workday and workweek before beginning work. Keep daily records of the number of unit-hours of operation. Submit the records along with certified copies of the payroll.

622.03 Acceptance. Rental equipment work will be evaluated under Subsection 106.02.

Measurement

622.04 Measure the Section 622 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

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.

Measure time for moving equipment between project work sites. Do not measure nonoperable equipment or equipment dependent upon another piece of nonoperable equipment.

Payment

622.05 The accepted quantities will be paid at the contract price per unit of measurement for the Section 622 pay item 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 furnishing workers and hand tools for construction work ordered by the CO and not otherwise provided for under the contract.

Construction Requirements

623.02 Workers and Equipment. Furnish competent workers and appropriate hand tools for the work.

Obtain approval of the length of workday and workweek before beginning work. Keep daily records of the number of hours worked. Submit the records along with certified copies of the payroll.

623.03 Acceptance. General labor work will be evaluated under Subsection 106.02.

Measurement

623.04 Measure the Section 623 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

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.

Do not measure time for workers' transportation.

Payment

623.05 The accepted quantities will be paid at the contract price per unit of measurement for the Section 623 pay item 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 furnishing and placing topsoil and placing conserved topsoil.

Material

624.02 Conform to the following Subsections:

Furnished topsoil	713.01(a)
Conserved topsoil	713.01(b)

Construction Requirements

624.03 Preparing Areas. Shape all slopes and disturbed areas to be covered with topsoil. Disk or scarify slopes 1V:3H or flatter to a depth of 4 inches.

624.04 Placing Topsoil. 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 all conserved topsoil before furnishing topsoil. Keep the roadway surfaces clean during hauling and spreading operations.

Spread topsoil to a depth that, after settlement, provides the required depth. Break clods and lumps with harrows, disks, or other appropriate 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 Subsection 203.05.

Construct longitudinal depressions at least 2 inches deep perpendicular to the natural flow of water without overly compacting the topsoil surface.

624.05 Acceptance. Material for furnished topsoil will be evaluated under Subsections 106.02 and 106.03.

Material for conserved topsoil will be evaluated under Subsection 106.02.

Placing furnished and conserved topsoil material will be evaluated under Subsections 106.02 and 106.04.

Measurement

624.06 Measure the Section 624 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure furnishing and placing topsoil by the cubic yard in the hauling vehicle or by the acre on the ground surface.

Measure placing conserved topsoil by the cubic yard in the hauling vehicle or by the acre on the ground surface.

Payment

624.07 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.

Seeding and mulching methods are designated as dry or hydraulic.

Material

625.02 Conform to the following Subsections:

Agricultural limestone	713.02
Fertilizer	713.03
Mulch	713.05
Seed	713.04
Stabilizing emulsion tackifiers	713.12
Water	725.01

Construction Requirements

625.03 General. Apply turf establishment to finished slopes and ditches within 14 days after completion of construction on a portion 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. Grade the seeding area to line and grade. Remove all weeds, sticks, stones 2 inches in diameter and larger, and other debris detrimental to application, growth, or maintenance of the turf.

If required by the contract, apply limestone and grubproofing.

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 under Section 305.

625.05 Watering. Moisten seeding areas before seeding and maintain the moisture until 10 days after germination.

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. Lightly compact the seedbed within 24 hours after seeding.

(b) Hydraulic method. Use hydraulic-type equipment capable of providing 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. Apply mulch within 48 hours after seeding by the following methods:

(a) Dry method. Spread all 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 3200 pounds per acre. Anchor the mulch material with an approved stabilizing emulsion 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 1500 pounds per acre.

Apply bonded fiber matrix hydraulic mulch at a minimum rate of 3000 pounds per acre. Apply so no hole in the matrix is greater than 0.04 inches. 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 until final acceptance. Repair all damage to seeded areas by reseeding, refertilizing, and remulching. Apply supplemental applications of seed, mulch, fertilizer, lime, or ammonium nitrate.

625.10 Acceptance. Seed will be evaluated under Subsections 106.02, 106.03, and 713.04.

Mulch, fertilizer, and other turf establishment material will be evaluated under Subsections 106.02 and 106.03.

Turf establishment work will be evaluated under Subsections 106.02 and 106.04.

Measurement

625.11 Measure the Section 625 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure seeding and mulching by the acre on the ground surface or by the slurry unit. A slurry unit consists of approximately 1,000 gallons of water plus the specified turf establishment material. Four slurry units contain the material to cover one acre.

Measure turf establishment and supplemental applications by the acre on the ground surface.

Measure water by the M-gallon 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.

Section 626. — PLANTS, TREES, SHRUBS, VINES, AND GROUNDCOVERS

Description

626.01 This work consists of furnishing 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	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.

Furnish stock with a fibrous, cohesive root system. Do not provide container-grown stock that is pot-bound, that has a top system out of proportion (larger) to the size of the container, or that has roots growing out of the container.

626.04 Inspecting and Delivering. Notify the CO 30 days in advance of the delivery of material to permit the CO the opportunity to select material at the source. Submit commercial certifications and complete written information concerning the source of supply for all plant material at least 15 days before delivery of plants to the project.

626.05 Protection and Temporary Storage. Package plants to provide protection against climate and breakage during transit. When shipment is made by open vehicle, tie and cover plant materials to prevent wind damage and dehydration. Spray evergreen and deciduous trees in leaf with an anti-transpirant according to the manufacturer's instructions. When shipment is made by closed vehicle, carefully pack and adequately ventilate plants to prevent "sweating."

Keep all plant material moist and exercise care to prevent damage to bark, branches, and root systems. Replace all damaged plants including plants with cracked or crushed root balls.

Tag each plant delivered to the project with a weatherproof tag showing the plant name and date of delivery.

Protect plants delivered, but not scheduled for immediate planting, as follows:

(a) Open the bundles of bare root material, separate plants, and cover the roots in moist trenches.

(b) Cover the earth balls of balled and burlapped material with mulch or other suitable material and keep moist.

Install all plant material received on site within 30 days.

626.06 Excavation for Plant Pits and Beds. At least 14 days before planting, submit planting locations and methods of planting to the CO for approval. Mark planting locations with stakes or flagging. Remove all 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 4 feet, dig the pits circular in outline to the root spread plus 2 feet.

(2) For root spreads or ball diameters over 4 feet, excavate 1.5 times the root spread.

(b) Depth of excavation. Dig the pits to a depth that permits a minimum of 6 inches of backfill under the roots or balls or dig the pits to the following depths, whichever is deeper:

(1) Deciduous trees.

(a) Under 1½-inch caliper. 2 feet deep

(b) Over1½-inch caliper. 3 feet deep

(2) Deciduous and evergreen shrubs.

(a) Under 2 feet height. 1 foot deep

(b) Over 2 feet height. 2 feet 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 by the CO. Plants not meeting specifications, arriving on site in an unsatisfactory condition, or showing sign of improper handling will be rejected. Immediately remove and dispose of all rejected plants off site and replace with approved nursery stock.

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 all 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. Cut broken or damaged roots back to sound root growth. 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 half 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 just before planting. Place plants in the prepared pits on tamped backfill mixture. Backfill the remainder of the plant with backfill mixture and tamp.

626.08 Fertilizing. Fertilize using either 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 and throughout the plant establishment period. Saturate the soil around each plant at each watering.

626.10 Guying and Staking. When guying and staking is specified, guy deciduous trees just below the first lateral branch and guy evergreen trees half way up the height of the tree. Do not leave the guys and stakes on a tree for more than one growing season.

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 practice. Paint cuts over 3/4 inch in diameter with tree wound dressing.

626.12 Mulching. Place mulch within 24 hours after planting. Place mulch material over all pit or water basin areas of individual trees and shrubs and over the entire shrub bed. If wood fiber is used, apply nitrogen at the rate of 8 pounds per cubic yard to the mulch material.

626.13 Plant Establishment Period. The plant establishment period is a one-year period beginning at the completion of the project. Employ all necessary means to preserve the plants in a healthy growing condition during the plant establishment period. Care during the establishment period includes watering, cultivating, pruning, repairing, adjusting guys and stakes, and controlling insects and disease. At the end of the plant establishment period, remove all guys and stakes.

626.14 Acceptance. Plant material (including plants, fertilizer, mulch, and topsoil) will be evaluated under Subsections 106.02 and 106.03.

Planting of trees, shrubs, vines, groundcovers and other plants will be evaluated under Subsections 106.02 and 106.04 and as follows:

An inspection of the plant material will be made about 15 days before the end of the plant establishment period to identify all dead, dying, or diseased plants for removal and replacement. During the following planting season, remove and replace all identified plants according to this Section. A final inspection of all plant material within 15 days after completion of all replacement planting will be the basis for final acceptance.

Measurement

626.15 Measure the Section 626 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 item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for plants will be made as follows:

(a) 75 percent of the unit bid price will be paid following initial planting.

(b) The remaining 25 percent of the unit bid price will be paid after the final inspection.

Section 627. — SOD

Description

627.01 This work consists of furnishing and placing living sod of perennial turf-forming grasses.

Sod placement is designated as solid, strip, or spot according to Subsection 627.06.

Material

627.02 Conform to the following Subsections:

Agricultural limestone	713.02
Fertilizer	713.03
Pegs for sod	713.11
Sod	713.10
Water	725.01

Construction Requirements

627.03 General. Move and lay sod during dry weather and on dry, unfrozen ground.

627.04 Inspecting and Delivering. Provide at least 3 days notice before cutting sod. The CO will approve 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 area to be sodded. Cultivate, disk, harrow, or otherwise loosen the grade to a depth of not less than 4 inches. Remove stones larger than 2 inches in any diameter, sticks, stumps, and other debris that might interfere with the proper placement or subsequent growth.

Topsoil according to Section 624.

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 when 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 2-foot centers after rolling or tamping. Drive pegs flush with the sod bed surface.

(b) Strip sod. Lay strip sod in shallow trenches in parallel rows. Firmly roll or tamp until the surface of the sod is level with or below the adjacent soil. Seed the soil between the strips of sod according to Section 625. Rake or drag the seeded areas to cover the seed.

(c) 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 free from abrupt changes in slope.

627.07 Maintaining Sodded Areas. Water sod when placing and keep moist. Avoid erosion when watering.

Erect warning signs and barriers to protect newly sodded areas. Do not allow wheeled vehicles 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 all nonliving sod until final acceptance of the project.

627.08 Acceptance. Material, including lime and fertilizer, for sodding will be evaluated under Subsections 106.02 and 106.03.

Sod placement will be evaluated under Subsections 106.02 and 106.04.

Topsoil will be evaluated under Section 624.

Seed will be evaluated under Section 625.

Measurement

627.09 Measure the Section 627 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Do not measure non-sodded areas adjacent to strip and spot sodding.

Measure topsoil under Section 624.

Measure water and seeding under Section 625.

Payment

627.10 The accepted quantities will be paid at the contract price per unit of measurement for the Section 627 pay item listed in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Section 628. — Reserved

Section 629. — ROLLED EROSION CONTROL PRODUCTS AND CELLULAR CONFINEMENT SYSTEMS

Description

629.01 This work consists of constructing temporary and permanent installations to control erosion and enhance vegetation establishment and survivability on slopes and channels. This work includes installing rolled erosion control products (RECP) and cellular confinement systems.

RECP are designated according to Subsections 713.17, 713.18, and the following:

(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 to provide erosion control and facilitate vegetation establishment.

(d) Turf reinforcement mat. A long term non-degradable RECP composed of UV stabilized, non-degradable, synthetic fibers, filaments, nettings, or wire mesh processed into three dimensional reinforcement matrices designed for permanent and critical hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature, natural vegetation. Turf reinforcement mats provide sufficient thickness, strength and void space to permit soil filling and retention and the development of vegetation within the matrix.

Cellular confinement system cell depths are designated according to Table 713-2.

Material

629.02 Conform to the following Sections and Subsections:

Cellular confinement systems	713.07
Permanent RECP	713.18
Temporary RECP	713.17
Topsoil	624
Turf establishment	625

Construction Requirements

629.03 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 ultra-short term temporary RECP consisting of rapidly degrading nettings with a service life of 3 months or less.

629.04 Mulch Control Netting (RECP, Types 1.A, 2.A, and 3.A). Apply mulch according to Subsection 625.08(a). Immediately after mulching, install mulch control netting according to Subsection 629.05.

629.05 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, 5.A, 5.B, and 5.C). 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 1/4 to 3/4 inch of topsoil into the voids in the RECP filling the full product thickness.

Use staples that are at least 6 inches long to secure the RECP. Longer staples may be necessary in sandy, loose, or wet soils.

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 2 to 4 inches. Use a sufficient number of staples to prevent seam separation. Overlap roll ends of joining RECP 2 to 6 inches in the direction of flow.

(a) Slope Installations. At the top of slope, anchor the RECP by one of the following methods:

(1) Staples. Install the RECP 36 inches over the shoulder of the slope onto flat final grade. Secure with a single row of staples on 12-inch centers.

(2) Anchor trench. Construct a 6-inch by 6-inch trench. Extend the upslope terminal end of the RECP 36 inches past the trench. Use staples on 12-inch centers to fasten the RECP into the trench. Backfill the trench and compact the soil. Secure the terminal end with a single row of staples 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 all staple heads flush with soil surface.

Securely fasten all RECP to the soil by installing staples at a minimum rate of 1.5 per square yard.

(b) Channel Installations. At the beginning of the channel, construct a full width anchor trench according to paragraph (a)(2) above. Construct additional anchor trenches or check slots at intervals along the channel reach and at the channel end according to paragraph (a)(2) or (a)(3) and the manufacturer's installation guidelines.

Securely fasten all RECP to the soil by installing staples at a minimum rate of 2.0 per square yard. Significantly higher anchor rates may be necessary in sandy, loose, or wet soils and in severe applications.

Repair all damaged areas immediately by restoring soil to finished grade, re-applying turf establishment, and replacing the RECP.

629.06 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 1 foot below the base of the cellular confinement layer.

Backfill the system with topsoil. Hand-compact the topsoil within each cell and apply turf establishment.

629.07 Acceptance. RECP and cellular confinement system material will be evaluated under Subsection 106.02 and 106.03.

Installation of RECP and cellular confinement systems will be evaluated under Subsections 106.02 and 106.04.

Topsoil will be evaluated under Section 624.

Turf establishment will be evaluated under Section 625.

Measurement

629.08 Measure the Section 629 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure topsoil under Section 624.

Measure turf establishment under Section 625.

Payment

629.09 The accepted quantities will be paid at the contract price per unit of measurement for the Section 629 pay items shown 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. — Reserved

Section 633. — PERMANENT TRAFFIC CONTROL

Description

633.01 This work consists of constructing permanent traffic control signs, supports, delineators, and object markers, and removing and resetting permanent traffic control devices.

Sign panels are designated as plywood, aluminum, steel, plastic, or fiberglass reinforced plastic.

Sign retroreflective sheeting type is designated according to Subsection 718.01.

Posts are designated as wood, aluminum, galvanized steel, or corrosion resistant steel.

Material

633.02 Conform to the MUTCD and the following Section and Subsections:

Aluminum panels	718.05
Concrete	601
Delineator and object marker retroreflectors	718.12
Extruded aluminum panels	718.07
Fiberglass reinforced plastic panels	718.06(b)
Hardware	718.10
Letters, numerals, arrows, symbols, and borders	718.11
Object marker and delineator posts	718.09
Plastic panels	718.06(a)
Plywood panels	718.03
Retroreflective sheeting	718.01
Signposts	718.08
Steel panels	718.04

Construction Requirements

633.03 General. Furnish traffic control devices according to the MUTCD and *Standard Highway Signs* published by FHWA. Submit the sign list for approval before ordering.

633.04 Supports. Sign locations may be changed to fit field conditions as approved by the CO. Determine sign support lengths at time of staking. Install supports plumb and according to the manufacturer's instructions. Make all supports within the clear zone crashworthy.

Drive posts with a suitable driving head or set posts in drilled or punched holes. Replace all damaged posts.

Construct concrete footings according to Section 601. Excavate and backfill according to Section 209.

633.05 Panels. Use type III, VII, VIII, or IX retroreflective sheeting. For permanent sign panels, use type L-1 letters, numerals, arrows, symbols, and borders. Cut panels to size and shape and drill or punch all holes. Make panels flat and free of buckles, warp, dents, cockles, burrs, and other defects.

Clean and degrease the face of metal panels using methods recommended by the retroreflective sheeting manufacturer. Abrade, clean, and degrease the face of the plywood panels using methods recommended by the retroreflective sheeting manufacturer. Treat the edges of the plywood panel with an approved edge sealant. Apply the retroreflective sheeting material to the panels. Package sign panels in protective material and transport them in a vertical position.

Mount sign panels with the legend horizontal. Where multiple panels adjoin, limit the gap between adjacent panels to 1/16 inch. To reduce specular glare (mirror reflection), turn the sign panel 3 degrees away from the road in the direction of travel.

Use oversized bolt heads and neoprene or nylon washers for fastening plastic sign panels.

Do not field drill holes in any part of the panel. Use antitheft fasteners where possible. Paint all bolt heads, screw heads, and washers that are exposed on the sign face. Match the color of the paint to the color of the background or message area at the point where the fitting is exposed.

If a sign message is not applicable, completely cover the face of the sign with an opaque material. Maintain the covering in good condition until the message becomes applicable. Do not use adhesive tape on the sign face.

Repair or replace damaged parts including sheeting.

633.06 Delineators and Object Markers. Attach delineators and object markers to posts according to the manufacturer's recommendation.

633.07 Removing and Resetting Permanent Traffic Control Devices. Remove and store the existing signs, delineators, and object markers. Replace all devices, posts, and hardware damaged during removal, storage, and raising.

633.08 Acceptance. Material (including signs panels, retroreflective sheeting, supports, delineators, object markers, and hardware) for traffic control devices will be evaluated under Subsections 106.02 and 106.03.

Installation of traffic control devices will be evaluated under Subsections 106.02 and 106.04.

Excavation and backfill will be evaluated under Section 209.

Concrete will be evaluated under Section 601.

Measurement

633.09 Measure the Section 633 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

Measure sign systems by the square foot of front face of sign panel as follows:

(a) When a sign system is measured by the each, measure each system as one sign regardless of the number of sign panels or posts.

(b) When a sign system is measured by the square foot, measure the nominal dimensions of all the sign panels.

(c) A sign system includes the supports.

Measure sign panel by the square foot of front face.

Measure each sign panel in a multiple configuration.

Measure removing and resetting permanent traffic control devices after they are reset. Measure based on the number of devices reset in their final position as described in (a) above.

Payment

633.10 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 permanent pavement markings and raised pavement markers on the completed pavement.

Pavement markings are designated as follows:

Type A — Conventional traffic paint with type 1 glass beads

Type B — Waterborne traffic paint with type 1 glass beads

Type C — Waterborne traffic paint with type 3 glass beads

Type D — Epoxy markings with type 1 glass beads

Type E — Epoxy markings with type 1 and type 4 glass beads

Type F — Polyester markings with type 1 glass beads

Type G — Polyester markings with type 1 and type 4 glass beads

Type H — Thermoplastic markings with type 1 glass beads

Type I — Thermoplastic markings with type 1 and type 5 glass beads

Type J — Preformed plastic markings

Type K — Nonreflectorized markings

Material

634.02 Conform to the MUTCD and the following Subsections:

Conventional traffic paint	718.13
Epoxy markings	718.15
Epoxy resin adhesives	718.23
Glass beads	718.19
Polyester markings	718.16
Preformed plastic markings	718.18
Raised pavement markers	718.20
Thermoplastic markings	718.17
Waterborne traffic paint	718.14

Construction Requirements

634.03 General. Where existing and final pavement marking locations are identical, stake the limits of all existing pavement markings (no-passing zones, edge stripes, etc.) before any pavement work. Upon completion of the final surface course, establish line limits for the new pavement for approval before marking. Establish markings according to the MUTCD. In curve widening areas, apply the pavement edge markings at the edge of the traveled way and the centerline markings midway between the pavement 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 all residue and curing compounds. Remove temporary pavement markings the same day permanent pavement markings are applied. Apply markings to a clean, dry surface according to the MUTCD.

At least 7 days before applying pavement markings, furnish a written copy of the marking manufacturer's recommendations for use. A field demonstration may be required to verify the adequacy of recommendations.

Ship marking material in appropriate containers plainly marked with the following information, as appropriate, for the material being furnished:

(a) Manufacturer's name and address;

(b) Name of product;

(c) Lot/batch numbers;

(d) Color;

(e) Net mass and volume of contents;

(f) Date of manufacture;

(g) Date of expiration;

(h) Statement of contents (if mixing of components is required);

(i) Mixing proportions and instructions; and

(j) Safety information.

Apply pavement markings in the direction of traffic according to the manufacturer's recommendations. Apply all markings to provide a clean-cut, uniform, and workmanlike appearance by day and night.

Make lines 4 inches wide. Make broken lines 10 feet long with 30-foot gaps. Make dotted lines 2 feet long with 4-foot gaps. Separate double lines with a 4-inch space.

Protect marked areas from traffic until the markings are dried to no-tracking condition. Remove all tracking marks, spilled marking material, markings in unauthorized areas, and defective markings.

Remove all conflicting pavement markings according to Subsection 635.13.

634.04 Conventional Traffic Paint (Type A). Apply paint when the pavement and air temperatures are above 40 ºF. Spray paint at 15 mil minimum wet film thickness before glass beads or at a rate of 107square feet per gallon. Immediately apply type 1 glass beads on the paint at a minimum rate of 6 pounds per gallon of paint.

On new asphalt pavements or new asphalt surface treatments, apply two coats. Apply the first coat at 360 square feet per gallon and the second coat at 150 square feet per gallon.

634.05 Waterborne Traffic Paint (Type B and C). Apply paint when the pavement and air temperatures are above 50 ºF. Spray paint at 15 mil minimum wet film thickness before glass beads or at a rate of 107 square feet per gallon.

(a) Type B. Immediately apply type 1 glass beads on the paint at a minimum rate of 6 pounds per gallon of paint.

(b) Type C. Immediately apply type 3 glass beads on the paint at a minimum rate of 12 pounds per gallon of paint.

On new asphalt pavements or new asphalt surface treatments, apply two coats. Apply each coat at 210 square feet per gallon.

634.06 Epoxy Markings (Types D and E). Heat components A and B separately at 110±30 ºF and mix. Discard all material heated over 140 ºF. Apply epoxy when the pavement and air temperatures are above 50 ºF. Apply as a spray at 110±30 ºF (gun tip temperature) at a 15 mil minimum dry film thickness or 107 square feet per gallon.

(a) Type D. Immediately apply type 1 glass beads on the epoxy at a minimum rate of 15 pounds per gallon of epoxy.

(b) Type E. Use two bead dispensers. Immediately apply type 4 glass beads on the epoxy at a minimum rate of 12 pounds per gallon of epoxy immediately followed by an application of type 1 glass beads at a minimum rate of 12 pounds per gallon.

634.07 Polyester Markings (Types F and G). Apply polyester when the pavement and air temperatures are above 50 ºF. Spray at 128±7 ºF (gun tip temperature) at a 15 mil minimum dry film thickness or 107 square feet per gallon. Discard all material heated over 150 ºF. Do not use fast dry polyester markings on asphalt pavements less than 1 year old.

(a) Type F. Immediately apply type 1 glass beads on the polyester at a minimum rate of 15 pounds per gallon of polyester.

(b) Type G. Use two bead dispensers. Immediately apply type 4 glass beads on the polyester at a minimum rate of 12 pounds per gallon of polyester immediately followed by an application of type 1 glass beads at a minimum rate of 12 pounds per gallon.

634.08 Thermoplastic Markings (Type H and I). On areas to be marked on rigid pavements and old asphalt pavements, apply an epoxy resin primer/sealer according to the thermoplastic manufacturer's recommendations. Allow the primer/sealer to dry.

Apply thermoplastic when the pavement and air temperatures are above 50 ºF. Spray or extrude the thermoplastic at 430±5 ºF. For centerlines and lane lines, spray or extrude 90 mil minimum dry film thickness or at a rate of 17.8 square feet per gallon. For edge lines, spray or extrude 60 mil minimum dry film thickness or at a rate of 26.7 square feet per gallon.

(a) Type H. Immediately apply type 1 glass beads on the thermoplastic at a minimum rate of 12 pound per 100 square feet.

(b) Type I. Use two bead dispensers. Immediately apply type 5 glass beads on the thermoplastic at a minimum rate of 12 pounds per 100 square feet immediately followed by an application of type 1 glass beads at a minimum rate of 12 pounds per 100 square feet.

The minimum bond strength of the thermoplastic shall be 175 pounds per square inch on rigid pavements.

634.09 Preformed Plastic Markings (Type J). Install to form a durable, weather resistant bond to the pavement. Apply preformed plastic markings according to the manufacturer's recommendation.

Where applied during final compaction of asphalt pavement, apply preformed plastic when the pavement temperature is about 140 ºF. Roll the marking into the surface with a steel wheel roller. The finished pavement marking may extend approximately 10 mil above the final surface.

634.10 Nonreflectorized Markings (Type K). Apply conventional traffic paint, waterborne traffic paint, epoxy markings, polyester markings, or thermoplastic markings as described above, but with no glass beads added.

634.11 Raised Pavement Markers. Install raised pavement markers when the pavement and air temperatures are above 50 ºF. Apply raised pavement markers with epoxy resin or asphalt adhesive.

Heat epoxy components A and B separately with indirect heat, mix, and apply at 70±10 ºF. Discard all material heated over 120 ºF or stiffened by polymerization.

Heat and apply asphalt adhesives at 412±12 ºF. Discard all material heated over 450 ºF.

Space and align the markers to within 1/2 inch of the required location. Do not place raised pavement markers over pavement joints.

The minimum bond strength will be 1.75 pounds per square inch or a total tensile strength of 25 pounds.

634.12 Acceptance. Material for permanent pavement markings will be evaluated under Subsections 106.02 and 106.03.

Placement of permanent pavement marking will be evaluated under Subsections 106.02 and 106.04.

Measurement

634.13 Measure the Section 634 items listed in the bid schedule according to Subsection 109.02 and the following as applicable.

When two coats of paint are required, measure each coat.

When pavement markings are measured by the linear foot or station, measure the length of line applied along the centerline of each 4-inch-wide line applied regardless of color. Measure broken or dotted pavement lines from end to end of the line including gaps. Measure solid pavement lines from end to end of each continuous line. For line widths other than 4 inches, the measured length of line is adjusted in the ratio of the required width to 4 inches.

When pavement markings are measured by the square foot, measure the number of square feet of symbol or letter marking based on the marking area shown in the contract or, if not shown, the area of each marking measured 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 furnishing, 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 panel, barricade, and warning light types are designated as shown in the MUTCD.

Material

635.02 Conform to the MUTCD and the following Sections and Subsections:

Construction sign panels	633
Retroreflective sheeting	718.01
Temporary concrete barrier	618
Temporary plastic fence	710.11
Temporary guardrail	617
Temporary pavement markings	718.21
Temporary traffic control devices	718.22
Traffic markings	634

Construction Requirements

635.03 General. Install and maintain temporary traffic control devices adjacent to and within the project as required by the traffic control plan, Section 156, and the MUTCD. Install and maintain traffic control devices as follows:

(a) Furnish and install traffic control devices before the start of construction operations.

(b) Install only those traffic control devices needed for each stage or phase.

(c) Relocate temporary traffic control devices as necessary.

(d) Remove devices that no longer apply to the existing conditions.

(e) Immediately replace any device that is lost, stolen, destroyed, or inoperative.

(f) Keep temporary traffic control devices clean.

(g) Furnish and maintain traffic control devices that meet the "acceptable" standard described in *Quality Standards for Work Zone Traffic Control Devices* published by ATSSA. Amend the ATSSA standards as follows:

(1) Repair or remove and replace "marginal" devices within 48 hours; and

(2) Repair or remove and replace "unacceptable" devices immediately.

(h) Remove all temporary traffic control devices upon contract completion or when approved.

(i) Furnish temporary traffic control devices that meet the NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features*, for crashworthiness standards as applicable.

635.04 Advance Warning Arrow Panels. Perform the work described under MUTCD Part 6.

635.05 Barricades. Perform the work described under MUTCD Part 6. Use type III, VII, VIII, or IX retroreflective sheeting.

635.06 Cones and Tubular Markers. Perform the work described under MUTCD Part 6. Use 28-inch cones or tubular markers. Use type III, or VI retroreflective sheeting.

635.07 Construction Signs. Use type III, VII, VIII, or IX retroreflective sheeting. For roll-up signs, use type VI retroreflective sheeting. Remove or completely cover all unnecessary signs with metal, plywood, or other acceptable material.

Use crashworthy posts within the traversable area adjacent to traffic. Install posts according to Section 633.

635.08 Drums. Perform work described in MUTCD Part 6. Use plastic drums that are approximately 36 inches high and a minimum of 18 inches in diameter. Use type III or VI retroreflective sheeting.

635.09 Flaggers. Use flaggers certified by the American Traffic Safety Services Association, the National Safety Council, the International Municipal Signal Association, a state agency, or other acceptable organization. Perform the work described under MUTCD Part 6. Use type III, VII, VIII, or IX retroreflective sheeting on flagger paddles. Do not use flags.

635.10 Pilot Cars. Perform the work described under MUTCD Part 6. Use pilot car operators meeting the minimum qualifications of a flagger according to Subsection 635.09. Mount a rotating amber beacon on the roof of each pilot car. Do not use strobe light beacons.

635.11 Temporary Barriers. Perform the work described under MUTCD Part 6. Use temporary barriers that meet NCHRP Report 350 and are new or used provided they are not badly damaged. Lifting holes no larger than 4 inches or lifting loops are permitted. Individual sections may vary in length.

Mount 3-inch minimum dimension 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 2 feet above the pavement surface.

635.12 Temporary Guardrail. Construct temporary guardrail according to Section 617.

Mount 3-inch minimum dimension 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 2 feet above the pavement surface.

635.13 Temporary Pavement Markings and Delineation. Before opening a pavement surface to traffic, remove all conflicting pavement markings by sandblasting or other methods that do not damage the surface or texture of the pavement. Make the removal pattern uneven so it does not perpetuate the outline of the removed pavement markings. Lightly coat sandblasted or removal areas on asphalt surfaces with emulsified asphalt.

Place and maintain temporary pavement markings that are neat, crack free, true, straight, and unbroken. For temporary pavement markings, use preformed retroreflective tape, traffic paint, or temporary raised pavement markers as follows:

(a) Preformed retroreflective tape. Apply according to the manufacturer's instructions. Remove all loose temporary preformed retroreflective tape before placing additional pavement layers.

(b) Traffic paint. Do not apply temporary 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 consecutive days. Apply temporary traffic paint at a 15 mil minimum wet film thickness (0.9 gallons per 100 square feet). Immediately apply type 1 glass beads on the paint at a minimum rate of 6 pounds per gallon of paint.

(c) Raised pavement markers. Do not use raised pavement markers during seasonal suspensions. When chip seals, slurry seals, or tack coats are used after marker placement, protect the markers with an approved protective cover, which is removed after the asphalt material is sprayed. Temporary raised pavement markers may be used as temporary pavement markings as follows:

(1) 10-foot broken line. Four pavement markers spaced 3.33 feet apart followed by a 30-foot gap.

(2) 2-foot broken line. Two pavement markers spaced 2 feet apart followed by an 18-foot gap.

(3) Solid line. Pavement markers on 5-foot centers.

Remove all temporary raised pavement markers before placing additional pavement layers.

Remove all temporary pavement markings from the surface course before placing permanent pavement markings.

635.14 Vertical Panels. Perform the work described under MUTCD Part 6. Use type III, VII, VIII, or IX retroreflective sheeting.

635.15 Warning Lights. Perform the work described under MUTCD Part 6. When type C, steady-burn, warning lights are installed on barricades or drums and used in a series for delineation, use type A, flashing, warning lights on the first 2 barricades or drums in the series. Mount batteries for type B warning lights a maximum of 12 inches from ground or roadway surface as measured to top of the battery casing.

635.16 Shadow Vehicle. Use a shadow vehicle (15,000 pound gross vehicle mass minimum) equipped with a truck-mounted attenuator (crash cushion) attached to the rear of the vehicle, exterior flashing yellow dome light, and an advance warning arrow panel. Use advance warning arrow panel according to Subsection 635.04.

Use the shadow vehicle to provide physical protection to workers from traffic approaching from the rear during moving operations (i.e., pavement markings, traffic control set up and removal, etc.). Use the following procedures to close a lane of traffic. Alternate procedures may be used if approved by the CO.

(a) Move the shadow vehicle to a point approximately 200 feet from the first advance warning sign for the lane closure and stop on the shoulder.

(b) Activate the flashing lights and flashing arrow panel. Begin the arrow panel in the caution mode and after approximately 2 minutes display the correct flashing pass arrow.

(c) Move the shadow vehicle (now acting as a protection vehicle) along the shoulder to the first sign location, stopping approximately 100 feet before the sign location in a blocking position.

(d) Place the first sign then proceed to the next advance sign location. Repeat step (c) for the second sign and install that sign. Repeat this procedure until all advance warning signs are installed.

(e) After installing all of the advanced warning signs for the lane closure, move the shadow vehicle into the lane that is to be closed to a position 100 feet in advance of the closing taper location. Install the channelizing devices for the taper in the shielded lane.

(f) Move the shadow vehicle off the roadway and past the taper on the shoulder and remain in position until the flashing arrow panel for the closure (if one is to be provided) is placed and operating. Move the shadow vehicle with the workers as they proceed to set up the remaining devices as additional protection.

635.17 Pavement Patch. Use an asphalt mix according to Section 404 or 417 to repair potholes and rough spots in the traveled way before reopening travel lanes to traffic.

635.18 Portable Changeable Message Sign. Conform to the MUTCD Part 6.

635.19 Temporary Crash Cushions. Install an FHWA-approved temporary crash cushion conforming to the appropriate level of crashworthiness per NCHRP Report 350. FHWA-approved crash cushions are available on the FHWA Safety website. Install according to manufacturer's recommendations.

635.20 Temporary Signal System. Use a temporary signal system according to Section 636 and MUTCD Parts 4 and 6.

Use signal heads with three lenses, minimum 8 inches diameter, indicating red, yellow, and green phases. Use a signal controller capable of operating in either the solid red, solid green, or a red/yellow/green mode for each signal.

635.21 Temporary Fence. Use temporary fence according to Section 619.

635.22 Portable Rumble Strip. Use a strip 10 feet long, 18 inches wide, and 1¼ inches high to alert drivers of an approaching flagger station or work area.

635.23 Opposing Traffic Lane Divider. Use type III, VII, VIII, or IX retroreflective sheeting.

635.24 Steel Plates. Use 1-inch or thicker steel plates capable of safely carrying traffic. Secure the plates to the pavement to prevent any movement.

635.25 Acceptance. Material (including signs, drums, barricades, cones, tubular markers, crash cushions, concrete barriers, dividers, fence, guardrail, pavement markings, rumble strips, traffic signals, lights, and vertical panels) 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 Subsection 106.02.

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.

Measurement

635.26 Measure the Section 635 items listed in the bid schedule according to Subsection 109.02 and the following as applicable when ordered by the CO and installed.

Measure temporary traffic control items only one time even if relocated or replaced, except for items paid by the hour.

Measure advance warning arrow panels by the hour or by the each. When measurement is by the hour, round portions of an hour up to the half hour.

Measure barricades by the linear foot of width.

Measure construction signs by the square foot of front face sign panel. Do not measure posts and temporary supports.

Measure flaggers, for each hour a person is actually performing the work. Round portions of an hour up to the half hour. Measure time in excess of 40 hours per week at the same rate as the first 40 hours.

Measure pilot cars (including operators) for each hour the car is actually performing the work. Round portions of an hour up to the half hour. Measure time measured in excess of 40 hours per week at the same rate as the first 40 hours.

When there is a pay item for moving temporary barriers, do not measure movement of temporary barriers for work access or the convenience of the Contractor.

Measure temporary guardrail from center-to-center of end posts.

Measure temporary pavement markings for only one application of pavement markings per lift. When temporary pavement markings are measured by the linear foot or mile, measure the number of linear feet or miles of lines applied along the centerline of each 4-inch wide line applied regardless of color. Measure solid lines from end to end of each continuous line. Measure broken lines from end to end including gaps. For line widths greater than 4 inches, adjust the measured length of line in the ratio of the required width to 4 inches. When temporary pavement markings are measured by the square foot, measure the number of square feet of symbols or letter markings based on the marking area shown in the contract or, if not shown, the area of each marking measured in place to the nearest square foot.

Measure temporary raised pavement markers one time for each lift of pavement even if replaced. Measure temporary raised pavement markers used at the option of the Contractor in lieu of temporary pavement markings as equivalent temporary pavement markings and not as temporary raised pavement markers.

Measure pavement marking removal of actual line removed. Do not measure gaps.

Measure temporary crash cushions for each entire crash configuration.

When there is a pay item for moving temporary crash cushion, do not measure movement of temporary crash cushion for work access or the convenience of the Contractor.

Measure replacement barrels or cartridges for crash cushions for the barrels or cartridges damaged by public traffic.

Payment

635.27 The accepted quantities will be paid at the contract price per unit of measurement for the Section 635 pay items in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Progress payments for temporary traffic control devices will be made as follows:

(a) 50 percent of the unit bid price will be paid upon installation.

(b) An additional 25 percent of the unit bid price will be paid following completion of 50 percent of the contract amount.

(c) Payment of the remaining portion of the unit bid price will be paid when the temporary traffic control devices are removed from the project.

Progress payments for items paid for by the hour will be paid at 100 percent of the unit bid price when ordered by the CO and furnished.

Section 636. — SIGNAL, LIGHTING, AND ELECTRICAL SYSTEMS

Description

636.01 This work consists of installing, modifying, or removing traffic signals, 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(g)
Electrical material	721.01
Lighting material	721.02
Precast concrete units	725.11(d)
Sealant	712.01(a)

Construction Requirements

636.03 Regulations and Codes. Furnish material and workmanship conforming to the standards of the National Electrical Code, local safety code, UL, and the National Electrical Manufacturers Association.

Obtain permits, arrange for inspections, and pay all fees necessary to obtain electrical service.

Furnish luminaries with crashworthy supports.

Notify the CO, local traffic enforcement agency, local utility company, or railroad company 7 days before any operational shutdown to coordinate connections or disconnections to an existing utility or system.

636.04 General. At the preconstruction conference, submit a certified cost breakdown of items involved in the lump sum for use in making progress payments and price adjustments.

Fifteen days before installation, submit a list of proposed equipment and material. Include the manufacturer's name, size, and identification number of each item. Supplement the list with scale drawings, catalog cuts, and wiring diagrams showing locations and details of equipment and wiring.

The CO will establish the exact locations of the systems.

Remove structures and obstructions according to Section 203. Salvage all material acceptable for reuse in the work. Excavate and backfill according to Section 209. Construct concrete according to Section 601.

Where roadways are to remain open to traffic and existing systems will be modified, 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 a minimum of couplings to permit pulling conductors. Terminate conduit with bell fittings or bushings. Furnish 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 Installation of Signal and Lighting Systems. Design the control unit to energize the lighting circuit upon failure of any component of its circuit. Furnish a control with an "on" level adjustable between 1 and 5 foot candles. Operate luminaires with a series circuit distribution system at a potential not exceeding 2400 volts.

Control lights and luminaires by photocell controls. For current less than or equal to 10 amperes, furnish a photocell switch. For current greater than 10 amperes, furnish a photocell switch operating a magnetic relay for switching the lighting circuit.

636.07 Loop Installation. Do not install loops when the pavement is wet. Saw cut, wire, and seal for loop wires on the same day. Do not allow vehicular traffic to pass over an open saw cut unless covered by a protective panel.

Saw clean, smooth, well-defined, 5/16-inch wide, and 1¾-inch deep cuts without damaging the adjacent pavement. Overlap saw cuts to provide full depth at all corners. Saw cut the lead-in to the pull box as close as possible to the edge of pavement. Clean and dry saw cuts according to Subsection 502.06(a).

Install the loop wire in one continuous length at the bottom of the cut. Install without kinks, curls, or other damage to the wire or its insulation. Replace any damaged wires. Hold the loop wire in place with 2-foot long backer rods.

Where 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 1 turn per foot from the loop to the pull box. Color code the wires of each loop for identification of separate loops. Coil 3 feet of lead-in pair slack in the pull box for each loop.

Before applying sealant, test the loop and lead-in for continuity and resistance by applying a 1000-volt megger 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 megger readings and submit readings and test equipment data. Replace the loop if the megger reading is less than 10 megaohms or the inductance is less than 60 microhenries or more than 100 microhenries.

Apply sealant to the saw cuts with the backer rods in place. Apply the sealant in a manner that does not produce air bubbles. Remove excess sealant and finish level with the pavement. Follow the manufacturer's instructions 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 report.

636.08 Testing and Demonstration Period. Before energizing any portion of the system, demonstrate that the conductor system is clear and free of all 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.

After completing electrical component tests, conduct a demonstration test for 30 continuous days. Adjust and correct any deficiencies in the system during the 30-day demonstration period. If any part of the system is replaced or repaired, retest that part of the system for an additional 30 days.

636.09 Warranties, Guarantees, and Instruction Sheets. When installations are permanent, deliver manufacturers' warranties, guarantees, instruction sheets, and parts lists at the final inspection.

Upon completion of the work, also submit as-built drawings showing all detail changes from the original plans.

636.10 Relocations. Use material equivalent to existing material, unless present codes require different or improved material. Existing material may be salvaged and reused, provided all material and installation methods used meet the requirements of applicable codes and ordinances.

636.11 Acceptance. Material for signal systems, lighting systems, and electrical systems will be evaluated under Subsections 106.02 and 106.03.

Installation of signal systems, lighting systems, and electrical systems will be evaluated under Subsections 106.02 and 106.04.

Structural excavation and backfill will be evaluated under Section 209.

Concrete will be evaluated under Section 601.

Measurement

636.12 Measure the Section 636 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

636.13 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.

Payment for lump sum items will be prorated based on the total work completed.

Section 637. — FACILITIES AND SERVICES

Description

637.01 This work consists of furnishing, installing, maintaining, and removing facilities (including services) such as field offices and residential housing for the exclusive use of Government personnel.

Construction Requirements

637.02 General. Provide the facilities and services beginning 14 days before project work begins and ending 21 days after final acceptance. Facilities remain the property of the Contractor upon completion of the contract.

Perform all site work to set up and remove facilities. Provide weatherproof buildings or trailers in good condition. Facilities and their location are subject to approval. Suitable commercial or private facilities located near the project may be provided.

637.03 Facilities. Furnish facilities that are ample, safe, sanitary, and include the appropriate electrical service, potable water supply, toilet accommodations and waste disposal services. Pay utility bills (electricity and water) promptly for all facilities. When specified in the contract, provide local and long distance telephone services. The Government will pay the cost of all telephone calls. Conform to all applicable ordinances, safety codes, and regulations.

(a) Field office. Furnish and maintain a field office according to Tables 637-1 and 637-2.

(b) Residential housing. Furnish and maintain residential housing according to Tables 637-1 and 637-2. When the unit is part of a larger building, separate units with partitions and furnish separate outside doors with locks.

Table 637-1
Minimum Requirements for Field Facilities

Property	Field Office	Residential Housing
Floor space — square feet	400	500
Locking outside door — deadbolt with keys	1	1
Steps with slipproof 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 ºF	√	√
Adequate electrical outlets	√	√
Surge protectors	√	√
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 3 vehicles on gravel surface	√	√
6-foot high chain link fence with gate around building and parking area	√	√

(1) As required.
(2) Includes 2 bedrooms.

Table 637-2
Minimum Facility Furnishings and Services

Property	Field Office	Residential Housing
Table — 30-inch wide x 8-foot long x 30-inch high	1	
File cabinet, 2-drawer, fire resistant, metal, with lock	1	
File cabinet, 4-drawer, metal	1	
Desk — 12-square foot	2	
Desk lamp	2	
Office chair	5	
Storage cabinet, 6-inch wide x 36-inch wide x 18-inch high	1	
Fire extinguisher	1	2
Refrigerator, 10-cubic foot		1
Range and oven, standard 36-inch		1
Kitchen table with 2 chairs		1 set
Sofa, 6-foot		1
Coffee table		1
Easy chair		1
End table		1
Table lamp		1
Double bed		2
Night stand		2
Night stand lamp		2
Dresser, 4-drawer, 36-inch		2

637.04 Acceptance. Facilities and services will be evaluated under Subsections 106.02 and 106.04.

Measurement

637.05 Measure the Section 637 items listed in the bid schedule according to Subsection 109.02.

Payment

637.06 The accepted quantity, 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 each facility will be paid as follows:

(a) 60 percent of the item amount will be paid after the facility is accepted for occupancy.

(b) Payment of the remaining 40 percent of the item amount will be paid after final acceptance or when CO determines the facility is no longer needed.

DIVISION 700

MATERIAL

Section 701. — CEMENT

701.01 Hydraulic Cement. Do not mix cement brands or types. Furnish cement according to the following:

(a) Portland Cement. Conform to AASHTO M 85, type I, II, or V.

(b) Blended Hydraulic Cement. Conform to AASHTO M 240, type IS, IP P, I(PM), or I(SM).

701.02 Masonry and Mortar Cement.

(a) Masonry Cement. Conform to ASTM C 91, type N, S, or M.

(b) Mortar Cement. Conform to ASTM C 1329, type N, S, or M.

Section 702. — ASPHALT MATERIAL

702.01 Asphalt Binder. Conform to AASHTO M 20, M 226, or M320. Conform to Subsection 702.04.

702.02 Cut-Back Asphalt. Conform to Subsection 702.04.

(a) Rapid-curing. Conform to AASHTO M 81.

(b) Medium-curing. Conform to AASHTO M 82.

702.03 Emulsified Asphalt. Conform to Subsection 702.04. When specified for tack coat, an equivalent anionic grade emulsion may be substituted for a cationic grade and vice versa. The sieve test in AASHTO M 140 and M 208 is not required.

(a) Anionic emulsions. Conform to AASHTO M 140. For RS-1h and RS-2h, conform to AASHTO M 140 for RS-1 and RS-2, except conform the following for the penetration on the residue.

Ductility, 77 ºF, 2 inches/min, AASHTO T 51 40 mm min.

(b) Cationic emulsions. Conform to AASHTO M 208. For CRS-1h and CRS-2h, conform to AASHTO M 208 for CRS-1 and CRS-2, except conform to the following for the penetration on the residue.

Ductility, 77 ºF, 2 inches/min, AASHTO T 51 40 mm min.

(c) Quick-setting emulsions. Conform to AASHTO M 208.

(d) Polymer modified emulsions. For micro-surfacing, mill or blend the polymer material into the asphalt or emulsifier solution before the emulsification process. Use a polymer quick set emulsified asphalt conforming to AASHTO M 208, ISSA 143, and the following:

(1) Residue by distillation, AASHTO T 59 62 %min.

(2) Softening point, AASHTO T 53 135 °F min.

(3) Penetration at 77 °F, ASTM D 2397 40-90

702.04 Application Temperatures. Apply asphalt within the temperature ranges shown in Table 702-1.

Table 702-1
Application Temperatures - Range °F

Type and Grade of Asphalt	Temperature Ranges Minimum – Maximum	
	Spraying Temperatures	Mixing Temperatures (1)
Cut-back asphalt		
MC-30	85 - (2)	—
RC or MC-70	120 - (2)	—
RC or MC-250	165 - (2)	135 - 175(3)
RC or MC-800	200 - (2)	165 - 210(3)
RC or MC-3000	230 - (2)	180 - 240(3)
Emulsified asphalt		
RS-1	70 - 140	—
RS-2	125 - 185	—
MS-1	70 - 160	70 - 160
MS-2, MS-2h	—	70 - 160
HFMS-1, 2, 2h, 2s	70 - 160	50 - 160
SS-1, 1h, CSS-1, 1h	70 - 160(4)	70 - 160
CRS-1	125 - 185	—
CRS-2	140 - 185	—
CMS-2, CMS-2h	100 - 160	120 - 140
Asphalt binder		
All grades	365 max.	365 max.

(1) Temperature of mix immediately after discharge.
(2) The maximum temperature at which fogging or foaming does not occur.
(3) Temperature may be above flash point. Take precautions to prevent fire or explosion.
(4) For fog seals and tack coats.

702.05 Material for Dampproofing and Waterproofing Concrete and Masonry Surfaces.

(a) Primer. Conform to ASTM D 41.

(b) Asphalt. For mop coat, conform to ASTM D 449, type III.

(c) Waterproofing fabric. Furnish asphalt saturated fabric conforming to ASTM D 173.

(d) Mortar. Conform to Subsection 712.05(b).

(e) Asphalt plank. Conform to ASTM D 517 and the following:

(1) Thickness. 1.25 inches.

(2) Width. 9±3 inches. Use only one width of plank for a single structure except for necessary closers.

(3) Length. 3 to 8 feet. Use length that permit the laying of planks to the best advantage on the surface to be covered.

(f) Asphalt roll roofing. Conform to ASTM D 224, type II.

702.06 Recycling Agent. Conform to AASHTO R 14 or use an approved petroleum product additive that restores aged asphalt to the required specifications.

702.07 Asphalt Mastic. Conform to AASHTO M 243.

702.08 Antistrip Additive. Conform to the following:

(a) Type 1. Furnish 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. Furnish cement conforming to Subsection 701.01 or fly ash conforming to Subsection 725.04.

(c) Type 3. Furnish lime conforming to AASHTO M 303.

702.09 Evaluation Procedures for Asphalt. Evaluate under Subsection 106.04 subject to the following:

(a) Shipping container. Before loading, examine the shipping container and remove all remnants of previous cargos that may contaminate the asphalt.

(b) Delivery ticket. Furnish with each shipment 2 copies of the delivery ticket containing the following:

(1) Consignees;

(2) Project number;

(3) Grade;

(4) Net volume;

(5) Net mass;

(6) Type and amount of antistrip additive;

(7) Identification number (truck, car, tank, etc.);

(8) Destination;

(9) Date;

(10) Loading temperature; and

(11) Specific gravity at 59 ºF

(c) Sampling procedures. Obtain samples of asphalt according to AASHTO T 40 at the applicable sampling location as follows:

(1) Asphalt used in direct application on the road. Take samples from each shipping container at the time of discharge into distributors or other conveyances on the project.

(2) Asphalt initially discharged into storage tanks on the project. Take samples from the line between the storage tank and the distributor or the mixing plant after each delivery. Take samples after a sufficient period of circulation to ensure samples are representative of the material in the storage tank.

702.10 Cold Asphalt Mix. Conform to ASTM D 4215.

Do not use an aggregate asphalt mix that strips. For patching mixes, use an asphalt grade and mix that remains pliable and workable at 14 ºF.

Section 703. — AGGREGATE

703.01 Fine Aggregate for Concrete. Furnish sand conforming to AASHTO M 6, class B including the reactive aggregate supplementary requirement, except as amended or supplemented by the following:

(a) Material passing No. 200 sieve, AASHTO T 11	3.0% max.
(b) Sand equivalent value, AASHTO T 176, alternate method no. 2, reference method	75 min.

For lightweight fine aggregate, conform to AASHTO M 195.

703.02 Coarse Aggregate for Concrete. Conform to AASHTO M 80, class A, except as amended or supplemented by the following:

(a) Los Angeles abrasion, AASHTO T 96	40% max.
(b) Adherent coating, ASTM D 5711	1.0% max.
(c) Grading, AASHTO M 43	All sizes except numbers 8, 89, 9, or 10

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 D 3042.

For lightweight coarse aggregate, conform to AASHTO M 195.

703.03 Granular Backfill. Furnish aggregate for the following installations.

(a) Underdrain pipe with geotextile. Furnish granular backfill conforming to AASHTO M 80, class E and AASHTO M 43, size number 3, 4, 5, 7, 57, or 67.

(b) Underdrain pipe without geotextile. Furnish granular backfill conforming to AASHTO M 6, except the soundness test is not required.

703.04 Permeable Backfill. Furnish either sand conforming to Subsection 703.15 or coarse aggregate consisting of sound, durable particles of gravel, slag, or crushed stone conforming to Table 703-1.

Table 703 - 1
Permeable Backfill Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
3 inch	100
3/4 inch	50 – 90
No. 4	20 – 50
No. 200	0.0 – 2.0

703.05 Subbase, Base, and Surface Course Aggregate.

(a) General. Furnish hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming the following:

(1) Los Angeles abrasion, AASHTO T 96	50% max.
(2) Sodium sulfate soundness loss (5 cycles), AASHTO T 104	12% max.
(3) Durability index (coarse), AASHTO T 210	35 min.
(4) Durability index (fine), AASHTO T 210	35 min.
(5) Fractured faces, ASTM D 5821	50% min.
(6) Free from organic matter and lumps or balls of clay	

Do not use material that breaks up when alternately frozen and thawed or wetted and dried.

Obtain the aggregate gradation by crushing, screening, and blending processes as necessary. Fine aggregate, material passing the No. 4 sieve, shall consist of natural or crushed sand and fine mineral particles.

(b) Subbase or base aggregate. In addition to (a) above, conform to the following:

(1) Gradation	Table 703-2
(2) Liquid limit, AASHTO T 89	25 max.

Table 703-2
Target Value Ranges for Subbase and Base Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 and T 11)				
	Grading Designation				
	A (Subbase)	**B (Subbase)**	**C (Base)**	**D (Base)**	**E (Base)**
2½ inch	100(1)				
2 inch	97 – 100(1)	100(1)	100(1)		
1½ inch		97 – 100(1)			
1 inch	65 – 79 (6)		80 – 100 (6)	100(1)	
3/4 inch			64 – 94 (6)	86 – 100 (6)	100(1)
1/2 inch	45 – 59 (7)				
3/8 inch			40 – 69 (6)	51 – 82 (6)	62 – 90 (6)
No. 4	28 – 42 (6)	40 – 60 (8)	31 – 54 (6)	36 – 64 (6)	436 – 74 (6)
No. 40	9 – 17 (4)			12 – 26 (4)	12 – 26 (4)
No. 200	4.0 – 8.0 (3)	4.0 – 12.0 (4)	4.0 –7.0 (3)	4.0 – 7.0 (3)	4.0 – 7.0 (3)

(1) Statistical procedures do not apply.

( ) The value in the parentheses is the allowable deviation (±) from the target values..

(c) Surface course aggregate. In addition to (a) above, conform to the following:

(1) Gradation and plasticity index, AASHTO T 90	Table 703-3
(2) Liquid limit, AASHTO T 89	35 max.

Do not furnish material that contains asbestos fibers.

Table 703-3
Target Value Ranges for
Surface Course Gradation and Plasticity Index

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
1 inch	100$^{(1)}$
3/4 inch	9[illegible] - 100$^{(1)}$
No. 4	4[illegible] - 71 (7)
No. 40	1[illegible] - 28 (5)
No. 200	[illegible] - 16 (4)
Plasticity index	8 (4)

(1) Statistical procedures do not apply.
( ) The value in the parentheses is the allowable deviation (±) from the target values.

703.06 Crushed Aggregate. Furnish 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. Furnish crushed aggregate with a maximum size of 1 inch as determined by AASHTO T 27 and T 11. Furnish crushed aggregate uniformly graded from coarse to fine and free of organic matter, lumps or balls of clay, and other deleterious matter.

703.07 Hot Asphalt Concrete Pavement Aggregate.

(a) Coarse aggregate (retained on a No. 4 sieve). Furnish hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

(1) Los Angeles abrasion, AASHTO T 96	40% max.
(2) Sodium sulfate soundness loss (5 cycles), AASHTO T 104	12% max.
(3) Fractured faces, ASTM D 5821	75% min.

(4) Durability index (coarse), AASHTO T 210 35 min.

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 D 3042.

(b) Fine aggregate (passing a No. 4 sieve). Furnish natural sand, stone screenings, slag screenings, or a combination thereof conforming to AASHTO M 29 including sulfate soundness and the following:

(1) Durability index (fine), AASHTO T 210	35 min.
(2) Sand equivalent value, AASHTO T 176, alternate method no. 2, reference method	45 min.

(c) Composite aggregate blend. Size, grade, and combine the aggregate fractions in mix proportions conforming to the following:

(1) Gradation	Table 703-4
(2) Clay lumps and friable particles, AASHTO T 112	1.0% max.
(3) Reasonably free from organic or other deleterious material	

(d) Lightweight aggregate (slag). Furnish crushed slag conforming to the quality requirements of AASHTO M 195. Do not use any other kind or type of lightweight aggregate as defined in AASHTO M 195.

Table 703-4
Target Value Ranges for
Hot Asphalt Concrete Pavement Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)					
	Grading Designation					
	A	B	C	D	E	F
1½ inch	100$^{(1)}$					
1 inch	97-100$^{(1)}$	100$^{(1)}$	100$^{(1)}$			
3/4 inch	—	97-100$^{(1)}$	97-100$^{(1)}$	100$^{(1)}$	100$^{(1)}$	
1/2 inch	—	76-88(5)	*(5)	97-100$^{(1)}$	97-100$^{(1)}$	
3/8 inch	53-70(6)	—	*(6)	—	*(5)	100$^{(1)}$
No. 4	40-52(6)	49-59(7)	*(7)	57-69(6)	*(6)	33-47(6)
No. 8	25-39(4)	36-45(5)	*(5)	41-49(6)	*(6)	7-13(4)
No. 30	12-22(4)	20-28(4)	*(4)	22-30(4)	*(4)	—
No. 50	8-16(3)	13-21(3)	*(3)	13-21(3)	*(3)	—
No. 200	3-8(2)	3-7(2)	3-8(2)	3-8(2)	3-8(2)	2-4(2)

(1) Statistical procedures do not apply.
* Contractor specified target value.
( ) The value in the parentheses is the allowable deviation (±) from the target values.

703.08 Open-Graded Asphalt Friction Course Aggregate. Conform to Subsection 703.07 grading F and the following:

(a) 2 or more fractured faces, ASTM D 5821 — 75% min.

(b) 1 or more fractured faces, ASTM D 5821 — 90% min.

(c) Flakiness index, ASTM D 4791 — 30 max.

703.09 and Tables 703-5 and 703-6 Reserved.

703.10 Asphalt Surface Treatment Aggregate. Furnish hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel. Use only one type of aggregate on a project.

Size, grade, and combine the aggregate fractions in mix proportions conforming to the following:

(a) Gradation	Table 703-7
(b) Los Angeles abrasion, AASHTO T 96	40% max.
(c) Sodium sulfate soundness loss, AASHTO T 104	12% max.
(d) Fractured faces, ASTM D 5821	90% min.
(e) Flat and elongated particles, 1:3 ratio & 3/8-inch sieve calculated by mass, weighted average, ASTM D 4791	10% max.
(f) Durability index (coarse), AASHTO T 210	35 min.
(g) Durability index (fine), AASHTO T 210	35 min.
(h) Clay lumps and friable particles, AASHTO T 112	1.0% max.

Do not use lightweight aggregate according to AASHTO M 195.

Table 703-7
Target Value Ranges for
Single and Multiple Course Surface Treatment Aggregate Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)					
	Grading Designation					
	A	B	C	D	E	F
1½ inch	100(1)					
1 inch	90-100(3)	100(1)				
3/4 inch	0-35(5)	90-100(3)	100(1)			
1/2 inch	0-8(3)	0-35(5)	90-100(3)	100(1)		
3/8 inch	—	0-12(3)	0-35(5)	85-100(3)	100(1)	100(1)
No. 4	—	—	0-12(3)	0-35(5)	85-100(3)	85-100(1)
No. 8	—	—	—	0-8(3)	0-23(4)	—
No. 200	0-1(1)	0-1(1)	0-1(1)	0-1(1)	0-1(1)	0-10(1)

(1) Statistical procedures do not apply.
( ) The value in the parentheses is the allowable deviation (±) from the target values.

703.11 Slurry Seal and Micro-Surfacing Aggregate. Furnish natural or manufactured sand, slag, crushed fines, or other mineral aggregate conforming to AASHTO M 29 and the following:

(a) Slurry seal aggregate.

(1) Gradation	Table 703-8
(2) Los Angeles abrasion, AASHTO T 96	35% max.
(3) Sand equivalent value, AASHTO T 176, alternate method no. 2, reference method	45 min.
(4) Smooth textured sand with < 1.25% water absorption content by weight of total combined aggregate	50% max.

Table 703-8
Slurry Seal and Micro-Surfacing Aggregate
Gradation[1] and Application Rates[2]

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)		
	Slurry Seal Type		
	I	II	III
3/8 inch	—	100	100
No. 4	100	90-100	70-90
No. 8	90-100	65-90	45-70
No. 16	65-90	45-70	28-50
No. 30	40-65	30-50	19-34
No. 50	25-42	18-30	12-25
No. 100	15-30	10-21	7-18
No. 200	10-20	5-15	5-15
Application rate[2] pounds per square yard	6 - 10	10 - 15	15 or more

(1) Statistical procedures do not apply.
(2) Based on the dry mass of the aggregate.

(b) Micro-surfacing aggregate.

(1) Gradation, type II or III	Table 703-8
(2) Los Angeles abrasion, AASHTO T 96	30% max.
(3) Sand equivalent value, AASHTO T 176, alternate method no. 2, reference method	65 min.
(4) Sodium sulfate soundness, AASHTO T 104	
Using NA_2SO_4	15 max.
Using $MgSO_4$	25 max.

703.12 Choker Aggregate. Furnish hard durable particles or fragments of crushed gravel or crushed stone conforming to the following:

(a) Gradation Table 703-9

(b) Sand equivalent value, AASHTO T 176, alternate method no. 2, reference method — 75 min.

(c) Free from organic matter and clay balls

Table 703-9
Choker Aggregate Gradation(1)

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
3/8 inch	100
No. 4	0 – 100
No. 200	.0 - 5.0

(1) Statistical procedures do not apply.

703.13 Blotter. Furnish sound durable particles of gravel or crushed stone conforming to the following:

(a) Material passing 3/8-mm sieve, AASHTO T 27	100%
(b) Liquid limit, AASHTO T 89	25 max.
(c) Free of organic matter and clay balls	

703.14 Aggregate for Aggregate-Topsoil Course. Conform to the following:

(a) Gradation	AASHTO M 43, size number 57
(b) Quality	AASHTO M 80, class E

703.15 Sand. Furnish clean material conforming to the following:

(a) Gradation	AASHTO M 6
(b) Deleterious substances	AASHTO M 6, class B

703.16 Aggregate for Lean Concrete Backfill. Furnish hard, clean, durable, nonplastic, nonorganic, nonreactive aggregate.

703.17 Superpave Asphalt Concrete Pavement Aggregate. Furnish 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% max.
(b) Sodium sulfate soundness loss of coarse and fine aggregate (5 cycles), AASHTO T 104	12% max.
(c) Fractured faces, ASTM D 5821	Table 703-10
(d) Fine aggregate angularity, AASHTO T 304, method A	Table 703-11
(e) Flat and elongated particles, 3 to 1 ratio, ASTM D 4791	Table 703-11
(f) Sand equivalent value, AASHTO T 176, alternate method no. 2, reference method	Table 703-11

(g) Gradation. See Table 703-12. Size, grade, and combine the aggregate fractions in mix proportions that result in a composite blend between the control points. 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 T 11.

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 D 3042.

Table 703-10
Fractured Faces Coarse Aggregate Requirement

Traffic ESALs (million)	Fractured Faces (1face % min. / 2face % min.)	
	Depth from Surface	
	≤ 4 inch	> 4 inch
< 0.3	55/-	-/-
0.3 to < 3	75/-	50/-
3 to < 10	85/80	60/-
10 to < 30	95/90	80/75
≥ 30	100/100	100/100

Note: "85/80" denotes that a minimum of 85 percent of the coarse aggregate has one fractured face and a minimum of 80 percent has two fractured faces.

Table 703-11
Superpave Aggregate Requirements

Traffic ESALs (million)	Uncompacted Void Content of Fine Aggregate (% minimum)		Sand Equivalent (minimum)	Flat and Elongated (% max.) 3:1 Ratio
	Depth from Surface			
	≤ 4 inch	> 4 inch		
< 3	40	40	40	10
3 to < 10	45	40	45	
10 to < 30	45	40	45	
≥ 30	45	45	50	

Table 703-12
Superpave Aggregate Gradation

Sieve Size	Nominal Maximum Aggregate Size – Percent Passing							
	Grading Designation							
	1 inch		3/4 inch		1/2 inch		3/8 inch	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1½ inch	100							
1 inch	90	100	100					
3/4 inch	*	*	90	100	100			
1/2 inch	*	*	*	*	90	100	100	
3/8 inch	*	*	*	*	*	*	90	100
No. 4	*	*	*	*	*	*	*	*
No. 8	*	*	*	*	*	*	*	*
No. 30	*	*	*	*	*	*	*	*
No. 50	*	*	*	*	*	*	*	*
No. 200	3	8	3	8	3	8	3	8

* Contractor specified target values. See Table 703-13 for allowable deviations.

Table 703-13
Allowable Deviations for Target Value Gradations

Gradation Range (inches)		Allowable Deviation (percent)
Minimum	**Maximum**	
2.76	3.54	4
2.37	2.75	5
2.17	2.36	6
1.78	2.16	7
1.58	1.77	6
1.19	1.57	5
0.83	1.18	4
0.32	0.82	3
0	0.31	2

Table 703-14
Coarse and Fine Gradation Classification

Nominal Maximum Aggregate Size	Primary Control Sieve (PCS) for Mixture Nominal Maximum Sieve Size			
	1 inch	**3/4 inch**	**1/2 inch**	**3/8 inch**
PCS	No. 4	No. 4	No. 8	No. 8
PCS Control Point (% Passing)	40	47	39	47

703.18 Shotcrete Aggregate. For fine aggregate, furnish rounded particles conforming to Subsection 703.01. For coarse aggregate, conform to AASHTO M 80, class B, except as amended or supplemented by the following:

(a) Los Angeles abrasion, AASHTO T 96 40 % max.

(b) Adherent coating, ASTM D 5711 1.0 % max.

Combine the aggregates to meet the designated gradation in Table 703-15

Table 703 - 15
Shotcrete Gradation Limits for Combined Aggregates

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)		
	Grading Designation		
	A	B	C
3/4 inch	—	—	100
1/2 inch	—	100	80-95
3/8 inch	100	90-100	70-90
No. 4	95-100	70-85	50-70
No. 8	80-100	50-70	35-55
No. 16	50-85	35-55	20-40
No. 30	25-60	20-35	10-30
No. 50	10-30	8-20	5-17
No. 100	2-10	2-10	2-10

703.19 Recycled Asphalt Pavement. Furnish recycled asphalt pavement that is processed in some form (by crushing and screening) to produce a well graded gradation and asphalt content. Process recycled asphalt pavement so that no particle in the mixture made with recycled asphalt pavement will exceed the mixture maximum aggregate size at the time of production. Millings will be considered processed provided they have a uniform gradation and asphalt content. Provide recycled asphalt pavement material with a maximum of 2 percent deleterious materials.

Section 704. — SOIL

704.01 Foundation Fill. Furnish granular material free of excess moisture, frozen lumps, roots, sod, or other deleterious material and conforming to the following:

(a) Maximum particle size	2 inches
(b) Soil classification, AASHTO M 145	A-1-a
(c) Material passing No. 200 sieve, AASHTO T 27 and T 11	6% max.

704.02 Bedding Material. Furnish material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Maximum particle size	1/2 inch or half the corrugation depth, whichever is smaller
(b) Soil classification, AASHTO M 145	A-1, A-2-4, A-2-5, or A-3

704.03 Backfill Material. Furnish a well-graded, compactable material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) For all structures and pipes other than plastic pipe:

(1) Maximum particle size	3 inches
(2) Soil classification, AASHTO M 145	A-1, A-2, or A-3

(b) For plastic pipe:

(1) Maximum particle size	1½ inches
(2) Soil classification, AASHTO M 145	A-1, A-2-4, A-2-5, or A-3

704.04 Structural Backfill. Furnish free draining granular material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Maximum particle size	3 inches
(b) Material passing No. 200 sieve, AASHTO T 27 and T 11	15% max.
(c) Liquid limit, AASHTO T 89	30% max.

704.05 Topping. Furnish a granular material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Maximum particle size 4 inches

(b) Soil classification, AASHTO M 145 A-1 or A-2-4

704.06 Unclassified Borrow. Furnish granular material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Maximum particle size 24 inches

(b) Soil classification, AASHTO M 145 A-1, A-3, or A-2-4

704.07 Select Borrow. Furnish granular material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Gradation Table 704-1

(b) Liquid limit, AASHTO T 89 30 max.

Table 704-1
Select Borrow Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
3 inch	100
1 inch	70-100
No. 4	30-70
No. 200	0-5

704.08 Select Topping. Furnish granular material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Gradation, well graded coarse to fine Table 704-2

(b) Liquid limit, AASHTO T 89 30 max.

Table 704-2
Select Topping Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
3 inch	100
No. 200	0-15

704.09 Bed Course. Furnish porous, free-draining granular material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material conforming to the following:

(a) Gradation, well graded coarse to fine — Table 704-3

(b) Liquid limit, AASHTO T 89 — 30 max.

Table 704-3
Bed Course Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 & T 11)
1/2 inch	100
No. 200	0 10

704.10 Select Granular Backfill. Furnish sound, durable, granular material free from organic matter or other deleterious material. Conform to the following:

(a) Quality requirements.

(1) Gradation — Table 704-4

(2) Angle of internal friction on the portion passing the No. 10 sieve, AASHTO T 236 — 34° min.

Note: Compact samples for AASHTO T 236 to 95 percent of the maximum density determined according to AASHTO T 99, method C or D and corrected for oversized material according to AASHTO T 99, Note 9.

(3) Sodium sulfate soundness loss (5 cycles), AASHTO T 104 — 15% max.

(4) Plasticity index, AASHTO T 90 — 6 max.

(b) Electrochemical requirements for MSE walls with metallic reinforcements.

(1) Resistivity, AASHTO T 288 — 3000 Ωcm min.

(2) pH, AASHTO T 289 — 5.0 to 10.0

(3) Sulfate content, AASHTO T 290 — 200 ppm max.

(4) Chloride content, AASHTO T 291 — 100 ppm max.

Note: Tests for sulfate and chloride content are not required when resistivity is greater than 5000 ohm centimeters.

(c) Electrochemical requirements for MSE walls with geosynthetic reinforcements.

pH, AASHTO T 289 5.0 to 10.0

Table 704-4
Select Granular Backfill Gradation

Sieve Size	Percen by Mass Passing De ignated Sieve (AASI TO T 27 & T 11)
4 inch	100
No. 40	0 – 60
No. 200	0 – 15

704.11 Reserved.

704.12 Crib Wall Backfill. Furnish material according to Subsection 704.10, except conform to the gradation in Table 704-5.

Table 704-5
Crib Wall Backfill Gradation

Sieve Size	Percen by Mass Passing De ignated Sieve (AASI TO T 27 & T 11)
3 inch	100
No. 4	25 – 70
No. 50	5 – 20
No. 200	0 – 5

Section 705. — ROCK

705.01 Gabion and Revet Mattress Rock. Furnish hard, durable rock that is resistant to weathering and reasonably free of organic and spoil material. Conform to the following:

(a) Coarse durability index, AASHTO T 210	52 min.
(b) Unit mass of a filled basket	100 pounds per cubic foot min.
(c) Gradation:	
(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

705.02 Riprap Rock. Furnish hard, durable, angular rock that is resistant to weathering and water action and free of 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) Apparent specific gravity, AASHTO T 85	2.50 min.
(b) Absorption, AASHTO T 85	4.2% max.
(c) Coarse durability index, AASHTO T 210	50 min.
(d) Gradation for the class specified	Table 705-1

Table 705-1
Gradation Requirements for Riprap

Class	Percent of Rock by Mass	Mass (pounds)	Approximate Cubic Dimension$^{(2)(3)}$ (inches)
1	20	22 to 33	6 to 8
	30	11 to 22	5 to 6
	40	1 to 11	2 to 5
	10 $^{(1)}$	0 to 1	0 to 2
2	20	55 to 110	8 to 10
	30	22 to 55	6 to 8
	40	2 to 22	3 to 6
	10 $^{(1)}$	0 to 2	0 to 3
3	20	220 to 330	14 to 16
	30	110 to 220	10 to 14
	40	11 to 110	5 to 10
	10 $^{(1)}$	0 to 11	0 to 5
4	20	550 to 770	18 to 20
	30	220 to 550	14 to 18
	40	22 to 220	6 to 14
	10 $^{(1)}$	0 to 22	0 to 6
5	20	1540 to 2200	26 to 28
	30	770 to 1540	20 to 26
	40	55 to 770	8 to 20
	10 $^{(1)}$	0 to 55	0 to 8
6	20	1870 to 3530	28 to 34
	30	1100 to 1870	22 to 28
	40	110 to 1100	10 to 22
	10 $^{(1)}$	0 to 110	0 to 10

(1) Furnish spalls and rock fragments graded to provide a stable dense mass.
(2) The volume of a rock with these cubic dimensions has a mass approximately equal to the specified rock mass.
(3) Furnish rock with breadth and thickness at least one-third its length.

705.03 Rock for Masonry Structures. Furnish sound, durable rock that is native to the vicinity of the work or is similar in texture and color to the native rock and has been proven satisfactory for the intended use.

Furnish dimensioned masonry rock free of reeds, rifts, seams, laminations, and minerals that may cause discoloration or deterioration from weathering.

(a) Sizes and shapes. Do not use rock with depressions or projections that might weaken it or prevent it from being properly bedded.

When no dimensions are shown on the plans, furnish the rocks in the sizes and face areas necessary to produce the general characteristics and appearance indicated on the plans.

Unless otherwise specified, furnish rock fragments with the following dimensions:

(1) Minimum thickness	5 inches
(2) Minimum width	12 inches or 1½ times the thickness, whichever is greater
(3) Minimum length	1½ times the width
(4) Rocks with volume ≳ 1 cubic foot	50% min.

When headers are required, furnish headers with lengths no less than the width of bed of the widest adjacent stretcher plus 12 inches.

(b) Dressing. Remove all thin or weak portions. Dress face rock bed and joint lines to a maximum variation from true line as follows:

(1) Rubble masonry	1½ inches
(2) Class B masonry	3/4 inch
(3) Class A masonry	1/4 inch
(4) Dimensioned masonry	Reasonably true

(c) Bed surfaces. Dress face rock bed surfaces normal to the face to a depth of 3 inches. Beyond that point, the departure from normal may not exceed 1 inch in 12 inches for dimensioned masonry or 2 inches in 12 inches for all other classes.

(d) Joint surfaces. For dimensioned masonry, dress face rock joint surfaces normal to the bed surface. For all other classes of masonry, dress face rock joint surfaces to form an angle with the bed surface of not less than 45 degrees.

Dress face rock joint surfaces normal to the face to a depth of 2 inches. Beyond that point, the departure from normal may not exceed 1 inch in 12 inches.

Do not round corners at the meeting of the bed and joint lines in excess of the following radii:

(1) Rubble masonry	1½ inches
(2) Class B masonry	1 inch
(3) Class A masonry	No rounding
(4) Dimensioned masonry	No rounding

(e) 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, the departure from the radial or normal may not exceed 3/4 inch in 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. When concrete is placed after the masonry is constructed, vary adjacent ring stones at least 6 inches in depth.

(f) Finish for exposed faces. Remove all drill or quarry marks from exposed faces. Pitch face stones to the line along all beds and joints. Finish the exposed faces as specified in the contract. The following symbols are used to represent the type of surface or dressing specified:

(1) Fine pointed (F.P.). Make point depressions approximately 3/8 inch apart. Limit surface variations to 1/8 inch or less from the pitch line.

(2) Medium pointed (M.P.). Make point depressions approximately 5/8 inch apart. Limit surface variations to 1/4 inch or less from the pitch line.

(3) Coarse pointed (C.P.). Make point depressions approximately 1⅛ inches apart. Limit surface variations to 3/8 inch or less from the pitch line.

(4) Split or seam face (S.). Provide a smooth appearance, free from tool marks, with no depressions below the pitch line, and no projection exceeding 3/4 inch beyond the pitch line.

(5) Rock faced (R.F.). 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.

705.04 Rock for Special Rock Embankment.

(a) Mechanically-placed embankments. Furnish hard, durable rock that is angular in shape, resistant to weathering, and graded in a well-balanced range conforming to Table 705-2.

Table 705-2
Gradation for Mechanically-placed Rock

Percent of Rock Fragments by Mass	Mass (pounds)	Equivalent Cubic Dimension (inches)
50	Greater than 2000	Larger than 28
50	90 to 2000	10 to 28

(b) Hand-placed embankments. Furnish hard, durable rock that is angular in shape, resistant to weathering, and graded in a well-balanced range conforming to Table 705-3.

Table 705-3
Gradation for Hand-placed Rock

Percent of Rock Fragments by Mass	Mass (pounds)	Equivalent Cubic Dimension (inches)
75	Greater than 165	Larger than 12
25	90 to 165	10 to 12

705.05 Rock for Buttresses.

(a) General. Furnish hard, durable, angular rock free of organic and spoil material, resistant to weathering and water action. Furnish rock with breadth and thickness at least one-third its length. Conform to the following:

(1) Apparent specific gravity, AASHTO T 85 — 2.50 min.

(2) Absorption, AASHTO T 85 — 4.2% max.

(3) Coarse durability index, AASHTO T 210 — 52 min.

(b) Mechanically-placed buttresses. In addition to (a) above, furnish rock graded in a well-balanced range conforming to Table 705-2.

(c) Hand-placed buttresses. In addition to (a) above, furnish rock graded in a well-balanced range conforming to Table 705-3.

705.06 Stone Curbing.

(a) Stone curb, type I. Conform to the size and shape specified and the following:

Furnish quarried limestone, sandstone, or granite from an approved source. Use one type of stone throughout the project. Do not use stone with visible drill marks on the exposed faces.

Saw or point the top surface of all vertical stone curb to an approximate true plane with no depression or projection on that surface of over 1/4 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 with the top back and face and finish so when the sections are placed end to end, no space more than 1/2 inch shall show in the joint 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.

The minimum length of any segment of vertical stone curb is 4 feet. However the length may vary where a depressed or modified section of curb is required for driveways, crossings, closures, etc.

(b) Stone curb, type II. Slope stone curb shall conform to the requirements for type I stone curb except as follows:

The maximum allowable projection or depression on a horizontal top surface is limited to 1/2 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 2-foot length shall be 3 inches.

The maximum allowable space showing on exposed faces between adjacent segments of slope stone curb is 3/4 inch. The minimum length of any segment of slope stone curb is 2 feet.

Section 706. — CONCRETE AND PLASTIC 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 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 AASHTO M 259 or M 273, as applicable, for dimensions and loading conditions specified.

706.08 Plastic Pipe. Furnish perforated and nonperforated plastic pipe conforming to the following for the sizes and types specified. For watertight joints, conform to ASTM D 3212.

(a) Smooth wall polyethylene pipe. Furnish 12- to 42-inch diameter pipe conforming to ASTM F 714 and minimum cell class, ASTM D 3350, 335434C.

(b) Corrugated polyethylene pipe. Furnish 12- to 36-inch diameter pipe conforming to AASHTO M 294. For sanitary sewer applications, furnish AASHTO M 294, type S pipe with watertight joints.

(c) Profile wall (ribbed) polyethylene pipe. Furnish 18- to 48-inch diameter pipe conforming to ASTM F 894 and minimum cell class, ASTM D 3350, 334433C or 335434C.

(d) Corrugated polyethylene drainage tubing. Furnish 3- to 10-inch diameter tubing conforming to AASHTO M 252.

(e) Smooth wall polyvinyl chloride pipe. Furnish 4- to 15-inch diameter pipe conforming to AASHTO M 278 and minimum cell class, ASTM D 1784, 12454 or 12364. For sanitary sewer applications, conform to ASTM D 3034.

(f) Profile wall (ribbed) polyvinyl chloride pipe. Furnish 4- to 48-inch diameter pipe conforming to AASHTO M 304 and minimum cell class, ASTM D 1784, 12454C or 12364C. For sanitary sewer applications, conform to ASTM F 794 or F 949.

(g) Acrylonitrile-butadiene-styrene (ABS) pipe. Conform to AASHTO M 264. For perforations, conform to AASHTO M 278.

Section 707. — METAL PIPE

707.01 Ductile Iron Culvert Pipe. Conform to ASTM A 716 for the sizes specified.

707.02 Metallic-Coated Corrugated Steel Pipe. Furnish 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, M 274, or M 289 for the dimensions and thicknesses specified.

Fabricate underdrain pipe from steel sheets with a minimum thickness of 0.052 inches. Use any class of perforation specified in AASHTO M 36.

707.03 Aluminum-Alloy Corrugated Pipe. Furnish pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections), and coupling bands conforming to AASHTO M 196 for the dimensions and thicknesses specified.

Fabricate underdrain pipe from aluminum sheets with a minimum thickness of 0.048 inches. Use any class of perforation.

707.04 Asphalt-Coated Pipe. Furnish pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections), and coupling bands conforming to Section 707 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. Furnish 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. Furnish 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. Furnish 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. Furnish pipe, special sections (such as elbows and branch connections), and coupling bands conforming to AASHTO M 245, grade 250/250 and M 246, grade 250/250.

707.09 Fiber-Bonded Asphalt Coated Steel Pipe. Furnish pipe, special sections (such as elbows, branch connections, and prefabricated flared end sections), and coupling bands conforming to Subsection 707.02 except use a zinc metallic coating impregnated with an aramid fiber composite conforming to ASTM A 885.

After fabrication, coat the pipe sections with asphalt material according to AASHTO M 190 for the type of coating specified.

Coat coupling bands with a asphalt material according to AASHTO M 190, type A. Coupling bands do not require fiber bonding.

707.10 Slotted Drain Pipe. Furnish pipe conforming to AASHTO M 36 and either AASHTO M 218, M 274, or M 289 for the dimensions and thicknesses specified. Fabricate the pipe with either angle slots or grate slots and as shown on the plans.

Furnish grate assemblies for the grate slot drain conforming to ASTM A 570, grade 250. Galvanize slot angles and grate slot assemblies according to Subsection 725.12.

707.11 Metallic-Coated Spiral Rib Pipe. Furnish pipe, special sections (such as elbows and branch connections), and coupling bands conforming to AASHTO M 36, type IR and IIR, AASHTO M 218, M 274, or M 289 for the dimensions and thicknesses specified.

707.12 Aluminum-Alloy Spiral Rib Pipe. Furnish pipe, special sections (such as elbows and branch connections), and coupling bands conforming to AASHTO M 196, type IR and IIR for the dimensions and thicknesses specified.

707.13 Concrete-Lined Corrugated Steel Pipe. Furnish 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 A 849, class C.

707.14 Invert-Paved Corrugated Steel Pipe. Furnish 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 A 849, class C or B, as specified.

Section 708. — PAINT

708.01 General. Furnish a contrasting color for each coat of paint. For the finish coat color, conform to Federal Standard 595 B. If requested, provide color chips from the paint supplier.

(a) Packaging. Furnish paint in strong, substantial containers, plainly marked with the following:

(1) Trade name or trade mark;

(2) Paint type, color, formulation, lot number, and date of manufacture;

(3) Net mass;

(4) Volume including the percent of solids and the percent of volatile organic compound (VOC);

(5) Storage requirements;

(6) Mixing instructions and equipment cleanup instructions; and

(7) Name and address of the manufacturer.

(b) Volatile organic compound (VOC) content. Conform to the following VOC limits for both shop and field painting:

(1) Clear (unpigmented) coatings	3.7 pounds per gallon max.
(2) Other coatings	2.9 pounds per gallon max.

(c) Lead content. max. 0.06% by mass in the dried film

(d) Other properties. Furnish paint that:

(1) Does not show excessive settling in a freshly-opened full can;

(2) Easily redisperses with a paddle to a smooth, homogeneous state free of curdling, livering, caking, color separation, lumps, and skins;

(3) Does not skin within 48 hours in a ¾ filled, closed container;

(4) Brushes on easily;

(5) Possess good leveling properties;

(6) Shows no running or sagging tendencies when applied to smooth steel vertical surfaces;

(7) Dries to a smooth uniform finish, free from roughness, grit, unevenness and other surface imperfections;

(8) Shows no streaking or separation when flowed on clean glass; and

(9) Shows no thickening, curdling, gelling, or hard caking after 6 months of storage in a full, tightly-covered container at a temperature of 70 ºF.

708.02 Paint for Timber Structures.

(a) Primer. Conform to MPI no. 5 or 7.

(b) Paint. Conform to MPI no. 8, 9, 10, 11, 94, or 119.

708.03 Paint for Concrete and Masonry Block Structures. Conform to MPI 10, 11, or 119. Color tint with universal or all purpose concentrates.

708.04 Paint for Steel Structures. Conform to the following:

(a) Inorganic zinc primer.	SSPC no. 20, type I
(b) Vinyl wash primer.	SSPC no. 27
(c) Aluminum vinyl paint.	SSPC no. 8
(d) White or colored vinyl paint.	SSPC no. 9
(e) Aliphatic urethane coating.	SSPC no. 36
(f) Latex primer for steel surfaces.	SSPC no. 23
(g) Acrylic latex coating.	SSPC no. 24
(h) Epoxy coating.	SSPC no. 22
(i) Alkyd primer.	SSPC no. 31
(j) Silicone alkyd coating.	SSPC no. 21

708.05 Penetrating Stain. Conform to the following:

(a) Weatherometer on base material, ASTM G 23	1000 h
(b) Acrylic dispersion	73.4% of nonvolatile vehicle
(c) Viscosity	58±2 Krebs units
(d) Solids volatile content	40.3

Store stain according to the manufacturer's recommendations.

Section 709. — REINFORCING STEEL AND WIRE ROPE

709.01 Reinforcing Steel.

(a) General. Furnish the following information with each shipment of steel to the project:

(1) Name and location of the steel rolling mill;

(2) Manufacturing process;

(3) Heat number(s);

(4) Size(s);

(5) Specifications;

(6) Copies of mill test analyses for chemical and physical tests; and

(7) Consignee and destination of shipment.

(b) Reinforcing bars. Furnish deformed, grade 60 bars conforming to AASHTO M 31, M 42, or M 53.

(c) Epoxy-coated reinforcing bars. Furnish bars conforming to Subsection 709.01 (b). Conform to AASHTO M 284.

Inspect the reinforcing bars after the near white blast cleaning. Reject all bars with steel slivers or scabs. Selective sorting and rejection at the fabricator's shop may avoid unnecessary delays and subsequent rejection of bars during the precoating inspection at the coating applicator's shop.

Coat epoxy coated reinforcing steel in a plant certified by CRSI as a fusion bonded epoxy applicator.

(d) Tie bars. Furnish deformed, grade 60 bars conforming to AASHTO M 31 or M 42, except do not use AASHTO M 42 steel for tie bars bent and restraightened during construction.

(e) Hook bolts. Furnish plain, grade 60 bars conforming to AASHTO M 31 or M 42 with M14 rolled threads or M16 cut threads. Furnish a threaded sleeve nut capable of sustaining a minimum axial load of 15,000 pounds.

(f) Dowel bars. Conform to AASHTO M 254, type A or B. Use plain round bars, free from burring or other deformation restricting free movement in the concrete. Paint half 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, furnish a dowel cap that snugly covers 2±1/4 inches of the dowel, has a closed end, and has a suitable stop to hold the closed end 1 inch from the end of the dowel bar.

Lubricants for type B dowels may be rapid-curing cut-back asphalt, medium setting emulsified asphalt, or a flaked graphite and vehicle. Lubricants are not required for type A coated dowel bars.

Furnish dowel assemblies that hold dowel bars within 1/4-inch tolerance vertically and horizontally during concrete placement and permit unrestricted movement of the pavement slab.

Use wire conforming to AASHTO M 32 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 225.

(h) Welded steel wire fabric. Conform to AASHTO M 55.

(i) Cold-drawn steel wire. Conform to AASHTO M 32.

(j) Welded deformed steel wire fabric. Conform to AASHTO M 221.

(k) Fabricated deformed steel bar or rod mats. Conform to AASHTO M 54.

(l) Low alloy steel deformed bars. Conform to ASTM A 706.

709.02 Wire Rope or Wire Cable. Conform to AASHTO M 30 for the size and strength class specified.

709.03 Prestressing Steel. Fabricate from one of the following:

- Stress-relieved wire strand, AASHTO M 204, type BA or WA;
- Stress-relieved seven-wire strand, AASHTO M 203, grade 270; or
- High-strength steel bars, AASHTO M 275, type II

Submit representative samples from prestressed members fabricated off site. In the case of wire or strand, take the sample from the same master roll.

(a) Pretensioning method. Furnish a sample at least 6 feet long of each strand size from each coil.

(b) Post-tensioning method. Furnish 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 furnished.

(3) For strands furnished with fittings, 5 feet between near ends of fittings.

(4) For bars to be furnished with threaded ends and nuts, 5 feet between threads at ends.

Section 710. — FENCE AND GUARDRAIL

710.01 Barbed Wire. Furnish galvanized wire conforming to AASHTO M 280 or aluminum coated wire conforming to AASHTO M 305, type I.

710.02 Woven Wire. Furnish galvanized fabric conforming to AASHTO M 279 or aluminum coated fabric conforming to ASTM A 584.

710.03 Chain Link Fence. Furnish fabric, posts, rails, ties, bands, bars, rods, and other fittings and hardware conforming to AASHTO M 181.

Furnish 0.177-inch coiled spring steel tension wire conforming to ASTM A 641 hard temper with a class 3 galvanized coating or an aluminized coating having a minimum coating mass of 0.40 ounces per square foot of aluminum. Use the same coating on the tension wire as used on the rest of the chain link fence.

710.04 Fence Posts and Bollards.

(a) Wood. Conform to AASHTO M 168.

Peel all bark, except for red cedar posts and bracing, which do not require peeling. Trim all knots flush with the surface and season the wood.

For dimension lumber for fences, bollards, or gates, use timber that is sound, straight, and reasonably free from knots, splits, and shakes. Provide S4S finish.

(b) Concrete. Conform to Section 601.

(c) Steel. For line fence posts, conform to AASHTO M 281. For chain link fence, conform to AASHTO M 181.

710.05 Fence Gates. For frame gates used with chain link fences, conform to AASHTO M 181. Use the same chain link fabric in the gate and the fence.

710.06 Metal Beam Rail. Conform to AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware*.

(a) Galvanized steel rail. Furnish W-beam or thrie beam rail elements fabricated from corrugated sheet steel conforming to AASHTO M 180 for the designated shape, class, type, and mass of coating specified.

(b) Corrosion resistant steel rail. Furnish W-beam or thrie beam rail elements and associated weathering steel hardware conforming to the following:

(1) Shapes and plates	ASTM A 242
(2) Rail elements	AASHTO M 180
(3) Fasteners	AASHTO M 180

710.07 Box Beam Rail. Furnish steel box beam rail elements conforming to the AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware*.

710.08 Steel-Backed Timber Rail. Furnish timber conforming to AASHTO M 168. Fabricate the timber rail, blockouts, and posts from dry, well seasoned, and dressed rough sawn Douglas fir, southern pine, or other species having a stress grade of at least 1,500 pounds per square inch. Treat the timber rail, blockout elements, and posts according to AASHTO M 133.

Fabricate the steel backing elements from 3/8-inch structural steel conforming to ASTM A 242. For fastener hardware, conform to ASTM A 242.

710.09 Guardrail Posts. Conform to AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware*.

Do not use a wood guardrail post that has 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.

For steel-backed timber rail posts, furnish 10- by 12-inch posts conforming to Subsection 710.08.

710.10 Guardrail Hardware. Conform to the AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware*.

For angles, channels, wide flanges, and plates not contained in the above standard, conform to ASTM A 36. For structural tubing for short steel posts, conform to ASTM A 500 or ASTM A 513, grade 1008. Galvanize soil plates and structural tubing according to AASHTO M 111. Do not punch, drill, cut, or weld the metal after galvanizing.

Manufacture reflector tabs from 0.15-inch aluminum or galvanized steel sheets. 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.

710.11 Temporary Plastic Fence. Furnish plastic noncorrosive fence fabricated from polyethylene (HDPE) and UV stabilized for outdoor weathering. Conform to the following:

(a) Height	47 inches min.
(b) Mesh openings	3.15 to 3.35 inches
(c) Color	International orange
(d) Mass	0.16 pound per foot, min.

Section 711. — CONCRETE CURING MATERIAL AND ADMIXTURES

711.01 Curing Material. Conform to the following:

(a) Burlap cloth	AASHTO M 182
(b) Waterproof paper	AASHTO M 171
(c) Polyethylene film	AASHTO M 171
(d) Liquid membrane forming compounds	AASHTO M 148, type 1-D or 2

711.02 Air-Entraining Admixtures. Conform to AASHTO M 154.

711.03 Chemical Admixtures. Furnish 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 D.

711.04 Latex Modifier. Furnish a homogeneous, nontoxic, film forming polymeric emulsion with stabilizers added at the point of manufacture. Conform to the following:

(a) Color	white
(b) Styrene butadiene polymer type	68±4% styrene 32±4% butadiene
(c) Chlorides	0%
(d) Polymer particle size	1,500 to 2,500 Angstroms avg.
(e) Emulsion stabilizers	anionic and non-ionic surfactant
(f) Solids	46.5 to 49.0%
(g) Mass	8.40 to 8.55 pounds per gallon
(h) pH	9 to 13
(i) Shelf life	2 years min.

711.05 Concrete Coloring Agents. Conform to ASTM C 979. Use only coloring agents composed of synthetic or natural inorganic iron oxides.

Section 712. — JOINT MATERIAL

712.01 Sealants, Fillers, Seals, and Sleeves. Conform to the following:

(a) Joint sealants and crack fillers. Furnish a commercial certification identifying the batch and lot number, material, quantity of batch, date and time of manufacture, and the name and address of the manufacturer.

(1) Concrete joint-sealer, hot-poured elastic type	AASHTO M 173
(2) Joint sealants, hot-poured, for rigid and asphalt pavement	ASHTO M 301
(3) Crack filler, hot applied, for asphalt concrete and rigid pavements	ASTM D 5078

(4) For proprietary asphalt-rubber products, furnish the following:

(a) Source and grade of asphalt binder;

(b) Total granulated rubber content and mass, as percent of the asphalt-rubber mixture;

(c) Granulated rubber type(s) and content 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.

(5) Multi-component joint sealant, conforming to TT-S-00227E, type I, class A or ASTM C 920, type M, grade P, class 25, use T. Provide sealant matching the color of the adjacent sidewalk. Conform to the sealant manufacturer’s recommendations for use of primers.

(6) Flexible cellular joint filler ASTM D 1056, type 2, grade 4 or 5

(b) Preformed expansion joint fillers. Furnish 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 fillers for concrete paving and structural construction	AASHTO M 153
(3) Preformed cork expansion joint fillers for concrete paving and structural construction(1)	AASHTO M 153
(4) Preformed expansion joint fillers for concrete paving and structural construction (nonextruding and resilient bituminous types)	AASHTO M 213

Note: (1) Do not use in major concrete structures.

(c) Preformed joint seals and sleeves.

(1) Paving applications. Conform to AASHTO M 220. Use a lubricant conforming to ASTM D 2835, which was manufactured within 9 months of use.

(2) Circular concrete sewer and culvert pipes using rubber gaskets. Furnish oil resistant gaskets conforming to AASHTO M 315 and the following:

(a) Minimum thickness	Recommendation of drainage element manufacturer
(b) Tear resistance, ASTM D 624 (die B)	
(1) Ethylene propylene dimonomer (EPDM)	230 pounds per inch min.
(2) Neoprene	115 pounds per inch min.

(3) Resilient connectors between reinforced concrete manhole structures and pipes. Conform to ASTM C 923.

(4) Preformed flexible joint sealants for concrete pipe, manholes, and precast box sections. Conform to ASTM C 990.

(d) Foam filler. Furnish an expanded polystyrene filler having a compressive strength of not less than 10 pounds per square inch.

(e) Silicone joint sealer. Conform to ASTM D 5893, type NS.

(f) Low-modulus silicone joint sealant. Conform to ASTM D 5893, type SL.

(g) Backer rod. Conform to ASTM D 5249, type 1. Use a compatible sealant as recommended by the rod manufacture. For size of backer rod, conform to Table 712-2.

712.02 Joint Mortar. Conform to Subsection 712.05. Use the mortar within 30 minutes after mixing.

712.03 Watertight Gaskets. For ring gaskets for rigid pipe, conform to AASHTO M 198. For ring gaskets for flexible metal pipe, conform to ASTM C 361. For continuous flat gaskets for flexible metal pipe with flat bands or bands with projections, conform to ASTM D 1056, grade SCE 41 and use a gasket with a thickness 1/2 inch greater than the nominal depth of the pipe corrugations. For continuous flat gaskets for flexible metal pipe with corrugated bands, conform to ASTM D 1056, grade SCE 43 and use a 3/8-inch thick gasket.

Table 712-2
Backer Rod Sizes

Joint Width After Preparation	Rod Diameter
[illegible]/16 inch	3/8 inch
3/8 inch	1/2 inch
1/2 inch	5/8 inch
5/8 inch	3/4 inch
3/4 inch	1 inch
1 inch	1¼ inch
1¼ inch	1½ inch
1½ inch	2 inch

712.04 Reserved.

712.05 Mortar for Masonry Beds and Joints.

(a) Type I mortar. Furnish and proportion masonry mortar according to ASTM C 270 proportion specifications. Mortar may be preblended or mixed on site. Use only masonry cement mortar type M or S.

(b) Type II mortar. Furnish mortar and material for use in mortar conforming to the following:

(1) Cement

(a) Portland Cement	Subsection 701.01(a), type I, IA, II, IIA, III, or IIIA
(b) Blended hydraulic cement	Subsection 701.01 (b), type IS, IS-A, IP, IP-A, I(PM) or I(PM)-A
(c) Masonry cement	Subsection 701.02

(2) Fine aggregate	Subsection 703.01or AASHTO M 45
(3) Lime	ASTM C 207, type S or SA. Type N or NA, if tests show it not to be detrimental to mortar soundness.
(4) Water	Subsection 725.01
(5) Air entraining admixture	Subsection 711.02
(6) Composition	Conform to the proportions for one of the mixes in Table 712-3. Uniformly mix with water to a spreading consistency.
(7) Compressive strength	2,000 pounds per square inch, 28-day min., AASHTO T 106

Table 712-3
Mortar Proportions by Volume

Mortar	Portland Cement	Hydraulic Cement	Masonry Cement	Lime	Aggregate	Air (%)*
Cement – Lime	1	—	—	¼ to ½	Not less than 2-1/4 and not more than 3 times total volume of cementous material	8-12
Masonry Cement	—	—	1	—		8-12
Hydraulic Cement	—	1	—	¼ to ½		8-12

* When air is required, determine air content per ASTM C 91 except use the same material and proportions used in construction.

Section 713. — ROADSIDE IMPROVEMENT MATERIAL

713.01 Topsoil.

(a) Furnished topsoil. Furnish 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 vegetative growth. Demonstrate that the soil can sustain healthy crops of grass, shrubs, or other plant growth. Conform to the following:

(1) Texture

(a) Organic matter, AASHTO T 267	3 to 10%
(b) Sand, AASHTO T 88	20 to 70%
(c) Silt, AASHTO T 88	10 to 60%
(d) Clay, AASHTO T 88	5 to 30%
(2) pH, AASHTO T 289	6 to 8

(b) Conserved topsoil. See Subsection 204.02(c).

713.02 Agricultural Limestone. Furnish calcic or dolomitic ground limestone conforming to the standards of the Association of Official Analytical Chemists International, applicable State and Federal regulations, and the following:

(a) Purity (calcium and magnesium) carbonates	75% min.
(b) Gradation	Table 713-1

Table 713-1
Agricultural Limestone Gradation

Sieve Size	Minimun Percent by Mass Passing)esignated Sieve (AA HTO 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. Furnish standard commercial grade dry formulated fertilizer conforming to the standards of the Association of Official Analytical Chemists International, applicable State and Federal regulations, and required minimum percentages of available nutrients.

Supply 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 Noxious Weed Act, and applicable State and local seed and noxious weed laws. Do not use wet, moldy, or otherwise contaminated or damaged seed. Furnish each seed type in separate sealed container. 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 instructions.

713.05 Mulch.

(a) Straw. Furnish certified weed free straw from oats, wheat, rye, or other grain crops that is free from mold or other objectionable material. Furnish straw in an air-dry condition suitable for placing with mulch blower equipment.

(b) Wood fiber. Furnish processed wood fiber from wood chips conforming to the following:

(1) Colored with a green dye noninjurious 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 an equilibrium moisture content of 12±3 percent;

(7) Packaged in new labeled containers; 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. Furnish processed grass straw fiber conforming to the following:

(1) Colored with a green dye noninjurious 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. Furnish a granulated sphagnum peat moss conforming to the following:

(1) Sticks, stones, and mineral matter	0%
(2) Partially decomposed stems and leaves of sphagnum	75% min.
(3) Color	brown
(4) Textured from porous fibrous to spongy fibrous	
(5) pH	3.5 to 7.5

(6) Air-dried

(e) Mature compost. Furnish 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. Furnish 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% max.
(5) Particle size	
(a) Seeding and sodding	1/2 inch max.
(b) Erosion control	1 inch max.
(6) Organic material	50% min.
(7) Man-made inserts (plastic, glass, metal)	2% max.

(f) Straw for hydroseeding. Furnish 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. Furnish a mixture of long-wood 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 noninjurious to plant growth.

(h) Recycled pulp fiber. Furnish 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. The fiber shall readily blend with water, grass seed, fertilizer, and other additives to for a slurry suitable for application with power spray equipment. Furnish a homogeneous mixture conforming to the following:

(1) Synthetic, plastic, metal, or glass material	0%
(2) Weed Seed	0%
(3) Moisture content	15% max.
(4) Ash content	7% max.
(5) Organic matter	90% min.
(6) Boron	250 ppm max.
(7) Water-holding capacity	800 to 1200% by mass
(8) pH	4.0 to 8.5

713.06 Plant Material. Conform to the *American Standard for Nursery Stock.*

(a) Quality of plant material. Furnish plants that are excellent representatives of their normal species or varieties. Furnish nursery grown stock that has been transplanted or root-trimmed two or more times according to the kind and size of plant. Furnish plants with a normally developed branch system. Do not furnish plants with disfiguring knots, sun-scald, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements.

Furnish 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 *Standardized Plant Names* as adopted by the American Joint Committee on Horticultural Nomenclature. Legibly tag and identify all plants by name and size.

(c) Grading standards. Conform to *American Standard for Nursery Stock* as approved by ANSI.

(d) Nursery inspection and plant quarantine. Furnish plants that are essentially free from plant diseases and insect pests.

Comply with all nursery inspection and plant quarantine regulations of the states of origin and destination including Federal 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 (B&B) plants. Furnish plants from the original and undisturbed soil in which the plants were grown. Dig B&B plants to retain as many fibrous roots as possible. Wrap, transport, and handle the plants so the soil ball and small and fibrous roots remain intact.

713.07 Cellular Confinement Systems. Furnish a flexible honeycomb 3-dimensional structure fabricated from light stabilized polyethylene plastic. Conform to the following:

(a) Functional longevity	120 months min.
(b) Cell area	31.0 to 46.5 square inches
(c) Sheet thickness, ASTM D 751	48.8 to 49.6 mils
(d) Density, ASTM D 792	0.549 to 0.555 ounces per cubic inch
(e) Carbon black content, ASTM D 1603	1.5 to 2.5 %
(f) Environmental stress crack resistance, ASTM D 1693	2000 hours min.

(g) Conform to Table 713-2 for the depth specified.

Table 713-2
Cellular Confinement Systems

Property	Specifications				
Nominal cell depth	2 inch	3 inch	4 inch	6 inch	8 inch
Cell joint strength	110 pounds min.	160 pounds min.	225 pounds min.	315 pounds min.	450 pounds min.

713.08 Miscellaneous Planting Material.

(a) Stakes for bracing and anchoring. Conform to the *American Lumber Standards*. Fabricate stakes for bracing and anchoring trees from rough cypress, cedar, locust, or other approved wood essentially free from knots, rot, crossgrain, or other defects that would impair the strength of the stake. Furnish stakes with a minimum 2- by 2-inch square cross-section and adequate length.

Furnish anchor stakes of the same size and quality as bracing stakes. The diameter and length of the deadman is specified in the contract.

(b) Hose. Furnish 1-inch diameter garden or steam hose (rubber and fabric) to be used with wire for bracing and anchoring trees.

(c) Wire. Furnish 0.15-inch diameter soft annealed galvanized steel wire for bracing and anchoring trees.

(d) Wrapping material. Furnish 4-inch wide rolls of waterproof paper (triple lamination 30-30-30) or 6-inch wide rolls of burlap for wrapping trees.

(e) Twine. Furnish 2-ply twine for trees 3 inches and less in diameter and 3-ply twine for trees over 3 inches in diameter for tying wrapping material to the trees.

(f) Antidesiccant. If approved, furnish a commercially available antidesiccant emulsion to provide a film over plant surfaces that is permeable enough to permit transpiration.

(g) Tree wound dressing. Furnish a commercially available product with asphalt base and fungicide. Furnish 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 Reserved.

713.10 Sod. Furnish living vigorous sod of the type of grass and thickness specified in the contract. Furnish sod with a dense root system that is reasonably free from noxious weeds and grasses. Before taking up the sod, cut the top growth to less than 3-inch height.

713.11 Pegs for Sod. Furnish square or round pegs of sound wood and conform to the following:

(a) Length	8 inches min.
(b) Approximate cross-sectional area	1 square inch

713.12 Stabilizing Emulsion Tackifiers. Furnish a commercially available product containing no solvents or other diluting agents toxic to plant life. Conform to one of the following:

(a) Emulsified asphalt grades SS-1, SS-1h, CSS-1, or CSS-1h;

(b) Nonasphalt emulsions having a water soluble natural vegetable gum, blended with gelling and hardening agents or a water soluble blend of hydrophilic polymers, viscosifiers, sticking agents, and gums; and

(c) Polyvinyl acetate using emulsion resins and containing 60±1 percent total solids by mass.

713.13 Erosion Control Bales, Wattles, Logs, and Rolls.

(a) Straw bales. Furnish bales tied with either commercial quality baling wire or string. Conform to the following:

(1) Straw	Subsection 713.05(a)
(2) Approximate length	3.5 feet
(3) Shape	rectangular
(4) Approximate mass	70 pounds

(b) Wood excelsior bales. Furnish bales of curled wood excelsior. Tie the bales with either a commercial bailing wire, plastic, or string. Conform to the following:

(1) Approximate dimensions	16 by 18 by 36 inches
(2) Approximate mass	70 pounds

(c) Excelsior fiber wattles, logs or rolls. Furnish wattles, logs, or rolls of curled excelsior fiber rolled into a cylindrical shape and encased in a seamless photodegradable tubular netting. Conform to the following:

(1) Diameter	12 inches min.
(2) Mass	3 pounds per foot min.

(d) Straw wattles, logs or rolls. Furnish straw wattles that are manufactured from weed free straw and wrapped in a tubular photodegradable plastic netting made from 85% high density polyethylene, 14% ethyl vinyl acetate and 1% color for UV inhibition. Conform to the following:

(1) Diameter	9 inches min.
(2) Netting strand thickness	0.030 inches
(3) Netting knot thickness	0.055 inches
(4) Mass of netting	0.315 to 0.385 ounces per foot

713.14 Sandbags. Use clean, silt free material for sand filler. Conform to the following:

(a) Bag material	canvas or burlap
(b) Volume per bag	1/3 cubic foot min.

713.15 Erosion Control Culvert Pipe. Furnish culvert pipe fabricated from corrugated metal, plastic, or concrete for use in diverting live streams through work areas. Provide for AASHTO loading M18 on temporary culvert pipe placed beneath the traveled way.

713.16 Silt Fence. Conform to AASHTO M 288.

713.17 Temporary Rolled Erosion Control Products. Furnish temporary rolled erosion control products conforming to Table 713-3 and the following. See the Erosion Control Technology Council website (ECTC.org) for commercially available products that may conform to these specifications.

(a) Type 1.A, ultra-short term mulch control netting. Furnish a mulch control netting consisting of rapidly degrading photodegradable synthetic mesh or woven biodegradable natural fiber netting with a 3-month typical functional longevity designed for use on geotechnically stable slopes with gradients up to 1V:5H and channels with shear stresses up to 0.25 pounds per square foot.

(b) Type 1.B, ultra-short term netless erosion control blanket. Furnish an erosion control blanket composed of processed rapidly degrading natural or polymer fibers mechanically interlocked or chemically adhered together to form a continuous matrix with a 3-month typical functional longevity designed for use on geotechnically stable slopes with gradients up to 1V:4H and channels with shear stresses up to 0.50 pounds per square foot.

(c) Type 1.C, ultra-short term single-net erosion control blanket and open weave textile. Furnish one of the following materials: (1) an erosion control blanket composed of processed degradable natural or polymer fibers mechanically-bound together by a single rapidly degrading, synthetic or natural fiber netting to form a continuous matrix or (2) an open weave textile composed of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix. The material must have a 3-month typical functional longevity and be designed for use on geotechnically stable slopes with gradients up to 1V:3H and channels with shear stresses up to 1.50 pounds per square foot.

(d) Type 1.D, ultra-short term double-net erosion control blankets. Furnish an erosion control blanket composed of processed natural or polymer fibers mechanically-bound between two rapidly degrading, synthetic or natural fiber nettings to form a continuous matrix, with a 3-month typical functional longevity designed for use on geotechnically stable slopes with gradients up to 1V:2H and channels with shear stresses up to 1.75 pounds per square foot.

(e) Type 2.A, short-term mulch control netting. Furnish a mulch control netting consisting of photodegradable synthetic mesh or woven biodegradable natural fiber netting with a 12-month typical functional longevity designed for use on geotechnically stable slopes up to 1V:5H and channels with shear stresses up to 0.25 pounds per square foot.

(f) Type 2.B, short-term netless erosion control blanket. Furnish an erosion control blanket composed of processed degradable natural or polymer fibers mechanically-interlocked or chemically-adhered together to form a continuous matrix with a 12-month typical functional longevity designed for use on geotechnically stable slopes with gradients up to 1V:4H and channels with shear stresses up to 0.50 pounds per square foot.

(g) Type 2.C, short-term single-net erosion control blanket or open weave textile. Furnish one of the following materials: (1) an erosion control blanket composed of processed degradable natural or polymer fibers mechanically-bound together by a single degradable synthetic or natural fiber netting to form a continuous matrix; or (2) an open weave textile composed of processed degradable natural or polymer yarns or twines woven into a continuous matrix. The material must have a 12-month typical functional longevity and be designed for use on geotechnically stable slopes with gradients up to 1V:3H and channels with shear stresses up to 1.50 pounds per square foot.

(h) Type 2.D, short-term double-net erosion control blankets. Furnish an erosion control blanket composed of processed natural or polymer fibers mechanically bound between two natural fiber or synthetic nettings to form a continuous matrix with a 12-month typical functional longevity designed for use on geotechnically stable slopes with gradients up to 1V:2H and channels with shear stresses up to 1.75 pounds per square foot.

(i) Type 3.A, extended term mulch control netting. Furnish a mulch control netting consisting of a slow degrading synthetic mesh or woven natural fiber netting with a 24-month typical functional longevity designed for use on geotechnically stable slopes with gradients up to 1V:5H and channels with shear stresses up to 0.25 pounds per square foot.

(j) Type 3.B, extended term erosion control blanket or open weave textile. Furnish one of the following materials: (1) 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; or (2) an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix. The material must have a 24-month typical functional longevity and be designed for use on geotechnically stable slopes with gradients up to 1V:1½H and channels with shear stresses up to 2.00 pounds per square foot.

(k) Type 4, long-term erosion control blanket or open weave textile. Furnish one of the following materials: (1) 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; or (2) an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix. The material must have a 36-month typical functional longevity and be designed for use on geotechnically stable slopes with gradients up to 1V:1H and channels with shear stresses up to 2.25 pounds per square foot.

Table 713-3
Temporary Rolled Erosion Control Products

Property	Rolled Erosion Control Product Type											Test Method
	1.A[(1)]	1.B	1.C	1.D	2.A [(1)]	2.B	2.C	2.D	3.A [(1)]	3.B	4	
Typical functional longevity[(2)] (months)	3	3	3	3	12	12	12	12	24	24	36	N/A
Minimum tensile strength[(3)] (pounds per foot)	5	5	50	75	5	50	50	75	25	100	125	ASTM D 4595
Maximum "C" factor[(4)]	0.10 at 1V:5H	0.10 at 1V:4H	0.15 at 1V:3H	0.20 at 1V:2H	0.10 at 1V:5H	0.10 at 1V:4H	0.15 at 1V:3H	0.20 at 1V:2H	0.10 at 1V:5H	0.25 at 1V:1½H	0.25 at 1V:1H	ASTM D6459 or other qualified independent test[(7)]
Minimum permissible shear stress[(5)(6)] (pounds per square foot)	0.25	0.50	1.50	1.75	0.25	0.50	1.50	1.75	0.25	2.00	2.25	ASTM D6460 or other qualified independent test[(7)]

(1) Obtain max "C" factor and allowable shear stress for mulch control nettings with the 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) Minimum average roll values, machine direction.

(4) "C" factor calculated as ratio of soil loss from rolled erosion control product protected slope (tested at specified or greater gradient, v:h) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #2).

(5) Minimum shear stress the rolled erosion control product (unvegetated) can sustain without physical damage or excess erosion (> 1/2-inch soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using ECTC Test Method #3.

(6) The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 to 0.05.

(7) Other large scale test methods determined acceptable by the CO.

713.18 Permanent Rolled Erosion Control Products. Furnish permanent turf reinforcement mats conforming to Table 713-4 and the following. See the Erosion Control Technology Council website (ECTC.org) for commercially available products that may conform to these specifications.

(a) Type 5.A, permanent turf reinforcement mat. Furnish a non-degradable turf reinforcement mat with sufficient thickness, strength and void space for permanent erosion protection and vegetation reinforcement on geotechnically stable slopes with gradients up to 2V:1H, channels with design shear stresses up to 6.0 pounds per square foot, and other areas where design flow conditions exceed the limits of natural vegetation.

(b) Type 5.B, permanent turf reinforcement mat. Furnish a non-degradable turf reinforcement mat with sufficient thickness, strength and void space for permanent erosion protection and vegetation reinforcement on geotechnically stable slopes with gradients up to 2V:1H, channels with design shear stresses up to 8.0 pounds per square foot, and other areas where design flow conditions exceed the limits of natural vegetation.

(c) Type 5.C, permanent turf reinforcement mat. Furnish a non-degradable turf reinforcement mat with sufficient thickness, strength and void space for permanent erosion protection and void space for permanent erosion protection and vegetation reinforcement on geotechnically stable slopes up to 2V:1H, channels with design shear stresses up to 10.0 pounds per square foot, and other areas where design flow conditions exceed the limits of natural vegetation.

Table 713-4
Permanent Turf Reinforcement Mats

Properties(1)	Rolled Erosion Control Product Type			Test Method
	5.A	5.B	5.C	
Minimum tensile strength(2)(3) (pounds per foot)	125	150	175	ASTM D4595
UV stability (minimum % tensile retention)	80	80	80	ASTM D 4355 (500-hour exposure)
Minimum thickness(2) (inches)	1/4	1/4	1/4	ASTM D 6525
Minimum permissible shear stress(4) (pounds per square foot)	6.0	8.0	10.0	ASTM D 6460 or other qualified independent test(5)

(1) For turf reinforcement mats containing degradable components, obtain all property values on the non-degradable portion of the matting alone.
(2) Minimum average roll values, machine direction only.
(3) Field conditions with high loading and high survivability requirements may warrant the use of turf reinforcement mats with tensile strengths of 3,000 pounds per foot or greater.
(4) Minimum shear stress the turf reinforcement mat (fully vegetated) can sustain without physical damage or excess erosion (>1/2-inch soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council Test Method #3.
(5) Other large-scale test methods determined acceptable by the CO.

Section 714. — GEOTEXTILE AND GEOCOMPOSITE DRAIN MATERIAL

714.01 Geotextile. Use long-chain, synthetic polymers, composed at least 95 percent by mass of polyolefins or polyesters, to manufacture geotextile or the threads used to sew geotextile. Form the geotextile, including selvedges, into a stable network such that the filaments or yarns retain their dimensional stability relative to each other.

(a) Physical requirements. Conform to the following tables for the type of geotextile specified:

(1) Type I (A - F) Subsurface drainage	Table 714-1
(2) Type II (A - C) Separation	Table 714-2
(3) Type III (A - B) Stabilization geotextile	Table 714-3
(4) Type IV (A - F) Permanent erosion control	Table 714-4
(5) Type V (A - C) Temporary silt fence	Table 714-5
(6) Type VI Paving fabric	Table 714-6

All property values, with the exception of apparent opening size (AOS), in these specifications represent minimum average roll values in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the specified values). Values for AOS represent maximum average roll values.

Elevate and protect rolls with a waterproof cover if stored outdoors. When using a geotextile for a permanent installation, limit the geotextile exposure to ultraviolet radiation to less than 10 days.

(b) Evaluation procedures. Geotextile will be evaluated under Subsection 106.03. Furnish a commercial certification including the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to fully describe the geotextile.

When samples are required, remove a 3-foot long, full-width 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.

Table 714-1
Physical Requirements for Subsurface Drainage Geotextile

Property	Test Method ASTM	Units	Specifications (1)					
			Type I-A	Type I-B	Type I-C	Type I-D	Type I-E	Type I-F
Grab strength	D 4632	N	1100/700	1100/700	1100/700	800/500	800/500	800/500
Sewn seam strength	D 4362	N	990/630	990/630	990/630	720/450	720/450	720/450
Tear strength	D 4533	N	400(3)/250	400(3)/250	400(3)/250	300/175	300/175	300/175
Puncture strength	D 4833	N	400/250	400/250	400/250	300/175	300/175	300/175
Burst strength	D 3786	kPa	2750/1350	2750/1350	2750/1350	2100/950	2100/950	2100/950
Permittivity	D 4491	s^{-1}	0.5	0.2	0.1	0.5	0.2	0.1
Apparent opening size	D 4751	mm	0.43 (2)	0.25 (2)	0.22 (2)	0.43 (2)	0.25 (2)	0.22 (2)
Ultraviolet stability	D 4355	%	50 % after 500 hours of exposure					

(1) The first values in a column apply to geotextiles that break at < 50 percent elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at ≥ 50 elongation (ASTM D 4632).

(2) Maximum average roll value.

(3) The minimum average roll tear strength for woven monofilament geotextile is 245 N.

In addition, when geotextile joints are sewn, submit the seam assembly description and a sample of the sewn material. This description shall include the seam type, seam allowance, stitch type, sewing thread tex ticket number(s) and type(s), stitch density, and stitch gauge. If the production seams are sewn in both the machine and cross-machine directions, provide sample sewn seams that are oriented in both the machine and cross-machine directions. Furnish a sewn sample that has at least 2 meters of sewn seam and is at least 1.5 meters wide. Sew the sample seams with the same equipment and procedures that are used to sew the production seams. For seams sewn on-site, conform to the manufacturer's recommendations. Obtain approval of the seam before installation.

Table 714-2
Physical Requirements For Separation Geotextile

Property	Test Method ASTM	Units	Specifications [1]		
			Type II-A	Type II-B	Type II-C
Grab strength	D 4632	N	1400/900	1100/700	800/500
Sewn seam strength	D 4632	N	1260/810	990/630	720/450
Tear strength	D 4533	N	500/350	400[3]/250	300/180
Puncture strength	D 4833	N	500/350	400/250	300/180
Burst strength	D 3786	kPa	3500/1700	2700/1300	2100/950
Permittivity	D 4491	s^{-1}	0.02	0.02	0.02
Apparent opening size	D 4751	mm	0.60 [2]	0.60 [2]	0.60 [2]
Ultraviolet stability	D 4355	%	50% after 500 hours of exposure		

(1) The first values in a column apply to geotextiles that break at < 50 percent elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at ≥ 50 percent elongation (ASTM D 4632).
(2) Maximum average roll value.
(3) The minimum average tear strength for woven monofilament geotextile is 245 N.

Table 714-3
Physical Requirements For Stabilization Geotextile

Property	Test Method ASTM	Units	Specifications (1)	
			Type III-A	Type III-B
Grab strength	D 4632	N	1400/900	1100/700
Sewn seam strength	D 4632	N	1260/810	990/630
Tear strength	D 4533	N	500/350	400(3)/250
Puncture strength	D 4833	N	500/350	400/250
Burst strength	D 3786	kPa	3500/1700	2700/1300
Permittivity	D 4491	s^{-1}	0.05	0.05
Apparent opening size	D 4751	mm	0.43 (2)	0.43 (2)
Ultraviolet stability	D 4355	%	50% after 500 hours of exposure	

(1) The first values in a column apply to geotextiles that break at < 50 percent elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at ≥ 50 percent elongation (ASTM D 4632).
(2) Maximum average roll value.
(3) The minimum average tear strength for woven monofilament geotextile is 245 N.

Table 714-4
Physical Requirements for Permanent Erosion Control Geotextile

Property	Test Method ASTM	Units	Specifications (1)					
			Type IV-A	Type IV-B	Type IV-C	Type IV-D	Type IV-E	Type IV-F
Grab strength	D 4632	N	1400/900	1400/900	1400/900	1100/700	1100/700	1100/700
Sewn seam strength	D 4632	N	1260/810	1260/810	1260/810	990/630	990/630	990/630
Tear strength	D 4533	N	500/350	500/350	500/350	400 (3)/250	400 (3)/250	400 (3)/250
Puncture strength	D 4833	N	500/350	500/350	500/350	400/250	400/250	400/250
Burst strength	D 3786	kPa	3500/1750	3500/1750	3500/1750	2750/1350	2750/1350	2750/1350
Permittivity	D 4491	s^{-1}	0.7	0.2	0.1	0.7	0.2	0.1
Apparent opening size	D 4751	mm	0.43 (2)	0.25 (2)	0.22 (2)	0.43 (2)	0.25 (2)	0.22 (2)
Ultraviolet stability	D 4355	%	50 % after 500 hours of exposure					

(1) The first values in a column apply to geotextiles that break at <50 percent elongation (ASTM D 4632). The second values in a column apply to geotextiles that break at ≥ 50 elongation (ASTM D 4632).

(2) Maximum average roll value.

(3) The minimum average roll tear strength for woven monofilament geotextile is 245 N.

Table 714-5
Physical Requirements For Temporary Silt Fence

Property	Test Method ASTM	Units	Specifications		
			Type V-A	Type V-B (2)	Type V-C (3)
Grab strength	D 4632	N			
Machine direction			400	550	550
Cross direction			400	450	450
Permittivity	D 4491	s^{-1}	0.05	0.05	0.05
Apparent opening size	D 4751	mm	0.60 (1)	0.60 (1)	0.60 (1)
Ultraviolet stability	D 4355	%	70% after 500 hours of exposure		

(1) Maximum average roll value.
(2) Elongation at break ≥ 50 percent elongation (ASTM D 4632).
(3) Elongation at break < 50 percent elongation (ASTM D 4632).

Table 714-6
Physical Requirements For Paving Fabric

Property	Test Method	Units	Specifications Type VI
Grab strength	ASTM D 4632	N	500
Ultimate elongation	ASTM D 4632	%	50% at break
Asphalt retention	ASTM D 6140	L/m^2	0.90
Mass per unit area	ASTM D 5261	g/m^2	140
Melting point	ASTM D 276	ºC	150

714.02 Geocomposite Drains. Furnish a drainage core with a subsurface drainage geotextile attached to or encapsulating the core. Include all necessary fittings and material to splice one sheet, panel, or roll to the next and to connect the geocomposite drain to the collector and outlet piping.

For the drainage core, use long chain synthetic polymers composed at least 85 percent by mass of polypropylene, polyester, polyamide, polyvinyl chloride, polyolefin, or polystyrene. Fabricate the core in sheets, panels, or rolls of adequate strength to resist installation stresses and long-term loading conditions. Build the core up in thickness by means of columns, cones, nubs, cusps, meshes, stiff filaments, or other configurations.

Furnish geocomposite drains with a minimum compressive strength of 40 pounds per square inch when tested according to ASTM D 1621, procedure A. Furnish splices, fittings, and connections with sufficient strength to maintain the integrity of the system during construction handling and permanent loading without impeding flow or damaging the core.

Elevate and protect sheets, panels, or rolls with a waterproof and ultraviolet resistant cover if stored outdoors.

When using a geocomposite drain for a permanent installation, limit the geocomposite exposure to ultraviolet radiation to less than 10 days.

Geocomposites will be evaluated under Subsection 106.03. When samples are required, provide a 3-foot square sample from products supplied as sheets or panels or a 3-foot length full-roll width sample from products supplied in rolls. Label the sample with the lot and batch number, date of sampling, project number, item number, manufacturer, and product name.

(a) Geocomposite underdrains. The horizontal and vertical flow of water within the core shall interconnect at all times for the full height of the core. The drainage core with the geotextile fully encapsulating the core shall provide a minimum flow rate of 5 gallons per minute per foot of width when tested according to ASTM D 4716 under the following test conditions:

(1) 14-inch long specimen;

(2) Applied load of 7.25 pounds per square inch;

(3) Gradient of 1.0;

(4) 100-hour seating period; and

(5) Rubber membrane between platens and geocomposite.

Firmly attach the geotextile to the core so folding, wrinkling, or other movement cannot occur either during handling or after placement. Achieve bonding using nonwater-soluble adhesive, heat sealing, or other methods recommended by the manufacturer. Do not use adhesive on areas of the geotextile fabric where flow is intended to occur.

If heat sealing is used, do not weaken the geotextile below the required strength values. Extend the geotextile below the bottom of the core a length sufficient to completely encapsulate the collector pipe.

(b) Geocomposite sheet drains. The horizontal and vertical flow of water within the sheet drain shall interconnect at all times for the full height of the core. The drainage core with the geotextile laminated to one side of the core shall provide a minimum flow rate of 5 gallons per minute per foot of width when tested according to ASTM D 4716 under test conditions (1) through (5) in (a) above.

If core construction separates the flow channel into two or more sections, only the flow rate on the in-flow face is considered in determining the core's acceptability.

Firmly attach the geotextile to the core so folding, wrinkling, or other movement cannot occur either during handling or after placement. Achieve bonding using nonwater-soluble adhesive, heat sealing, or other method recommended by the manufacturer. Do not use adhesive on areas of the geotextile fabric where flow is intended to occur.

If heat sealing is used, do not weaken the geotextile below the required strength values. Extend the geotextile below the bottom of the core length sufficient to completely encapsulate the collector pipe.

(c) Geocomposite pavement edge drains. The geotextile shall tightly encapsulate the geocomposite edge drain. The edge drains shall permit in-flow from both sides. The drain core with the geotextile in place shall provide a minimum flow rate of 15 gallons per minute per foot of width when tested according to ASTM D 4716 under test conditions (1) through (5) in (a) above, except the gradient shall be 0.1.

If the geocomposite polymer core separates the flow channel into two or more parts, consider only the tested flow rate of the channel facing the pavement.

All pipe and pipe fittings used for an outlet to the edge drain shall be non-perforated plastic pipe conforming to Subsection 706.08.

The solvent cement for the outlet pipe and fittings shall be according to ASTM D 2564. The material composition of the outlet fittings shall be compatible for direct solvent welding to PVC.

Section 715. — PILING

715.01 Untreated Timber Piles. Conform to AASHTO M 168. Fabricate the piles from the following species for the sizes and dimensions specified in the contract:

(a) Douglas fir;

(b) Larch;

(c) Norway pine;

(d) Red oak; or

(e) Southern yellow pine.

Install steel straps along the length of the pile at not more than 10-foot centers. In addition, place a strap at 3, 6, and 12 inches from the tip and 2 additional straps within 2 feet of the butt. Use 1¼-inch wide by 22 gage thick steel strapping material fabricated from cold-rolled, heat-treated, high-tensile steel having a minimum tensile strength of 5,000 pounds.

Hold straps in place with clips that are secured by crimping twice in the clip length with a notch type sealer. Fabricate the clips from 2¼-inch by 20 gage thick steel. The clip joint shall develop at least 75 percent of the strap tensile strength. Straps shall encircle the pile once and be tightened by hand-operated or power-assisted tensioning tools.

715.02 Treated Timber Piles. Conform to AASHTO M 133. Use Douglas fir or southern yellow pine for saltwater installations. Conform to Subsection 715.01 steel strap requirements.

Use the pressure method procedure prescribed in AWPA Standard C1. Apply the treatment to the piles after all millwork is completed.

Imprint legible symbols or legend on the end of all piles identifying the name of the treating company and type and year of treatment according to AWPA Standards M1 and M6.

715.03 Concrete Piles. Fabricate piles from class A (AE) concrete conforming to Section 552. For billet steel and rail steel reinforcement bars, conform to Subsection 709.01. For prestressing reinforcement steel, conform to Subsection 709.03.

Construct precast concrete piles according to Section 552. Construct prestressed concrete piles according to Section 553. When 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 all 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 free from 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 the surface of each pile with a class 1 ordinary surface finish according to Subsection 552.16. Cure the piles according to Sections 552 and 553 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 ºF or 21 days at a minimum temperature of 40 ºF. Do not transport or drive piles until cured for at least 21 days at a minimum of 60 ºF or 28 days at a minimum of 40 ºF. When high-early-strength cement is used, do not move, transport, or drive piles until cured for at least 7 days.

715.04 Steel Shells. Furnish either cylindrical or tapered pile shells of spiral welded, straight-seam welded, or seamless tube steel material. Use only one type of pile shell throughout a structure. Conform to the following minimum shell wall thicknesses:

• Outside cylinder diameter < 14 inches	1/4 inch
• Outside cylinder diameter ≥ 14 inches	3/8 inch
• Tapered or fluted	3/16 inch

(a) Shells driven without a mandrel. For tapered or step tapered cast-in-place concrete piles, furnish shells having a minimum 12-inch diameter at cutoff and a minimum 8-inch diameter tip. For constant diameter cast-in-place concrete piles, furnish shells having a minimum nominal diameter of 10¾ inches.

Fabricate shells from not less than 3/16-inch plate stock conforming to ASTM A 36. Shells may be either spirally welded or longitudinally welded and may be either tapered or constant in section. Seal the tips as noted on the drawings.

(b) Shells driven with a mandrel. Furnish shells of sufficient strength and thickness to withstand driving without injury and to resist harmful distortion and buckling due to soil pressure after being driven and the mandrel removed. Butt and tip dimensions are specified in the contract.

715.05 Steel Pipes. Conform to the following:

(a) Steel pipe to be filled with concrete	ASTM A 252, grade 2
(b) Closure plates for closed end piles	ASTM A 36
(c) Reinforced conical points for pipe closure at the tip	AASHTO M 103
(d) Unfilled tubular steel piles for welded and seamless steel pipe piles with chemical properties conforming to ASTM A 53, grade B	ASTM A 252, grade 2

715.06 Steel H-Piles. Furnish steel H-piles from rolled steel sections of the mass and shape specified in the contract. Fabricate the H-piles from structural steel conforming to ASTM A 36, except do not use steel manufactured by the acid-bessemer process.

For copper-bearing structural steel, furnish steel with 0.20 to 0.35 percent copper.

715.07 Sheet Piles. For steel sheet piles, conform to AASHTO M 202 or ASTM A 572. For all other sheet piles, conform to the requirements prescribed above for the particular material specified. Make the joints practically watertight when the piles are in place.

715.08 Pile Shoes. For timber piles, prefabricate shoes from cast steel conforming to AASHTO M 103.

715.09 Splices. For H or pipe piles, manufacture splices from structural steel conforming to ASTM A 36.

Section 716. — MATERIAL FOR TIMBER STRUCTURES

716.01 Untreated Structural Timber and Lumber. Conform to AASHTO M 168. Furnish an inspection certification from an agency accredited by the American Lumber Standards Committee for the species and grade. Mark all pieces with the inspection service, grade designation, species, and inspector identity.

Season and dry all 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. Boxed-heart pieces are defined as timber so sawed that, at any point in the length of a sawed piece, the pith lies entirely inside the four faces.

716.02 Hardware. Machine bolts, drift bolts and dowels may be medium steel. Fabricate washers from gray iron or malleable iron castings unless structural washers are specified.

Use square-headed bolts and nuts. Use a standard commercial type of cut or round nail. Use cut, round, or boat spikes as specified.

Galvanize all hardware according to AASHTO M 232 or cadmium plate all hardware according to ASTM B 766, class 12, type III.

Use ring or shear-plate timber connectors conforming to AASHTO *Standard Specifications for Highway Bridges* Division II, article 16.2.6, Timber Connectors.

716.03 Treated Structural Timber and Lumber. Furnish wood according to Subsection 716.01. Incise all wood and make all dimensional cuts and holes in the wood before pressure treatment. Treat the wood and mark each piece of treated timber according to AASHTO M 133. Treat glued laminated timber members according to AWPA Standards C14 and C28. Use the type of treatment and minimum net retention of preservative shown in the plans.

Treat timber members according to *Best Management Practices for the Use of Treated Wood in Aquatic Environments* as published by the Western Wood Preservers Association.

All treated timber members must have a quality mark approved by the American Lumber Standards Committee for individual pieces or sealed pallets assuring that treatment conforms to the appropriate AWPA standards.

Provide a production certification for each lot of treated wood according to Subsection 106.03. Indicate the preservative used, penetration in inches, retention in pounds per cubic foot (assay method), and the "Best Management Practices" used in treating timber members.

716.04 Structural Glued Laminated Timber. Furnish structural glued laminated timber according to AITC 117. Fabricate according to the combination and grade as indicated in the contract. Fabricate structural glued laminated members according to ANSI/AITC A190.1, Structural Glued Laminated Timber.

Manufacture members as industrial appearance grade for wet use conditions, using a phenol-resorcinol resin type of adhesive throughout. Use only single- or multiple-piece laminations with bonded edge joints.

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
(2) Fracture critical bridge members	AASHTO M 270, grade 36F
(3) Other shapes, plates, and bars	AASHTO M 270, grade 36

(b) High-strength low-alloy structural (HSLA) 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) High-strength quenched and tempered (QT) steel. Conform to the following:

(1) Primary bridge members	AASHTO M 270, grade 50WT, 100T, or 100WT
(2) Fracture critical bridge members	AASHTO M 270, grade 70WF, 100F, or 100WF
(3) Other shapes, plates, and bars	AASHTO M 270, grade 50W, 100, or 100W

(d) Bolts and nuts. Conform to ASTM A 307.

(e) High-strength bolts, nuts, and washers. Conform to either AASHTO M 164 or M 253 as specified.

717.02 Steel Forgings. Conform to AASHTO M 102, classes C, D, F, and G.

717.03 Pins and Rollers. Furnish pins and rollers more than 9 inches in diameter from annealed carbon-steel forgings conforming to AASHTO M 102, class C.

Furnish pins and rollers 9 inches or less in 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 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 Coarse Thread Series, class 2A. Thread pin ends with a diameter of 1⅜ inches or more with 6 threads to the inch.

717.04 Castings.

(a) Steel castings. Conform to AASHTO M103, grade 70-36.

(b) Chromium alloy steel castings. Conform to AASHTO M 163, grade CA-15.

(c) Gray iron castings. Conform to AASHTO M 105, class no. 30B, unless otherwise specified. Make the castings free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting strength and value for the service intended. Boldly fillet the castings at angles and make the arrises sharp and perfect. Sand blast all castings or otherwise effectively remove the scale and sand to present a smooth, clean, and uniform surface.

(d) Malleable iron castings. Conform to ASTM A 47, grade 35018, unless otherwise specified. For workmanship, finishing, and cleaning, conform to (c) above.

717.05 Welded Stud Shear Connectors. Conform to AASHTO M 169 and AASHTO *Standard Specifications for Highway Bridges* Division II, article 11.3.3, Welded Stud Shear Connectors.

717.06 Steel Pipe. Furnish galvanized steel pipe conforming to ASTM A 53, type F, standard weight class, and plain ends for the designation specified in the contract.

717.07 Galvanized Coatings. When specified, galvanize structural steel according to AASHTO M 111.

717.08 Sheet Lead. Furnish common desilverized lead conforming to ASTM B 29. Furnish sheets in a uniform 0.125±0.030-inch thickness free from cracks, seams, slivers, scale, and other defects.

717.09 Steel Grid Floors. Conform to ASTM D 5484, type I. Furnish galvanized steel grid floors unless painting is specified.

717.10 Bearings.

(a) Elastomeric bearings, plain or laminated. Conform to AASHTO M 251.

(b) Elastomeric bearings, high load rotational confined. Conform to ASTM D 5212.

(c) High load rotational spherical bearings. Conform to ASTM D 5977.

717.11 Polytetrafluoroethylene (PTFE) Surfaces for Bearings. When PTFE surfaces are specified for bearings, which are not listed in Subsection 717.10, conform to the following:

(a) PTFE resin. Furnish virgin PTFE resin material conforming to ASTM D 4895 and the following:

(1) Specific gravity	2.13 to 2.19
(2) Melting point	623 ºF ±2 ºF

(b) Filler material. Furnish milled glass fibers, carbon, or other approved inert material.

(c) Adhesive material. Furnish epoxy resin adhesive conforming to FSS MMM-A-134, FEP film, or an approved equal.

(d) Unfilled PTFE sheet. Furnish unfilled PTFE sheet made from PTFE resin. Conform to the following:

(1) Tensile strength, ASTM D 638	2,800 pounds per square inch min.
(2) Elongation, ASTM D 638	200% min.

(e) Filled PTFE sheet. Furnish filled PTFE sheet made from PTFE resin uniformly blended with filler material. For filled PTFE sheets containing glass fibers or carbon, conform to Table 717-1.

(f) Fabric containing PTFE fibers. Furnish fabric made from oriental multifilament PTFE fluorocarbon and other fibers. Use PTFE fibers, conform to the following:

(1) Tensile strength, ASTM D 2256	24,000 pounds per square inch min.
(2) Elongation, ASTM D 2256	75% min.

Table 717-1
Filled Polytetrafluoroethylene Sheeting

Property	ASTM Method	15% Glass Fibers	25% Carbon
Mechanical:			
Min. tensile strength	D 638	2,000 pounds per square inch	1,300 pounds per square inch
Min. elongation	D 638	150%	75%
Physical:			
Min. specific gravity	D 792	2.20	2.10
Melting point	D 638	620±18 ºF	620±18 ºF

(g) Interlocked bronze and filled PTFE components. Furnish a phosphor bronze plate conforming to AASHTO M 108 with an 0.010-inch thick porous bronze surface layer conforming to ASTM B 103 into which is impregnated a PTFE compound. Overlay the surface with compounded PTFE not less than 0.001 inches thick.

(h) PTFE metal composite. Furnish virgin PTFE molded on each side and completely through a 1.32-inch perforated stainless steel sheet conforming to ASTM A 240, type 304.

(i) Surface treatment. For epoxy bonding, factory treat one side of the PTFE sheet with a sodium napthalene or sodium ammonia process.

(j) Stainless steel mating surface. Conform to ASTM A 240, type 304 and the following:

(1) Thickness	0.0359 inches min.
(2) Surface finish	20 μ inches root mean square max.

Polish or roll stainless steel mating surfaces as necessary to meet the specified friction properties.

717.12 Structural Aluminum Alloy. Conform to the *Specifications for Aluminum Structures* published by the Aluminum Association, Inc. For aluminum expansion joint material, furnish aluminum extrusion alloy 6061-T6.

717.13 Aluminum Alloy for Bridge Rail. Conform to AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware*.

717.14 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.

717.15 Aluminum Welding Wire. Conform to Table 717-2.

Table 717-2
Aluminum Welding Wire

Alloys Series	Specification	Wire
3xxx and 6xxx		ER 4043
3x x, 5xxx, and 6xxx	AWS 5.10	ER 5356
5xxx and 6xxx		El 5556 or ER 5183

717.16 Elastomeric Compression Joint Seals. Conform to AASHTO M 297.

Section 718. — TRAFFIC SIGNING AND MARKING MATERIAL

718.01 Retroreflective Sheeting. Conform to ASTM D 4956.

Conform to ASTM D 4956 Supplemental Requirement S1, Fungus Resistance, if specified. For reboundable retroreflective sheeting, conform to ASTM D 4956 including Supplemental Requirement S2, Reboundable Sheeting Requirements.

When an adhesive is used, use ASTM D 4956, backing class 1, 2, or 3.

718.02 Reserved.

718.03 Plywood Panels. Furnish exterior type B-B high-density overlay plywood or better conforming to NIST specification PS-1 for construction and industrial plywood. Use 1/2-inch thick plywood for sign panels with a facial area 4 square feet or less and the horizontal dimension no greater than the vertical dimension. Use 3/4-inch thick plywood for larger panels.

Abrade, clean, and degrease the face of the plywood panel according to methods recommended by the manufacturer of the retroreflective sheeting. Treat the edges of the plywood panel with an approved edge sealant.

718.04 Steel Panels. Furnish 0.079-inch continuous coat galvanized sheet steel blanks conforming to ASTM A 653. Mill phosphatize the zinc coating (designation G 90) to a thickness of 0.0035 ± 0.00175 ounces per square foot of surface area.

Furnish panels with a substantially plane surface. Do not use twisted or buckled panels. Clean, degrease, or otherwise prepare the panels according to methods recommended by the sheeting manufacturer.

718.05 Aluminum Panels. Conform to ASTM B 209, alloy 6061-T6 or 5052-H38.

Fabricate all temporary panels and those permanent panels that are 30 by 30 inches or smaller from 0.080-inch thick aluminum sheets. Fabricate larger permanent panels from 0.125-inch thick aluminum sheets.

The blanks shall be free from laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. The thickness shall be uniform and the blank commercially flat. Perform shearing, cutting, and punching before preparing the blanks for application of reflective material.

Clean, degrease, and chromate the blanks or otherwise properly prepare the panels according to methods recommended by the sheeting manufacturer.

718.06 Plastic Panels.

(a) Plastic. Furnish light, flexible, high-impact, and ultraviolet chemical resistant polycarbonate material, or approved equal that will accept adhesives, coatings, and retroreflective sheeting material as recommended for such material.

Fabricate panels that are 24 by 24 inches or smaller from 0.08-inch thick plastic blanks. Fabricate larger panels from 0.125-inch thick plastic blanks.

The panels shall be flat and free of buckles, warps, and other defects. Where multiple panels adjoin, the gap between adjacent panels shall not be greater than 5/8 inches. Signs larger than 24 by 24 inches shall have reinforcement stiffeners attached on the back for rigidity and for mounting on the supports.

(b) Fiberglass reinforced plastic. Furnish fiberglass reinforced thermoset polyester acrylic modified laminate sheets. Furnish sign panel UV stabilized for outdoor weathering ability. The sign panel shall accept adhesives, coatings, and retroreflective sheeting material as recommended.

Furnish sign panel 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.

Wipe sign panel surface clean with a slightly dampened cloth before applying reflective sheeting.

Make fiberglass reinforced panels conform to the following mechanical and physical properties:

(1) Average tensile strength, ASTM D 638	10,000 psi min.
(2) Average tensile modulus, ASTM D 638	1,200,000 psi min.
(3) Average flexural strength, ASTM D 790	20,000 psi min.
(4) Average flexural modulus, ASTM D 790	1,200,000 psi min.
(5) Average compression strength, ASTM D 695	32,000 psi min.
(6) Average compression modulus, ASTM D 695	1,400,000 psi min.
(7) Punch shear, ASTM D 732	13,000 psi min.
(8) Thickness	0.13±0.004 inches
(9) Size, dimension < 12 feet, ASTM D 3841	±0.12 inches
(10) Squareness in 12-foot length, ASTM D 3841	±0.12 inches

(11) Surfaces, top and bottom	Smooth
(12) Color, visually uniform gray, Munsel[R] range	N.7.5/ - N.8.5/
(13) Coefficient of lineal thermal expansion, ASTM D 696	0.000004 inches/inch/ºF max.
(14) Impact resistance, -65 to 212 ºF, ASTM D 3841	1.2 pounds from 60 feet
(15) Flame resistance, ASTM D 635	1 inch max.
(16) Weather resistance, 3000±100 h, ASTM D 3841	grade II min.

718.07 Extruded Aluminum Panels. Furnish panels conforming to ASTM B 221, aluminum alloy 6063-T6. For panel thickness and fabrication, conform to Subsection 718.05. The maximum allowable deviation from flat on the face is 0.05 inches per foot.

718.08 Signposts. Furnish wood, steel, or aluminum signposts as specified.

(a) Wood posts. Furnish posts from dry no. 1 grade Douglas fir, southern or Ponderosa pine, hemlock, spruce, or western larch conforming to AASHTO M 168. Treat the posts with water-borne preservative ACA, ACZA, or CCA according to AWPA Standard C14 except the minimum preservative retention is 0.40 pounds per cubic foot.

(b) Galvanized steel posts. Furnish posts that are straight, smooth, and free from defects affecting strength, durability, or appearance. Conform to the following:

(1) U-channel steel posts. Furnish flanged, channel, galvanized steel posts conforming to ASTM A 499, grade 60, and the following:

(a) Dimensions of U cross-section

(1) Width of opened end of U including flanges	3.0 – 3.5 inches
(2) Width of closed end of U	1.0 – 1.6 inches
(3) Depth of U	1.0 – 2.0 inches
(4) Thickness of steel	0.12 – 0.20 inches

(b) Punching. Starting 1 inch from the top and extending the full length of the post, drill or punch 3/8-inch holes on 1-inch centers along the centerline of the bottom of the U. Remove all burrs and sharp edges.

(c) Galvanizing after punching	AASHTO M 111

(2) Square tubular steel posts. Furnish square tubular galvanized steel posts conforming to ASTM A 1011, grade 55, or ASTM A 715, grade 60, and the following:

(a) Dimensions

(1) Outside dimensions	1¾ by 1¾ inches or 2 by 2 inches
(2) Wall thickness	0.083 inches
(3) Mass	1.7 – 2.0 pounds per foot

(b) 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 all burrs and sharp edges.

(c) Galvanizing after punching (inside and outside of post)	ASTM A 635, coating Z275 designation

(c) Aluminum posts. Furnish approved standard shapes and thicknesses conforming to ASTM B 221, alloy 6061-T6, 6351-T5, 6063-T6, or 6005-T5.

(d) Corrosion resistant steel posts. Furnish posts conforming to ASTM A 588 or ASTM A 242.

718.09 Object Marker and Delineator Posts. Furnish wood, steel, or aluminum object marker and delineator posts. Delineator posts may also be fabricated from plastic.

(a) Wood posts. Furnish 4- by 4-inch wooden posts conforming to Subsection 718.08.

(b) Steel posts. Furnish flanged U-channel steel posts weighing not less than 2 pounds per foot and conforming to ASTM A 36. Galvanize the posts according to AASHTO M 111.

(c) Aluminum posts. Furnish standard shaped 1/8-inch thick aluminum posts conforming to ASTM B 221, alloy 356.0-T6.

(d) Plastic posts. Furnish flexible delineator posts made with high impact resistant polymer material.

718.10 Hardware. For lag screws, washers, clip angles, wood screws, shear plates, U-bolts, clamps, bolts, nuts, and other fasteners, use galvanized steel or aluminum alloy.

For high-strength steel bolts, nuts, and washers, conform to Subsection 717.01. Galvanize steel hardware according to AASHTO M 232.

For aluminum alloy bolts, nuts, and washers, conform to Subsections 717.13 and 717.14 as applicable.

Furnish oversize bolt heads and oversize neoprene or nylon washers for plastic sign panels.

718.11 Letters, Numerals, Arrows, Symbols, and Borders. Colors will be specified in the contract and shall conform to Subsection 718.01.

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. Conform to one of the following:

(a) Type L-1 (screen process). Apply letters, numerals, arrows, symbols, and borders on the retroreflective sheeting or opaque background of the sign by direct or reverse screen process. Apply messages and borders of a color darker than the background to the paint or the retroreflective sheeting by direct process. Produce messages and borders of a color lighter than sign background by the reverse screen process.

Use opaque or transparent colors, inks, and paints in the screen process of the type and quality recommended by the retroreflective sheeting manufacturer.

Perform the screening in a manner that results in a uniform color and tone, with sharply-defined edges of legends and borders, and without blemishes on the sign background that will affect intended use.

Air dry or bake the signs after screening according to manufacturer's recommendations to provide a smooth hard finish. Any signs with blisters or other blemishes will be rejected.

(b) Type L-3 (direct applied characters). Cut letters, numerals, symbols, borders, and other features of the sign message from the type and color of the retroreflective sheeting specified, and apply to the sign background's retroreflective sheeting according to the retroreflective sheeting manufacturer's instructions. For the retroreflective sheeting minimum coefficient of retroreflection (R_A), conform to AASHTO M 268.

718.12 Delineator and Object Marker Retroreflectors. Furnish type 1 or type 2 retroreflectors that are ready for mounting. Furnish antitheft hardware for mounting as required.

(a) Type 1 (acrylic plastic lens). Furnish a 7-square inch minimum acrylic plastic lens 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. Permanently seal the units against the intrusion of dust, water, or air. Conform to Table 718-1 regardless of the orientation angle.

Table 718-1
Minimum Coefficient of (Retroreflective) Luminous Intensity (R_I) (1)
Candelas per Footcandle

Observation Angle °	Entrance Angle °	White(2)	Yellow	Red
0.1	0	115	70	30
0.1	20	45	25	12

(1) See AASHTO T 257.
(2) Crystal, clear, or colorless are acceptable color designations.

Mount the retroreflector unit in a housing fabricated from 0.063-inch aluminum alloy 3003-H-14 or similar, or from cold rolled, hot dip, galvanized steel, having a thickness of 0.064 inches. Provide antitheft attachment hardware.

(b) Type 2 (retroreflective sheeting). Furnish a fungus resistant type III, V, VII, VIII, or IX retroreflective sheeting with a class 1 or 2 adhesive backing conforming to ASTM D 4956. Attach the sheeting to an aluminum or plastic support panel (target plate) of the size and dimension specified.

718.13 Conventional Traffic Paint. Conform to AASHTO M 248.

718.14 Waterborne Traffic Paint. Furnish an acrylic water-based, ready-mixed paint for use on asphalt and rigid pavements conforming to the following:

(a) Composition. Furnish 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, % by mass, ASTM D 3723	45% to 55%
(2) Lead, chromium, cadmium, or barium ASTM D 3335 & D3718	0%
(3) Volatile organic compounds, ASTM D 2369	20.0 ounces per gallon max.
(4) Mass of paint, ASTM D 1475	12.0 pounds per gallon min.

(b) Viscosity. ASTM D 562 — 75-90 Krebs units

(c) Drying time.

(1) Dry to no pickup, ASTM D 711	10 minutes max.
(2) Drying to no track, 6 pounds per gallon, type 1 waterproofed glass beads, 15±1 mil wet film thickness at 130 °F	90 seconds max.

(d) Flexibility. ASTM D 522, using the 1/4-inch cylindrical mandrel	No cracking or flaking
(e) Dry opacity. ASTM D 2805, contrast ratio at 319 square feet per gallon spreading rate	0.96 min.
(f) Color.	
(1) White, ASTM D 1729	Match FHWA standard highway white
(2) Yellow, ASTM D 1729	Match FHWA standard highway yellow
(g) Daylight reflectance. (Without glass beads)	
(1) White, FTMS 141 method 6121	84% relative to magnesium ASTM E 1347 oxide standard
(2) Yellow, FTMS 141 method 6121	55% relative to magnesium ASTM E 1347 oxide standard
(h) Bleeding ratio. ASTM 969. Determine reflectance according to ASTM D 1347 immediately after drying. Divide the average of 3 reflectance readings of the paint over the bleeding surface by the average of 3 readings over the non-bleeding surface to determine the bleeding ratio.	0.96 min.
(i) Scrub resistance. ASTM D 2486	300 cycles min.
(j) Freeze-thaw stability. ASTM D 2243	
(1) Change in viscosity	±5 Krebs units max.
(2) Decrease in scrub resistance	-10% max.

(k) Storage stability. During a 12-month storage period, conform to the following:

(1) No excessive setting, caking, or increase in viscosity; and

(2) Readily stirred to a consistency for use in the striping equipment.

718.15 Epoxy Markings. Furnish 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 D 476, type II and type III	18% min.
(b) Epoxy resin	75 to 82%

(2) Yellow:

(a) Chrome yellow ($PbCrO_4$), ASTM D 126, type III.	23% min.
(c) Epoxy resin	70 to 77%

(3) Non-Lead Yellow:

(a) Titanium dioxide (TiO_2) ASTM D 476, type II and type III.	14% min.
(b) Organic yellow	7 to 8%
(c) Epoxy resin	75 to 79%

(b) Epoxy content. Component A. Mass per epoxy equivalent, ASTM D 1652	Manufacturer's target value ±50
(c) Amine value. Component B, ASTM D 2074	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 D 1729	Match FHWA standard highway white
(2) Yellow, ASTM D 1729	Match FHWA standard highway yellow

(f) Directional reflectance. (Without glass beads)

(1) White, ASTM E 1347	84% relative to magnesium oxide standard
(2) Yellow, ASTM E 1347	55% relative to magnesium oxide standard

(g) Drying time. 15 mil film thickness with beads.

(1) Laboratory at 72 ºF, ASTM D 711 to no-pick-up condition	30 minutes maximum
(2) Field at 77 ºF, viewed from 50 feet to no-tracking condition	10 minutes maximum

(h) Abrasion resistance. Wear index with a CS-17 wheel under a 35.3 ounce load for 1000 cycles, ASTM D 4060	82 max.
(i) Hardness. Shore D hardness with 72- to 96-hour cure at 72 ºF, ASTM D 2240	75 to 100

(j) Storage. When stored for up to 12 months, individual epoxy components shall not require mixing before use.

718.16 Polyester Markings. Furnish a 2-component system conforming to the following:

(a) Directional reflectance. (Without glass beads)

(1) White, ASTM E 1347	80% relative to magnesium oxide standard
(2) Yellow, ASTM E 1347	55% relative to magnesium oxide standard

(b) Color.

(1) White, ASTM D 1729	Match FHWA standard highway white
(2) Yellow, ASTM D 1729	Match FHWA standard highway yellow

(c) Viscosity. Uncatalyzed polyester at 25 ºF, ASTM D 562	70 to 90 Krebs units

(d) Bleeding. ASTM D 969 — 6 minimum

(e) Drying time in field. Viewed from 50 feet — 45 minutes maximum to no-tracking condition

718.17 Thermoplastic Markings. Conform to AASHTO M 249.

718.18 Preformed Plastic Markings. Conform to ASTM D 4505, type I, V, VI, or VII, grade A, B, C, D, or E.

718.19 Glass Beads. Conform to AASHTO M 247 for the type specified. Table 1, Gradation of Glass Beads in AASHTO M 247 is supplemented by Table 718-2. Treat glass beads with an adherence coating as recommended by manufacturer.

Table 718-2
Gradation of Glass Beads

Sieve Size	Percent by Mass Passing Designated Sieve (ASTM D 1214)		
	Grading Designation		
	Type 3	Type 4	Type 5
No. 8			100
No. 10		100	95 - 100
No. 12	100	95 - 100	80 - 95
No. 14	95 - 100	80 - 95	10 - 40
No. 16	80 - 95	10 - 40	0 - 5
No. 18	10 - 40	0 - 5	0 - 2
No. 20	0 - 5	0 - 2	
No. 25	0 - 2		

For type 3, 4, and 5 glass beads, also conform to the following:

(a) Treat beads with a reactive adherence coating as recommended by the manufacturer.

(b) Roundness, FLH T 520 — 70% min. per sieve size

(c) Refractive index, AASHTO M 247 — 1.50 - 1.55

718.20 Raised Pavement Markers.

(a) Non-plowable, extended life, retroreflective, pavement markers. Conform to ASTM D 4280.

(b) Plowable, retroreflective, pavement markers. Conform to ASTM D 4383.

718.21 Temporary Pavement Markings.

(a) Preformed retroreflective tape. Furnish 4-inch wide tape conforming to ASTM D 4592, type I (removable).

(b) Raised pavement markers. Furnish an L-shaped polyurethane marker body with retroreflective tape on both faces of the vertical section, capable of retroreflecting light from opposite directions, and with an adhesive on the base.

Provide a minimum coefficient of retroreflection of 1200 candela per lux per square meter at 0.1-degree observation angle and -4 degrees entrance angle.

Fabricate the marker body from 60-mil minimum thickness polyurethane. Fabricate the vertical leg about 2 inches high by about 4 inches wide. Fabricate the base for the marker body about 1⅛ inches wide.

Factory apply a 125-mil minimum thickness and 750-mil wide pressure sensitive adhesive to the marker base and protect it with release paper.

If approved, variations in design and dimensions will be permitted to meet manufacturer's standards.

718.22 Temporary Traffic Control Devices. Use suitable commercial grade material for the fabrication of the temporary traffic control devices. Construct the devices from material capable of withstanding anticipated weather, traffic conditions, and suitable for the intended use. Do not use units used on other projects without approval.

718.23 Epoxy Resin Adhesives. Epoxy resin adhesives for bonding traffic markers to rigid and asphalt concrete pavements shall conform to AASHTO M 237.

Section 719. — Reserved

Section 720. — STRUCTURAL WALL AND STABILIZED EMBANKMENT MATERIAL

720.01 Mechanically-Stabilized Earth Wall Material.

(a) Concrete face panels. Conform to Section 552 and the following:

(1) Use concrete class A(AE) with a minimum 4,000-pound per square inch 28-day compressive strength.

(2) Conform to Section 562 and fully support the units until the concrete reaches a minimum compressive strength of 1,000 pounds per square inch. The units may be shipped and installed after the concrete reaches a minimum compressive strength of 3,400 pounds per square inch.

(3) Finish the front face of the panel with a class 1 finish according to Subsection 552.16. Screed the rear face of the panel to eliminate open pockets of aggregate and surface distortions in excess of 1/4 inch. Cast the panels on a flat area. Do not attach galvanized connecting devices or fasteners to the face panel reinforcement steel.

(4) Clearly scribe on an unexposed face of each panel the date of manufacture, the production lot number, and the piece mark.

(5) Handle, store, and ship all units in such a manner as to eliminate the dangers of chipping, discoloration, cracks, fractures, and excessive bending stresses. Support panels in storage on firm blocking to protect the panel connection devices and the exposed exterior finish.

(6) Manufacture all 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. Squareness, as determined by the difference between the 2 diagonals, shall not exceed 1/2 inch.

(c) Panel surface finish. Surface defects on smooth formed surfaces 5 feet or more in length shall not exceed 1/8 inch. Surface defects on textured-finished surfaces 5 feet or more in length shall not exceed 5/16 inch.

Concrete face panels having any or all of the following defects will be rejected.

- Defects that indicate imperfect molding;
- Defects indicating honeycombed or open texture concrete;
- Cracked or severely chipped panels; or
- Color variation on front face of panel due to excess form oil or other reasons.

(b) Wire facing. Fabricate from welded wire fabric conforming to AASHTO M 55, except that section 7.4. applies for all longitudinal and transverse wire sizes. After fabrication, galvanize according to AASHTO M 111.

(c) Backing mat. Fabricate from welded wire fabric conforming to AASHTO M 55 except that section 7.4 applies for all longitudinal and transverse wire sizes. After fabrication, galvanize according to AASHTO M 111.

(d) Clevis connector. Fabricate from cold-drawn steel wire conforming to AASHTO M 32, and weld according to AASHTO M 55. After fabrication, galvanize according to AASHTO M 111.

(e) Connector bars. Fabricate from cold-drawn steel wire conforming to AASHTO M 32. Galvanize according to AASHTO M 111.

(f) Fasteners. Furnish 1/2-inch diameter, heavy hexhead bolts, nuts, and washers conforming to AASHTO M 164. Galvanize according to AASHTO M 232.

(g) Hardware cloth. Fabricate with maximum 1/4-inch square mesh openings from woven or welded galvanized steel wire fabric conforming to ASTM A 740.

(h) Reinforcing mesh. Fabricate from cold-drawn steel wire conforming to AASHTO M 32. Weld the wire into the finished mesh fabric according to AASHTO M 55. After fabrication, galvanize according to AASHTO M 111. Repair all damage to the galvanized coating before installation.

(i) Reinforcing strips. Fabricate from high-strength, low-alloy structural steel conforming to ASTM A 572, grade 65, type 3. After fabrication, galvanize according to AASHTO M 111.

(j) Tie strip. Fabricate from hot-rolled steel conforming to ASTM A 570, grade 50. Galvanize according to AASHTO M 111.

720.02 Gabion and Revet Mattress Material.

(a) Basket mesh. Twist or weld the mesh from galvanized steel wire conforming to ASTM A 641, class 3 or aluminized steel wire conforming to ASTM A 809. Use wire with a minimum tensile strength of 60,000 pounds per square inch when tested according to AASHTO T 244. The galvanized or aluminized coating may be applied after mesh fabrication. Make the mesh openings with a maximum dimension less than 4½ inches, an area less than 10 square inches, and a size less than the gabion or revet mattress rock to be used with the mesh.

(1) Gabion baskets (1 foot or greater in the vertical dimension). Fabricate the mesh for galvanized or aluminized coated baskets from nominal-sized 0.12-inch or greater diameter wire and fabricate the mesh for polyvinyl chloride coated baskets from nominal-sized 0.11-inch or greater diameter wire.

(a) Twisted wire mesh. Form the mesh in a uniform hexagonal pattern with nonraveling double twists. For galvanized or aluminized coated baskets, tie the perimeter edges of the mesh for each panel to a 0.15-inch or greater diameter selvedge wire. For polyvinyl chloride coated baskets, tie the perimeter edges of the mesh for each panel to a 0.13-inch or greater diameter selvedge wire. Make the selvedge at least the same strength as the body of the mesh. Furnish selvedge wire from the same type of material used for the wire mesh.

(b) Welded wire mesh. For galvanized or aluminized coated baskets, weld each connection to obtain a minimum average weld shear strength of 585 pounds with no value less than 450 pounds. For polyvinyl chloride coated baskets, weld each connection to obtain a minimum average weld shear strength of 472 pounds with no value less than 360 pounds.

Fabricate gabion baskets in the dimensions required with a dimension tolerance of ±5 percent. Where the length of the basket exceeds 1.5 times its width, equally divide the basket into cells less than or equal to the basket width using diaphragms of the same type and size mesh as the basket panels. Prefabricate each basket with the necessary panels and diaphragms secured so they rotate into place.

(2) Revet mattresses (less than 1 foot in the vertical dimension). Fabricate the mesh from nominal-sized 0.086-inch or greater diameter wire.

(a) Twisted wire mesh. Form the mesh in a uniform hexagonal pattern with nonraveling double twists. Tie the perimeter edges of the mesh for each panel to a 0.11-inch or greater diameter selvedge wire. Make the selvedge at least the same strength as the body of the mesh. Furnish selvedge wire from the same type of material used for the wire mesh.

(b) Welded wire mesh. Weld each connection to obtain a minimum average weld shear strength of 292 pounds with no value less than 225 pounds.

Fabricate revet baskets in the dimensions required with a dimension tolerance of ±5 percent in length and width and ±10 percent in height. Where the length of the basket exceeds 0.5 times its width, equally divide the basket into cells less than or equal to 0.5 times the basket width using diaphragms of the same type and size mesh as the mattress panels. Prefabricate each basket with the necessary panels and diaphragms secured so they rotate into place.

(3) Polyvinyl chloride coated baskets. Use either a fusion bonded or extruded coating to coat the galvanized or aluminized mesh. Conform to the following:

(a) Color	Black or gray
(b) Thickness	0.125 inch min.
(c) Specific gravity, ASTM D 792	1.20 to 1.40
(d) Tensile strength, ASTM D 638	2,300 pounds per square inch min.
(e) Modulus of elasticity, ASTM D 638	2,000 pounds per square inch min. at 100 strain
(f) Hardness — shore "A", ASTM D 2240	75 min.
(g) Brittleness temperature, ASTM D 746	16 ºF max.
(h) Abrasion resistance, ASTM D 1242, method B at 200 cycles, CSI-A abrader tape, 80 grit	12% max. mass loss
(i) Salt spray (ASTM B 117) and ultraviolet light exposure (ASTM D 1499 and G 23 using apparatus type E and 145 ºF) for 3000 hours	No visual effect *(c)* Δ< 6% *(d)* Δ< 25% *(e)* Δ< 25% *(h)* Δ< 10%
(j) Mandrel bend, 360º bend at 0 ºF around a mandrel 10 times the wire diameter	No breaks or cracks in coating

(b) Permanent fasteners.

(1) Lacing wire. Furnish nominal-sized 0.086-inch diameter wire of the same type, strength, and coating as the basket mesh.

(2) Spiral binders. Form with wire having at least the same diameter, type, strength, and coating as the basket mesh.

(3) Alternate fasteners. Furnish fasteners according to the basket manufacturer's specification that remain closed when subjected to a 585-pound tensile force while confining the maximum number of wires to be confined in the gabion structure or revet mattress. Submit installation procedures and fastener test results.

(c) Internal connecting wire. Furnish lacing wire as described in (b)(1) above or alternate stiffeners according to the basket manufacturer's specification.

720.03 Metal Bin Type Crib Walls. Fabricate members from the type and kind of material specified in the contract. Conform to the following:

(a) Galvanized steel sheets	AASHTO M 218
(b) Aluminum sheets	AASHTO M 197
(c) Fiber-bonded steel sheets	Subsection 707.09
(d) Aluminum coated steel sheets	AASHTO M 274
(e) Bolts and nuts	ASTM A 307, grade A

Furnish heavy hexagon heads and nuts without washers or hexagon heads and nuts with 2 plate washers. Fabricate washers from 0.129-inch thick round steel plate including coating with holes not more than 0.0625 inches larger than the bolt diameter. Galvanize the bolts, nuts, and washers according to AASHTO M 232.

Section 721. — ELECTRICAL AND ILLUMINATION MATERIAL

721.01 Electrical Material. Conform to the following:

(a) Conduit. Conform to the following:

(1) Nonmetallic conduit and duct couplings, elbows, bends, and nipples. For above ground and underground use without concrete encasement, furnish rigid PVC, heavy wall conduit conforming to UL 651. For solvent cement to join conduit, conform to ASTM D 2564.

(2) Metallic conduit and duct, couplings, elbows, bends, and nipples. Furnish rigid galvanized steel conduit conforming to UL 6. Uniformly coat the conduit on the outside with an asphalt mastic conforming to AASHTO M 243 or a 20-mil PVC coating. Furnish rigid, full-mass sherardized or galvanized threaded fittings.

(3) Flexible conduit. Furnish a watertight metallic conduit conforming to UL 360, acceptable for equipment grounding. Furnish insulated throat, grounding, malleable iron watertight fittings.

(4) Conduit bodies, boxes, and fittings. Furnish watertight, galvanized steel conforming to UL 514 B.

(b) Pull boxes, frames, and covers. For boxes formed in concrete, fabricate with cast iron or welded sheet steel having a minimum thickness of 0.188 inches. Galvanize, inside and out, according to AASHTO M 232.

(c) Wire and cable. Furnish 600-volt stranded copper conductors, insulation, and jackets. Label and color code the wire and cable to identify its type, size, UL symbol, and manufacturer. Conform to the following:

(1) Rubber-insulated wires and cables	UL 44
(2) Thermoplastic-insulated wires and cables	UL 83
(3) Thermoplastic-insulated underground feeder and branch circuit cables	UL 493
(4) Nonmetallic sheathed cable	UL 719
(5) Service-entrance cables	UL 854
(6) Machine-tool wires and cables	UL 1063
(7) Reference standard for electrical wires, cables, and flexible cords	UL 1581

(d) Circuit breakers and panels. Conform to UL 489 and UL 67. Furnish molded case thermal magnetic trip type breakers. Furnish panel enclosures conforming to NEMA 3R, lockable with padlocks.

(e) Safety disconnect switches. Furnish heavy duty, NEMA 3R, safety disconnect switches conforming to UL 98.

(f) Grounding and bonding equipment. Furnish 5/8-inch diameter, 8-foot long, copper-clad steel ground rods, ground clamps, grounding and bonding bushings, and lock nuts conforming to UL 467.

(g) Contactors and control transformers. Furnish a magnetic, 60-ampere, 2-pole contactor with a 120-volt coil, equipped with control switches for automatic actuation conforming to UL 508. Furnish 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; and with a built-in surge protective device for protection from induced high-voltage and follow-through currents.

Furnish 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.

(h) Secondary lightning arrester. Furnish 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. Furnish 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 716.03.

(j) Meter cabinet. Conform to local power company requirements.

(k) Control cabinet. Furnish a NEMA type IV cabinet, equipped with door clamps on the unhinged sides, solid neoprene gasket, welded seams, continuous hinge with stainless steel pin, stainless steel external hardware, backboard for mounting apparatus, padlock with an outdoor, tumbler-type padlocks keyed the same, supplied with 2 keys for each lock. Furnish a cabinet constructed of one of the following:

(1) Code-gauge stainless steel, ASTM A 167, type 304; or

(2) Code-gauge aluminum sheet with mechanical properties equivalent or exceeding ASTM B 209, alloy 5052-H32.

721.02 Lighting Material. Conform to the following:

(a) Poles. Furnish 11-gage round steel conforming to ASTM A 595 or aluminum shafts conforming to ASTM B 429, alloy 6063-T6, tapered uniformly at 0.14 inches per foot. Provide hand holes with no rough edges and a reinforcing frame and cover designed to maintain the required pole strength. Weld a 2.375- 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.

Furnish pole sections in minimum 15-foot lengths. Furnish pole sections less than 70 feet in height in 2 sections or less; between 70 and 100 feet in 3 sections or less; and over 100 feet in 4 sections or less.

Design and furnish poles capable of sustaining 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 matching FSS 595A color 27040 for the finish coat.

(b) Pole arms.

(1) Material. Furnish steel or aluminum. Use the same material as the pole.

(2) Type. Furnish bracket type, truss or single member arms. Furnish single member arms with a minimum diameter of 2 inches and the same taper as the pole.

(3) Connection. Furnish a weather resistant connection to the pole and a smooth raceway for wiring. Furnish all fittings for connection to the pole.

(c) Anchor bases. Furnish 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 A 36
(3) Aluminum castings	ASTM B 26, alloy SG70A-T6 (356-T6)

(d) Bolts, nuts, and washers.

(1) Steel anchor bolts. Conform to ASTM A 36, except as amended by *(a)* or *(b)* below:

(a)	*(1)* Yield strength	55 kips per square inch min.
	(2) Tensile strength	75 to 95 kips per square inch
	(3) Elongation in 8 inches	18% min.
	(4) Elongation in 2 inches	21% min.
	(5) Area reduction	30% min.
(b)	*(1)* Yield strength	105 kips per square inch min.
	(2) Tensile strength	100 to 150 kips per square inch
	(3) Elongation in 2 inches	15% min.
	(4) Area reduction	45% min.

(2) Hex head bolts. Conform to the following:

(a) 55 kips per square inch yield anchor bolts	AASHTO M 164
(b) 105 kips per square inch yield anchor bolts	ASTM A 354, grade BC

(3) Nuts. Conform to AASHTO M 291. Furnish nuts appropriate for the strength of the anchor bolt.

(4) Washers. Furnish flat, circular washers conforming to AASHTO M 293.

Galvanize the top 12 inches of anchor bolts and all associated hardware according to AASHTO M 232.

(e) Anchor bolt covers. Furnish a bolt cover for each anchor bolt and 0.25-inch stainless steel, Phillips-head or hex-head screws to attach the cover to the base or pole.

(f) Luminaires. Operate luminaires on a 240-volt series circuit. Furnish the following types of luminaires.

(1) Conventional highway luminaires. Furnish 250-watt, 100-volt, high pressure sodium vapor lamps including all materials for a complete installation. Furnish aluminum housings with refractor holder and slipfitter. Furnish thermal shock-resistant glass prismatic refractors with gaskets and clips. Furnish aluminum detachable reflectors with ethylene propylene terpolymer gaskets.

Furnish 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 ºF.

(2) Sign lighting luminaires. Furnish deluxe white, 250-watt mercury vapor lamps with a minimum rated life of 24,000 hours. Include all material for a complete installation. Furnish die-cast aluminum housings with mounting bracket and door assembly. Furnish thermal, shock-resistant, borosilicate glass refractors with gaskets. Furnish aluminum reflectors.

Furnish 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 ºF.

Section 722. — ANCHOR MATERIAL

722.01 Anchorage Devices. For post-tensioning, furnish anchorage devices capable of holding the prestressing steel at a load producing a stress of not less than 95 percent of the guaranteed minimum tensile strength of the prestressing steel.

Use a steel distribution plate or assembly to effectively distribute the compressive stresses from the anchoring device to the concrete. If the anchorage device is sufficiently large and is used with a steel grillage embedded in the concrete, the distribution plate or assembly may be omitted. Conform to the following:

(a) The final unit compressive stress on the concrete directly beneath the plate or assembly shall not exceed 3,000 pounds per square inch.

(b) Bending stresses in the plates or assemblies induced by the pull of the prestressing shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 100 percent of the ultimate load is applied.

Furnish 2 anchorage devices (complete with distribution plates or assemblies) for each size and type to be used.

722.02 Ground Anchors. Conform to the following:

(a) Tendons. For either single or multiple elements, conform to one of the following:

(1) Steel strand uncoated seven-wire stress relieved for prestressed concrete	AASHTO M 203
(2) Uncoated high-strength steel bar for prestressed concrete	AASHTO M 275
(3) Steel strand uncoated seven-wire compacted stress relieved for prestressing concrete	ASTM A 779 and AASHTO M 203

(**b) Couplers.** Furnish couplers for tendon sections that are capable of developing 95 percent of the minimum specified ultimate tensile strength of the tendon.

(c) Sheathing. Conform to one of the following:

(1) Unbonded length.

(a) Polyethylene tube. Conform to ASTM D 1248, type II, III, or IV with a minimum wall thickness of 60 mils.

(b) Hot-melt extruded polypropylene tube. Conform to ASTM D 4101, cell classification PP 210 B5554211 with a minimum wall thickness of 60 mils.

(c) Hot-melt extruded polyethylene tube. Conform to ASTM D 3350 and D 1248 high-density type III with a minimum wall thickness of 60 mils.

(d) Steel tubing. Conform to ASTM A 500 with a minimum wall thickness of 0.20 inches.

(e) Steel pipe. Conform to ASTM A 53, schedule 40 minimum.

(f) Plastic pipe. Conform to ASTM D 1785, 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 D 1784, class 13464-B.

(c) Fusion-bonded epoxy. Conform to AASHTO M 284 with a minimum film thickness of 15 mils.

(d) Grease. Conform to Table 3.2.1 of the PTI *Post Tensioning Manual*. Formulate to provide corrosion inhibiting and lubricating properties.

(e) Grout. Furnish a pumpable mixture of portland cement, sand, water, and admixtures. Use type I, II or III portland cement conforming to AASHTO M 85.

Chemical additives 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.

For permanent ground anchors, furnish grout capable of reaching a cube strength (AASHTO T 106) of 3,500 pounds per square inch in 7 days. For soil nails, furnish grout capable of reaching a cube strength of 1,500 pounds per square inch in 3 days and 3,000 pounds per square inch in 28 days.

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 proof-testing each anchor. Grout cube testing will be required if admixtures are used or irregularities occur in anchor testing.

(f) Centralizers. Fabricate centralizers and spacers from any type of material, except wood, that is not deleterious to the prestressing steel.

(g) Anchorage devices. Conform to Section 3.2.3 of the PTI *Post Tensioning Manual*. For strand tendons, design anchorage devices to permit lift-off testing without the jack engaging the strand. For anchorage device bearing plates, furnish steel plates conforming to ASTM A 36 or A 588.

Extend a pipe or trumpet from the anchor plate a sufficient distance to encapsulate the protective sheath. Furnish anchorage devices capable of developing 95 percent of the minimum specified ultimate tensile strength of the anchor tendon.

722.03 Rock Bolts. Conform to ASTM F 432.

722.04 Soil Nails.

(a) Tendon. Furnish deformed bars conforming to one of the following:

(1) Deformed bars, grade 60 or 75	ASTM A 615
(2) Deformed bars, grade 150	ASTM A 722

Provide new, straight, continuous, undamaged, bare, epoxy coated, or encapsulated bars.

(b) Coupler. Furnish couplers that are capable of developing the full, ultimate tensile strength of the tendon as certified by the manufacturer.

(c) Fusion bonded epoxy coating. Apply epoxy coating conforming to ASTM A 775, with the exception of 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. Furnish corrugated polyethylene pipe conforming to AASHTO M 252 or corrugated polyvinyl chloride pipe conforming to ASTM D 1784, class 13464-B.

Section 723. — Reserved

Section 724. — Reserved

Section 725. — MISCELLANEOUS MATERIAL

725.01 Water. Conform to the following:

(a) Water for mixing or curing cement concrete, mortar, or grout. Conform to AASHTO M 157. Potable water of known quality may be used without testing according to AASHTO T 26. Potable water is safe for human consumption as defined by the public health authority having jurisdiction.

(b) Water for planting or care of vegetation. Furnish water that is free of substances injurious to plant life such as oils, acids, alkalies, or salts.

(c) Water for earthwork, pavement courses, dust control, and incidental construction. Furnish water free of substances detrimental to the work.

725.02 Calcium Chloride, Calcium Chloride Flakes and Magnesium Chloride.

(a) Calcium chloride liquid. Conform to AASHTO M 144, type L for the specified concentration.

(b) Calcium chloride flakes. Conform to AASHTO M 144, type S, grade 1, 2, or 3, class A.

(c) Magnesium chloride. Furnish a brine solution conforming to the following:

(1) Magnesium chloride by mass	28% minimum
(2) Water by mass	72% maximum
(3) Specific gravity, AASHTO T 227	1.290 to 1.330

725.03 Lime.

(a) Lime for masonry. Furnish hydrated lime conforming to ASTM C 207, type N.

(b) Lime for soil stabilization and paving. Conform to AASHTO M 216.

725.04 Pozzolans. Conform to the following:

(a) Fly ash	AASHTO M 295, class C or F
(b) Ground iron blast-furnace slag	AASHTO M 302, grade 100 or 120
(c) Silica fume (microsilica)	AASHTO M 307

725.05 Mineral Filler. Conform to AASHTO M 17.

725.06 Precast Concrete Curbing and Wheelstops. Furnish units conforming to the following:

(a) Concrete	Section 601
(b) Reinforcing steel	Subsection 709.01

725.07 Clay or Shale Brick. Conform to one of the following:

(a) Sewer brick	AASHTO M 91, grade SM
(b) Building brick	AASHTO M 114, grade SW

725.08 Concrete Brick. Conform to ASTM C 55, grade N-I.

725.09 Concrete Masonry Units. Conform to one of the following:

(a) Load-bearing concrete masonry units	ASTM C 90
(b) Concrete masonry units for constructing catch basins and manholes	ASTM C 139
(c) Nonload-bearing concrete masonry units	ASTM C 129

725.10 Cellular Concrete Blocks. Conform to ASTM C 936 or C 1319.

725.11 Precast Concrete Units and Accessories.

(a) Reinforced concrete manholes sections. Conform to AASHTO M 199

(b) Precast concrete barrier. Conform to ASTM C 825.

(c) Reinforced concrete crib wall members. Conform to ASTM C 915.

(d) Underground concrete utility structures. Conform to ASTM C 858.

(e) Concrete water and waste water structures. Conform to ASTM C 913.

(f) Solid concrete interlocking paving units. Conform to ASTM C 936.

(g) Other precast concrete units not covered by the preceding requirements. Cast the units in substantial permanent steel forms. When reinforcing steel is required, conform to Section 709. Provide additional reinforcement as necessary for handling the units. Use concrete conforming to the following.

(1) Minimum design strength (f'_c) at 28-day strength, AASHTO T 22	3,600 pounds per square inch min.

(2) Air entrained concrete for precast units exposed to freezing and thawing environment. For air-entrained concrete, conform to the following:

(a) 3/8 inch max. size aggregate	5% min.
(b) > 3/8 inch max. size aggregate	4% min.

Cure the units according to AASHTO M 170.

Sample for verification of required average compressive strength (f'_{cr}). Cast a sufficient number of concrete cylinders from each unit or randomly selected from a production run of units to permit compressive strength testing at 7, 14, and 28 days. Fabricate at least 2 cylinders for each test age. Each compressive strength test consists of two or more cylinders tested according to AASHTO T 22 at the same age. If the minimum required average (f'_{cr}) strength requirement is met at 7 or 14 days, the units may be used 14 days from date of casting.

Do not use precast concrete units when:

- Compressive strength as determined by AASHTO T 22 from each unit or production run does not meet the minimum required average (f'_{cr}) strength requirement by the age of 28 days.
- Cracks, honeycombed, or patched areas are larger than 30 square inches.

725.12 Frames, Grates, Covers, and Ladder Rungs. Fabricate metal grates and covers to evenly bear on the frames. Correct bearing inaccuracies by machining. Assemble all units before shipment. Mark all pieces to facilitate reassembly at the installation site. Uniformly coat all 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 A 36
(d) Galvanizing	AASHTO M 111
(e) Malleable iron castings	ASTM A 47
(f) Aluminum alloy ladder rung material	ASTM B 221, alloy 6061-T6
(g) Aluminum castings	ASTM B 26, alloy 356.0-T6

725.13 Corrugated Metal Units. For steel corrugated units, conform to AASHTO M 36. For aluminum corrugated units, conform to AASHTO M 196. For coatings, conform to the following:

(a) Asphalt-coated corrugated units	AASHTO M 190, type A
(b) Polymer precoated corrugated units	AASHTO M 245, grade 250/250
(c) Fiber-bonded units	Subsection 707.09

725.14 Protective Coatings for Concrete. Furnish protective coatings for bridge decks, curbs, sidewalks, and concrete portions of bridge railings conforming to one of the following:

(a) Boiled linseed oil	ASTM D 260, type I or II
(b) Petroleum spirits (mineral spirits)	ASTM D 235

725.15 Polyvinyl Chloride (PVC) Pipe for Water Distribution Systems. Conform to the following for the designated sizes and strength schedules:

(a) PVC pipe	ASTM D 1785
(b) Solvent cement for pipe and fittings	ASTM D 2564

725.16 Polyethylene (PE) Pipe for Water Distribution Systems. Conform to ASTM D 2447 for the designated sizes and strength schedules.

725.17 Cast Iron Soil Pipe and Fittings. Conform to ASTM A 74, class SV for the designated sizes.

725.18 Seamless Copper Water Tube and Fittings. Conform to ASTM B 88, type L for the designated sizes.

725.19 Plastic Lining. Furnish a film or fabric that is serviceable for the duration of the installation.

725.20 Lignosulfonate. Furnish a water solution with a base cation of ammonia, calcium, or sodium. Conform to the following:

(a) Solids(1)	50%
(b) Specific gravity	1.25
(c) pH, AASHTO T 289	4.5 min.

Note: (1) Determine the percentage of solids according to the modified Technical Association of the Pulp and Paper Industry Standard T 650-TM-84 or by a specific gravity/percent solids versus temperature graph that correlates with the standard.

725.21 Epoxy Resin Adhesives. Conform to AASHTO M 235.

725.22 Grout. Furnish grout mixtures conforming to the following for the type or types specified in the contract.

(a) Expansive hydraulic sanded cement grout. Furnish a mixture of hydraulic cement, fine aggregate, water, expansive admixture, and/or pozzolan, or additional admixtures, conforming to the following:

(1) 7-day compressive strength, AASHTO T 106	600 pounds per square inch min.
(2) Flow (time of efflux), ASTM C 939	16 to 26 seconds

Note: A more fluid mix, having a flow cone time of efflux of 9 to 15 seconds, may be used during the initial injection.

Submit the following with the production certification:

- Current material certifications for the hydraulic cement, fine aggregate, expansive admixture, and other grout additives; and
- Independent laboratory test results for 1-day, 3-day, and 7-day strengths, flow cone times, shrinkage and expansion observed, and time of initial set.

(b) Polymer grout. Furnish a polymer binder and fine aggregate in the proportions recommended by the polymer manufacturer with a minimum compressive strength of 3,500 pounds per square inch in 4 hours.

(c) Nonshrink grout. Conform to ASTM C 1107.

(d) Grout for Post-Tensioned Structures. Conform to the requirements of the *PTI Guide Specification for Grouting of Post-Tensioned Structures.*

(e) Sanded Hydraulic Cement Grout for Miscellaneous Applications. Furnish 1 part hydraulic cement and 3 parts sand. Thoroughly mix with water to produce a thick, creamy consistency.

(f) Neat hydraulic cement grout. Furnish a grout consisting of a mixture of hydraulic cement, water, and admixtures. Do not exceed a water/cement ratio of 0.44. Fly ash, if used, shall not exceed 20% of the cement by weight. Admixtures to reduce water content, improve the flowability, control bleeding, or control shrinkage may be added according to the manufacturer’s recommendations. Admixtures shall be free of chlorides, fluorides, sulphites, and nitrates.

725.23 Reserved.

725.24 Color Coating. Furnish a semiopaque 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. The color-toning pigments shall consist of laminar silicates, titanium dioxide, and inorganic oxides. Conform to the following:

(a) Mass per liter, ASTM D 1475	8.3 pounds min.
(b) Solids by mass, ASTM D 2369	30% min.
(c) Solids by volume	21% min.
(d) Drying time, ASTM D 1640	30 minutes at 70 ºF and 50% max. humidity
(e) Color change, ASTM D 822, 1000 h	No appreciable change
(f) Resistance to acids, alkalies, gasoline, and mineral spirits, ASTM D 543	Excellent
(g) Water vapor transmission from interior concrete, ASTM D 1653	Transmittable
(h) Exterior moisture absorption into the concrete surface pores, FSS TT-C-555	Reduces rate
(i) Oxidation over time	None

725.25 Explosives and Blasting Accessories. Only use explosives and initiating devices less than 1-year old. Explosives and initiating devices include, but are not necessarily limited to, dynamite and other high explosives, slurries, water gels, emulsions, blasting agents, initiating explosives, detonators, and detonating cord.

725.26 Mineral Slurry (Drillers Mud). Furnish commercially available sodium bentonite or attapulgite in potable water. Use a mineral grain size that remains in suspension with sufficient viscosity and gel characteristics, so the mixture is capable of transporting excavated material to a suitable screening system.

725.27 Form Liner. Furnish a high quality product that attaches easily to the forming system. Install the form liner so it does not compress more than 1/4 inch at a concrete pour rate of 750 pounds per square foot.

725.28 Aluminum-Impregnated Caulking Compound. Conform to FSS TT-C-598, grade 1.

725.29 Reinforcing Fibers. Use deformed steel or fibrillated polypropylene fibers conforming to ASTM C 1116.