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

FP-96

1996

U.S. Department
of Transportation
Federal Highway Administration

**Federal
Lands Highways**
"Commitment to Excellence"

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

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U.S. DEPARTMENT OF TRANSPORTATION
Federal Highway Administration

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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-96" indicating Standard Specifications issued in 1996.

When designated in a contract, the FP-96 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.
- Transportation Acquisition Regulation (TAR), Title 48, Code of Federal Regulations, Chapter 12.

The FAR and TAR regulations are not included in the FP-96. However, some FAR and TAR clauses are supplemented in the FP-96. A complete copy of the FAR is available from the Superintendent of Documents, Congressional Sales Office, U.S. Government Printing Office, Washington, DC 20402.

The International System of Units (SI) is used in the FP-96 as required by Public Law 100-418 (1988 Omnibus Trade and Competitiveness Act) and Executive Order 12770 (Metric Usage in Federal Government Programs).

SI [(1)] (METRIC) TO ENGLISH CONVERSION FACTORS (approximate)

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
μm	micrometers	3.9 x 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	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	caldela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
J	joule	0.7376	foot·poundforce	ft·lbf
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

(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 is *"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 when there is a pay item in the bid schedule. 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.

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 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
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
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
FLH	)	Federal Lands Highways
FSS	)	Federal Specifications and Standards
FTMS	)	Federal Test Method Standard
GSA	)	General Services Administration

ISSA	)	International Slurry Surfacing Association
ITE	)	Institute of Transportation Engineers
MIL	)	Military Specifications
MUTCD	)	Manual on Uniform Traffic Control Devices (for Streets and Highways)
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
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 Geologic 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 ($kg \cdot m/s^2$)	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
Ω	)	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) SI slope notation (vertical : horizontal). For slopes flatter than 1:1, express the slope as the ratio of one unit vertical to a number of units horizontal. For slopes steeper than 1:1, express the slope as the ratio of a number of units vertical to one unit horizontal.

101.04 Definitions. FAR Clause 52.202-1, Definitions, is supplemented as follows:

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.

Bid Bond) The security executed by the bidder and surety or sureties furnished to the Government to guarantee execution of the contract.

Bidder) Any individual or legal entity submitting a bid.

Bid Forms) The Government forms required for preparing and 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 6.1 meters long, including supports, spanning and providing passage over a depression, waterway, railroad, highway, or other obstruction.

Commercial Certification) See Subsection 106.03.

Construction Limits) The limits on each side of the project which 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 under Section 202.

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/or 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.

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.

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.

Falsework) Any temporary construction work used to support the permanent structure until it becomes self-supporting. Falsework includes steel or timber beams, girders, columns, piles, foundations, and any proprietary equipment including modular shoring frames, post shores, and adjustable horizontal shoring.

Forms) Temporary structures or molds used to retain plastic or fluid concrete in its designated shape until it hardens. Forms shall have enough strength to resist the fluid pressure exerted by plastic concrete and all additional fluid pressure effects generated by vibration.

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) When placing and compacting soils and aggregates, a lift is any single, continuous layer of material which receives, during a single work operation, the same compactive effort throughout. When installing culvert pipe less than or equal to 1200 millimeters 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.

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, 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 furnished to the Government to assure 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 and 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.

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 used for transportation purposes.

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.

Shoring) This term is used interchangeably with falsework.

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 related documents (whether attached or incorporated by reference) furnished to prospective bidders.

Special Contract Requirements) Additions and revisions to the standard and supplemental 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 one kilometer. (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 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 whom 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.

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

Superstructure) The entire bridge except the substructure.

Supplemental Specifications) Additions and revisions to the standard specifications.

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, exclusive of shoulders.

Unsuitable Material) Material that is earth, gravel, or sand not adequate (i.e. stability, drainage, etc.) to use in the construction of stable foundations, embankments, or roadbeds.

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. FAR Clause 52.214-18 - Preparation of Bids) Construction is supplemented as follows.

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. All participants in the joint venture shall sign in the manner prescribed in (a) through (c) above. Corporations shall also submit a certificate stating that the corporation is authorized to participate in the joint venture.

One party may sign on behalf of a joint venture if documentation is included and signed by all members of the joint venture, authorizing the party with authority to sign for the joint venture.

(e) Agents. When an agent signs, other than as stated in (a) through (d) 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 word *"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. FAR Clause 52.228-1 - Bid Guarantee is supplemented as follows:

(a) General. Submit a bid guarantee of not less than 20 percent of the amount of the bid with any bid in excess of $25,000. 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. FAR Clause 52.228-11 - Pledges of Assets is supplemented as follows.

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. Furnish a performance bond in the penal amount of 100 percent of the original contract price and a payment bond as follows:

(a) In the penal amount of 50 percent of the original contract price if the contract price is not more the $1 million.

(b) In the penal amount of 40 percent of the original contract price if the contract is more than $1 million but not more than $5 million.

(c) In the amount of $2.5 million if the contract price is more than $5 million.

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. FAR Clause 52.233-1 - Disputes is supplemented as follows.

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. FAR Clause 52.248-3 - Value Engineering) Construction is supplemented as follows.

Value engineering proposals that delete work without a related enhancement to the project will not be considered.

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 $20,000.

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 will 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 Government 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 reject work until the issue can be referred to and decided by the CO.

104.03 Specifications and Drawings. FAR Clause 52.236-21 - Specifications and Drawings for Construction is supplemented as follows:

(a) General. Prepare drawings as necessary to adequately construct the work. This includes, but is not limited to, traffic control drawings, falsework drawings, stress sheets, anchor bolt layouts, erection drawings, and equipment lists.

Limit drawings to a maximum size of 610 by 920 millimeters. 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. If drawings must be resubmitted, the time for acceptance starts over. Obtain prior written approval for changes or deviations from the accepted drawings.

(b) Specific requirements for concrete and miscellaneous structures. Furnish drawings for cribs, cofferdams, falsework, erection, temporary support systems, formwork, detour structures, and other temporary work and methods of construction proposed. Furnish drawings bearing the seal and signature of a professional engineer proficient in the pertinent design field.

104.04 Coordination of Contract Documents. The FAR, TAR, special contract requirements, plans, supplemental specifications, 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
(e) Supplemental specifications
(f) Standard specifications

104.05 Load Restrictions. FAR Clause 52.236-10 - Operations and Storage Areas, paragraph (c), is supplemented as follows.

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 within the project. Repair or replace in an acceptable manner all damages to project work resulting from the use of such equipment or vehicles at no cost to the Government.

On the portions of the project used to accommodate public travel, operate construction equipment and vehicles in a manner that does not conflict with traffic flow and minimizes delays to the traveling public.

Section 105.) CONTROL OF MATERIAL

105.01 Source of Supply and Quality Requirements. FAR Clause 52-.236-5 - Material and Workmanship is supplemented as follows.

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 Local Material Sources. Sources of rock, sand, gravel, earth, or other natural material located by the Government in the vicinity of the project may be identified in the contract. These identified sources may be listed as provided for the project or only listed as information to aid the Contractor in locating a source. The decision to use an identified source is solely that of the Contractor.

(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.

(b) Government-listed sources. The Government may list possible material sources. The Government makes no representation as to the quality or quantity of material, or rights to the availability of material from these sources. These sources are considered to be Contractor-located sources under (c) below.

(c) Contractor-located sources. The Contractor is responsible for these 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.

Comply with the following applicable requirements:

(a) 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.

(b) 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. Establish a vegetative cover to blend the site into the surrounding 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. FAR Clause 52.246-12 - Inspection of Construction is supplemented as follows.

References to standard test methods of AASHTO, ASTM, GSA, and other recognized standards 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.

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 is verified by Government testing, 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 shall 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, 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.

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

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

(4) Manufacturer's statement that the material complies with all contract requirements

(5) 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 the probability that work produced at an acceptable quality level (AQL) is rejected or accepted at a reduced contract price.

Acceptable quality level is the highest percentage of work outside the specification limits that is considered acceptable for payment at contract price. There are 2 categories. Category I is based on an AQL of 5 percent. Category II is based on an AQL of 10 percent. In both cases, the Contractor's risk is 5 percent.

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 or adjustments are required as provided under (b).

(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, which is the minimum number required to perform a statistical evaluation. The maximum obtainable pay factor with 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 are 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 inspection 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 5 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. If it is determined that the resumption of production involves a significant change to the production process, the current lot will be terminated and a new lot begun.

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 defective 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 that is determined to be defective 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 outside 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 outside of the specification limits for each quality characteristic will be determined as follows:

(1) Calculate the arithmetic mean $(\bar{X})$ of the test values: $\bar{X} = \frac{\Sigma x}{n}$

Where: Σ = summation of
x = individual test value
n = total number of test values

(2) Calculate the standard deviation (s):

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

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

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

(3) Calculate the upper quality index (Q_U): $Q_U = \dfrac{USL - \bar{X}}{s}$

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

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 outside the *USL*). P_U corresponds to a given Q_U. If a *USL* is not specified, P_U is 0.

(6) From Table 106-1, determine P_L (the estimated percentage of work within the lot outside the *LSL*). P_L corresponds to a given Q_L. If an *LSL* is not specified, P_L is 0.

(7) Calculate the total estimated percentage of work outside the *USL* and *LSL* (percent defective):

$$P_U + P_L$$

(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 outside 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).

(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 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.

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. FAR Clause 52.236-11 - Use and Possession Prior to Completion is supplemented as follows:

(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 will be accepted, and the Contractor will be relieved 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 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 Contractor will receive 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.

Table 106-1
Estimated Percent of Work Outside Specification Limits

Estimated Percent Outside Specification Limits (P_U and/or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L						
	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14
0	1.72	1.88	1.99	2.07	2.13	2.20	2.28
1	1.64	1.75	1.82	1.88	1.91	1.96	2.01
2	1.58	1.66	1.72	1.75	1.78	1.81	1.84
3	1.52	1.59	1.63	1.66	1.68	1.71	1.73
4	1.47	1.52	1.56	1.58	1.60	1.62	1.64
5	1.42	1.47	1.49	1.51	1.52	1.54	1.55
6	1.38	1.41	1.43	1.45	1.46	1.47	1.48
7	1.33	1.36	1.38	1.39	1.40	1.41	1.41
8	1.29	1.31	1.33	1.33	1.34	1.35	1.35
9	1.25	1.27	1.28	1.28	1.29	1.29	1.30
10	1.21	1.23	1.23	1.24	1.24	1.24	1.25
11	1.18	1.18	1.19	1.19	1.19	1.19	1.20
12	1.14	1.14	1.15	1.15	1.15	1.15	1.15
13	1.10	1.10	1.10	1.10	1.10	1.10	1.11
14	1.07	1.07	1.07	1.06	1.06	1.06	1.06
15	1.03	1.03	1.03	1.03	1.02	1.02	1.02
16	1.00	0.99	0.99	0.99	0.99	0.98	0.98
17	0.97	0.96	0.95	0.95	0.95	0.95	0.94
18	0.93	0.92	0.92	0.92	0.91	0.91	0.91
19	0.90	0.89	0.88	0.88	0.88	0.87	0.87
20	0.87	0.86	0.85	0.85	0.84	0.84	0.84
21	0.84	0.82	0.82	0.81	0.81	0.81	0.80
22	0.81	0.79	0.79	0.78	0.78	0.77	0.77
23	0.77	0.76	0.75	0.75	0.74	0.74	0.74
24	0.74	0.73	0.72	0.72	0.71	0.71	0.70
25	0.71	0.70	0.69	0.69	0.68	0.68	0.67
26	0.68	0.67	0.67	0.65	0.65	0.65	0.64
27	0.65	0.64	0.63	0.62	0.62	0.62	0.61
28	0.62	0.61	0.60	0.59	0.59	0.59	0.58
29	0.59	0.58	0.57	0.57	0.56	0.56	0.55
30	0.56	0.55	0.54	0.54	0.53	0.53	0.52
31	0.53	0.52	0.51	0.51	0.50	0.50	0.50
32	0.50	0.49	0.48	0.48	0.48	0.47	0.47
33	0.47	0.46	0.45	0.45	0.45	0.44	0.44
34	0.45	0.43	0.43	0.42	0.42	0.42	0.41
35	0.42	0.40	0.40	0.39	0.39	0.39	0.38
36	0.39	0.38	0.37	0.37	0.36	0.36	0.36
37	0.36	0.35	0.34	0.34	0.34	0.33	0.33
38	0.33	0.32	0.32	0.31	0.31	0.31	0.30
39	0.30	0.30	0.29	0.28	0.28	0.28	0.28
40	0.28	0.25	0.25	0.25	0.25	0.25	0.25
41	0.25	0.23	0.23	0.23	0.23	0.23	0.23
42	0.23	0.20	0.20	0.20	0.20	0.20	0.20
43	0.18	0.18	0.18	0.18	0.18	0.18	0.18
44	0.16	0.15	0.15	0.15	0.15	0.15	0.15
45	0.13	0.13	0.13	0.13	0.13	0.13	0.13
46	0.10	0.10	0.10	0.10	0.10	0.10	0.10
47	0.08	0.08	0.08	0.08	0.08	0.08	0.08
48	0.05	0.05	0.05	0.05	0.05	0.05	0.05
49	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

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

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

Estimated Percent Outside Specification Limits (P_U and/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 ∞
0	2.34	2.39	2.44	2.48	2.51	2.56
1	2.04	2.07	2.09	2.12	2.14	2.16
2	1.87	1.89	1.91	1.93	1.94	1.95
3	1.75	1.76	1.78	1.79	1.80	1.81
4	1.65	1.66	1.67	1.68	1.69	1.70
5	1.56	1.57	1.58	1.59	1.59	1.60
6	1.49	1.50	1.50	1.51	1.51	1.52
7	1.42	1.43	1.43	1.44	1.44	1.44
8	1.36	1.36	1.37	1.37	1.37	1.38
9	1.30	1.30	1.31	1.31	1.31	1.31
10	1.25	1.25	1.25	1.25	1.26	1.26
11	1.20	1.20	1.20	1.20	1.20	1.20
12	1.15	1.15	1.15	1.15	1.15	1.15
13	1.11	1.11	1.11	1.11	1.11	1.11
14	1.06	1.06	1.06	1.06	1.06	1.06
15	1.02	1.02	1.02	1.02	1.02	1.02
16	0.98	0.98	0.98	0.98	0.98	0.98
17	0.94	0.94	0.94	0.94	0.94	0.94
18	0.91	0.90	0.90	0.90	0.90	0.90
19	0.87	0.87	0.87	0.87	0.87	0.87
20	0.83	0.83	0.83	0.83	0.83	0.83
21	0.80	0.80	0.80	0.80	0.80	0.79
22	0.77	0.76	0.76	0.76	0.76	0.76
23	0.73	0.73	0.73	0.73	0.73	0.73
24	0.70	0.70	0.70	0.70	0.70	0.70
25	0.67	0.67	0.67	0.67	0.67	0.66
26	0.64	0.64	0.64	0.64	0.64	0.63
27	0.61	0.61	0.61	0.61	0.61	0.60
28	0.58	0.58	0.58	0.58	0.58	0.57
29	0.55	0.55	0.55	0.55	0.55	0.54
30	0.52	0.52	0.52	0.52	0.52	0.52
31	0.49	0.49	0.49	0.49	0.49	0.49
32	0.47	0.46	0.46	0.46	0.46	0.46
33	0.44	0.44	0.43	0.43	0.43	0.43
34	0.41	0.41	0.41	0.41	0.41	0.40
35	0.38	0.38	0.38	0.38	0.38	0.38
36	0.36	0.35	0.35	0.35	0.35	0.35
37	0.33	0.33	0.33	0.33	0.33	0.32
38	0.30	0.30	0.30	0.30	0.30	0.30
39	0.28	0.28	0.28	0.28	0.28	0.28
40	0.25	0.25	0.25	0.25	0.25	0.25
41	0.23	0.23	0.23	0.23	0.23	0.23
42	0.20	0.20	0.20	0.20	0.20	0.20
43	0.18	0.18	0.18	0.18	0.18	0.18
44	0.15	0.15	0.15	0.15	0.15	0.15
45	0.13	0.13	0.13	0.13	0.13	0.13
46	0.10	0.10	0.10	0.10	0.10	0.10
47	0.08	0.08	0.08	0.08	0.08	0.08
48	0.05	0.05	0.05	0.05	0.05	0.05
49	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 Category I	PAY FACTOR Category II	Maximum Allowable Percent of Work Outside Specification Limits for a Given Pay Factor $(P_U + P_L)$ 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					0	0	0	0	0	0	0	0	0	0
1.04				0	1	3	5	4	4	4	3	3	3	3
1.03			0	2	4	6	8	7	7	6	5	5	4	4
1.02			1	3	6	9	11	10	9	8	7	7	6	6
1.01		0	2	5	8	11	13	12	11	10	9	8	8	7
1.00		22	20	18	17	16	15	14	13	12	11	10	9	8
0.99		24	22	20	19	18	17	16	15	14	13	11	10	9
0.98		26	24	22	21	20	19	18	16	15	14	13	12	10
0.97		28	26	24	23	22	21	19	18	17	16	14	13	12
0.96		30	28	26	25	24	22	21	19	18	17	16	14	13
0.95	1.00	32	29	28	26	25	24	22	21	20	18	17	16	14
0.94	0.99	33	31	29	28	27	25	24	22	21	20	18	17	15
0.93	0.98	35	33	31	29	28	27	25	24	22	21	20	18	16
0.92	0.97	37	34	32	31	30	28	27	25	24	22	21	19	18
0.91	0.96	38	36	34	32	31	30	28	26	25	24	22	21	19
0.90	0.95	39	37	35	34	33	31	29	28	26	25	23	22	20
0.89	0.94	41	38	37	35	34	32	31	29	28	26	25	23	21
0.88	0.93	42	40	38	36	35	34	32	30	29	27	26	24	22
0.87	0.92	43	41	39	38	37	35	33	32	30	29	27	25	23
0.86	0.91	45	42	41	39	38	36	34	33	31	30	28	26	24

Note: To obtain a pay factor when the (P_U and/or P_L) value from Table 106-1 does not correspond to a ($P_U + P_L$) value in this table, use the next larger ($P_U + P_L$) value.

(continued)

Table 106-2 Pay Factors (continued)

PAY FACTOR Category I	PAY FACTOR Category II	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 ∞
		Maximum Allowable Percent of Work Outside Specification Limits for a Given Pay Factor ($P_U + P_L$)												
0.85	0.90	46	44	42	40	39	38	36	34	33	31	29	28	25
0.84	0.89	47	45	43	42	40	39	37	35	34	32	30	29	27
0.83	0.88	49	46	44	43	42	40	38	36	35	33	31	30	28
0.82	0.87	50	47	46	44	43	41	39	38	36	34	33	31	29
0.81	0.86	51	49	47	45	44	42	41	39	37	36	34	32	30
0.80	0.85	52	50	48	46	45	44	42	40	38	37	35	33	31
0.79	0.84	54	51	49	48	46	45	43	41	39	38	36	34	32
0.78	0.83	55	52	50	49	48	46	44	42	41	39	37	35	33
0.77	0.82	56	54	52	50	49	47	45	43	42	40	38	36	34
0.76	0.81	57	55	53	51	50	48	46	44	43	41	39	37	35
0.75	0.80	58	56	54	52	51	49	47	46	44	42	40	38	36
REJECT	0.79	60	57	55	53	52	51	48	47	45	43	41	40	37
REJECT	0.78	61	58	56	55	53	52	50	48	46	44	43	41	38
REJECT	0.77	62	59	57	56	54	53	51	49	47	45	44	42	39
REJECT	0.76	63	61	58	57	55	54	52	50	48	47	45	43	40
REJECT	0.75	64	62	60	58	57	55	53	51	49	48	46	44	41
REJECT	**REJECT**	Values Greater Than Those Shown Above												

Note: To obtain a pay factor when the (P_U and/or P_L) value from Table 106-1 does not correspond to a ($P_U + P_L$) value in this table, use the next larger ($P_U + P_L$) value.

Section 107.) LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

107.01 Laws to be Observed. FAR Clause 52.236-7 - Permits and Responsibilities is supplemented as follows.

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.

All permits and agreements obtained by the Government for performing the work are included in the contract. Comply with the requirements of these permits and/or agreements. Obtain all additional permits or agreements and modifications to Government obtained permits or agreements that are required by the Contractor's methods of operation.

107.02 Protection and Restoration of Property and Landscape. FAR Clause 52.236-9 - Protection of Existing Vegetation, Structures, Equipment, Utilities, and Improvements is supplemented as follows.

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.

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 within the time frames specified, or otherwise as soon as practicable.

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 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
(b) "Notice" that the project is subject to Title 18, U.S. Criminal Code, Section 1020
(c) "Notice to Employees" poster, WH-1321, regarding proper pay
(d)"Safety and Health Protection on the Job" poster, according to Title 29, Code of Federal Regulations, Part 1926
(e) "General Wage Decision" contained in the contract
(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 5 meters 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
(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 caused by declared enemies and terrorists of the Government and cataclysmic natural phenomenon such as tornadoes, earthquakes, major floods, and officially declared natural disasters.

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

107.08 Sanitation, Health, and Safety. FAR Clause 52.236-13 - Accident Prevention is supplemented as follows.

Observe rules and regulations of Federal, state, and local health officials. Do not permit any worker to work in surroundings or under conditions which 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 Occupational Injuries and Illnesses,"* OSHA form 100, and make it available for inspection.

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 including inspection of work, specification of safety measures and equipment, and ability to stop work.

107.10 Environmental Protection. FAR Clause 52.223-2 - Clean Air and Water is supplemented as follows.

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.
(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.

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, 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. FAR Clause 52.211-10 - Commencement, Prosecution, and Completion of Work is supplemented as follows.

A preconstruction conference will be held after the contract is awarded and before the notice to proceed is issued. Seven days before the preconstruction conference, furnish three copies of the preliminary construction schedule according to Section 155.

Furnish notification at least 24 hours in advance of resuming work after a suspension.

108.02 Subcontracting. FAR Clauses 52.219-14 - Limitations on subcontracting, 52.222-11 - Subcontracts, and 52.236-1 - Performance of Work by the Contractor are supplemented as follows.

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 and 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 Small Disadvantaged 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. FAR Clause 52.211-10 - Commencement, Prosecution, and Completion of Work is supplemented as follows.

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
(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. FAR Clause 52.211-12 - Liquidated Damages) Construction is supplemented as follows.

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.

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.

(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 Contract Price		**Daily Charge**
From More Than)	**To and Including)**	
$ 0	$ 250,000	$ 300
250,000	1,000,000	500
1,000,000	2,000,000	800
2,000,000	5,000,000	1,000
5,000,000	10,000,000	1,400
10,000,000	and more	2,100

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.
(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 Methods. Take or convert all measurements of work according to the International System of Units, ASTM E 380.

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 neat lines shown on the plans or to approved lines adjusted to fit field conditions.

The Measurement Subsection of each Section details specifics and exceptions for measuring work under each Section.

The CO will verify Contractor measurements.

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

(a) 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 meter (m^3).

(1) Cubic meter 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 meter in the hauling vehicle. Measure the cubic meter 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 meters for payment purposes if the conversion factors are mutually agreed to in writing.

(3) Cubic meter in the structure. Measure according to the neat 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 200 millimeters in diameter.

(4) Cubic meter by metering. Use an approved metering system.

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

(d) Hectare (ha). 10 000 square meters. 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 50 square meters or less.

(e) Hour. Measurement will be for the actual number of hours ordered by the CO and performed by the Contractor.

(f) Kilogram (kg). 1000 grams. Measure according to Subsection 109.03. If sacked or packaged material is furnished, the net mass as packed by the manufacturer may be used.

(g) Kilometer (km). 1000 meters. Measure horizontally along centerline of each roadway, approach road, or ramp.

(h) Liter (L). 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 liter, measure the volume at 15 °C or correct the volume to 15 °C using recognized standard correction factors.

(i) 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.

(j) Meter. Measure from end to end parallel to the base or foundation being measured.

(k) Metric ton (t). 1000 kilograms. 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 1000 liters per metric ton regardless of temperature.

When asphalt cement for asphalt concrete pavement is stored in tanks devoted exclusively to the project, base quantities on invoices. When asphalt cement 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.

(l) Square meter (m^2). Measure on a plane parallel to the surface being measured. Make no deductions from the area computation for individual fixtures having an area of 1 square meter or less.

109.03 Weighing Procedures and Devices. 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 50 kilograms. 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 bulk heads 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 50 kilograms
(8) Subtotal net mass for each haul unit since the beginning of the shift
(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.

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.

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
(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. All FAR clauses providing for an equitable price adjustment are supplemented as follows.

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 52.215-23 -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 SF 1411, *Contract Price Proposal Cover Sheet*, and the written proposal for pricing the work according to (1) above, with the cost or pricing data.

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), and paid subsistence and/or 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/or 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/or 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. FAR Clause 52.243-4) Changes is supplemented as follows.

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. No adjustments will be made in the contract time when individual items are eliminated.

109.08 Progress Payments. FAR Clauses 52.232-5) Payments under Fixed-Price Construction Contracts and 52.232-27) Prompt Payment for Construction Contracts are supplemented as follows.

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 when the work accomplished results in a net payment of less than $1,000.

The closing date for progress payments will be designated by the CO. Request changes in the closing date in writing.

Within 7 days after the closing date, the CO will be available by appointment at the Government's project office to advise the Contractor of quantities and unit prices appearing on the Government's receiving report. The receiving report will be submitted to the billing office unless the Contractor requests in writing that the submission be delayed for the Contractor's review or for consideration of an adjustment.

Submit the invoice to the designated billing office. The invoice shall include the following:

(a) 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 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.

(b) 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.

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

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

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

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

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

(1) Retent resulting from a failure to maintain acceptable progress.

(2) Retent resulting from violations of the labor provisions.

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

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

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

If any of the quantities or unit prices shown on the Contractor's invoice exceed the corresponding quantities and unit prices shown on the CO's receiving report, the invoice will be deemed defective and the Contractor so notified according to FAR Clause 52.232-27(a)(2). Defective invoices will not be corrected by the Government and will be returned to the Contractor. Revise and resubmit returned invoices.

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:

- 80 percent of the contract bid price for the item, or

- 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. FAR Clause 52.232-5) Payment under Fixed-Price Construction Contracts is supplemented as follows.

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 by the lump sum.

Payment

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

The mobilization lump sum will be paid as follows:

(a) Bond premiums will be reimbursed according to FAR Clause 52.-232-5, Payment Under Fixed-Price Construction Contracts, after receipt of the evidence of payment.

(b) 50 percent of the lump sum, not to exceed 5 percent of the original contract amount, will be paid following completion of 5 percent of the original contract amount not including mobilization and bond premiums.

(c) Payment of the remaining portion of the lump sum, up to 10 percent of the original contract amount, will be paid following completion of 10 percent of the original contract amount not including mobilization and bond premiums.

(d) Any portion of the lump sum in excess of 10 percent of the original contract amount will be paid after final acceptance.

Payment will be made under:

Pay Item	Pay Unit
15101 Mobilization	Lump sum

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. This Section supplements FAR Clause 52.236-17, Layout of Work.

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

(a) Personnel. Furnish technically qualified survey crews 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. 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
(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. Furnish calculations supporting pay quantities. 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.

(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 cross-sections normal to centerline. The centerline spacing between cross-section locations shall not exceed 20 meters. Take additional cross-sections at breaks in topography and at changes in the typical section. For each cross-section, measure and record points at breaks in topography, but at least every 5 meters. Measure and record points to at least the anticipated slopes 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. Spacing between centerline points shall not exceed 20 meters. Reestablish centerline as many times as necessary to construct the work.

(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 spacing between stakes in any direction is 20 meters. Use brushes or guard stakes at each stake. Reset grade finishing stakes as many times as necessary to construct the subgrade and each aggregate course.

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

(1) Survey and record the ground profile along centerline of structure.
(2) Determine the slope catch points at the inlet and outlet.
(3) Set reference points and record information necessary to determine structure length and end treatments.
(4) Stake ditches or grade to make the structure functional.
(5) Plot the profile along centerline of the structure to show the natural ground, the flow line, the roadway section, and the structure.
(6) Submit the plotted field-design cross-section for approval of final structure length and alignment.

(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 2 meters in front of the wall face. Every 5 meters 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 5 meters and at all major breaks in terrain. Set adequate references and horizontal and vertical control points.

(j) Borrow sites. Perform the work essential for initial layout and measurement of the borrow 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, control, and measurement of the following, as applicable:

(1) Topsoil stripping
(2) Waste
(3) Approach roads
(4) Special ditches
(5) Turf establishment

(m) Intermediate surveying and staking. Perform all survey, staking, recording of data, and calculations as necessary to construct the project from the basic layout and controls established in (a) through (l) above.

Perform additional surveying and staking necessary to execute individual work items.

Remeasure roadway excavation 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.

Table 152-1
Construction Survey and Staking Tolerances

Staking Phase	Horizontal	Vertical
Control points	1:10000	±5 mm
Centerline points[1]) (PC), (PT), (POT), and (POC) including references	1:5000	±10 mm
Other centerline points	±50 mm	±100 mm
Cross-section points and slope stakes[2]	±50 mm	±100 mm
Slope stake references[2]	±50 mm	±20 mm
Culverts, ditches, and minor drainage structures	±50 mm	±20 mm
Retaining walls	±20 mm	±10 mm
Bridge substructures	1:5000 NTE[3] ±20 mm	±10 mm
Bridge superstructures	1:5000 NTE[3] ±5 mm	±10 mm
Clearing and grubbing limits	±500 mm	)
Roadway subgrade finish stakes	±50 mm	±10 mm
Roadway finish grade stakes	±50 mm	±10 mm

(1) Centerline points: PC - point of curve, PT - point of tangent, POT - point on tangent, POC - point on curve.
(2) Take the cross-sections normal to the centerline ±1 degree.
(3) Not to exceed.

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

Measurement

152.05 Measure construction survey and staking, bridge survey and staking, and retaining wall survey and staking by the lump sum.

Measure slope, reference, and clearing and grubbing stakes by the kilometer.

Measure centerline reestablishment by the kilometer. Measure centerline reestablishment only one time.

Measure drainage structure survey and staking by the each.

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

Measure permanent monuments and markers by the each.

Measure miscellaneous survey and staking by the hour of survey work ordered or by the lump sum. 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.

Do not measure intermediate surveying and staking for payment.

Payment

152.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

The construction survey and staking lump sum item will be paid as follows:

(a) 25 percent of the lump sum, not to exceed 0.5 percent of the original contract amount, will be paid following completion of 10 percent of the original contract amount not including mobilization and payment for stockpiled material.

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

The bridge survey and staking and the retaining wall survey and staking lump sum items will be paid on a prorated basis as the applicable work progresses.

Payment will be made under:

Pay Item		**Pay Unit**
15201	Construction survey and staking	Lump sum
15202	Slope, reference, and clearing and grubbing stakes	Kilometer
15203	Centerline reestablishment	Kilometer
15204	Drainage structure survey and staking	Each
15205	Bridge survey and staking	Lump sum
15206	Retaining wall survey and staking	Lump sum
15207	Grade finishing stakes	Kilometer
15208	Permanent monuments and markers	Each
15209	Miscellaneous survey and staking	Hour
15210	Miscellaneous survey and staking	Lump sum

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. This Section supplements 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, 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 who will perform 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 phases before scheduled Government 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/or 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 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. 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, contract item number, test number, each test parameter, the upper and/or 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/or 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

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, 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. 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. Furnish approved containers for the Government's portion of split samples. Label Government samples. The CO will take possession of the Government samples.

154.03 Testing. When there is a contract pay item for Contractor testing, perform all tests required by the Sampling and Testing Tables for all applicable work. Allow the CO the opportunity to witness all testing. Testing of trial samples may be required to demonstrate testing competence.

154.04 Records. Record test results on acceptable forms. Furnish all test results in the minimum time reasonably necessary to perform the tests and transmit the results. When tests are on material being incorporated in the work, report test results within 24 hours. 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 Contractor testing by the lump sum.

Payment

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

The Contractor testing lump sum will be paid as follows:

(a) 25 percent of the lump sum, 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 lump sum 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.

Payment will be made under:

Pay Item	Pay Unit
15401 Contractor testing	Lump sum

Section 155.) SCHEDULES FOR CONSTRUCTION CONTRACTS

Description

155.01 This work consists of scheduling and monitoring all construction activities. This Section supplements 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
- **(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.

Do not show conflicts with any scheduled activities and order of work requirements in the contract.

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 will 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 meters 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, and any proposed logic and/or 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.

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

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

Measurement

155.08 Measure construction schedules by the lump sum.

Payment

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

The construction schedule lump sum will be paid as follows:

(a) 25 percent of the lump sum, not to exceed 0.5 percent of the original contract amount, will be paid after the preliminary construction schedule is accepted.

(b) 50 percent of the lump sum will be paid after the construction schedule is accepted.

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

Payment will be made under:

Pay Item	Pay Unit
15501 Construction schedule	Lump sum

Section 156.) PUBLIC TRAFFIC

Description

156.01 This work consists of controlling and protecting public traffic adjacent to and within the project. This section supplements 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 assures 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 detour 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) Provide access for snow removal by others.

(d) Maintain a reasonably dust-free traveled way.

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

Maintain the roadway and detours 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. The Government is responsible for snow removal.

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) Install permanent traffic barriers within 30 days of completing the surface course.

(c) For shoulder drop-offs in excess of 50 millimeters, provide *"Low Shoulder"* warning signs. For shoulder drop-offs in excess of 100 millimeters, provide a 1:3 fillet with *"Low Shoulder"* warning signs. Complete the construction of shoulders adjacent to traffic lanes to the same elevation within 14 days.

(d) Provide minimum lane widths of 3.0 meters. 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.

(e) Locate staging areas at least 10 meters 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.

(f) Park equipment at least 10 meters from the traveled way or behind acceptable traffic barriers.

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

(h) Provide two-way radio communications between flaggers and 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.

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

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

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 detour construction, when required by the contract, under the applicable pay items.

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
Bales	713.13
Erosion control culvert pipe	713.15
Fertilizer	713.03
Geotextile	714.01
Matting	629.02
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 approval 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 30 000 square meters 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 30 days according to Sections 624 and 625.

(d) Apply temporary turf establishment or other approved measures on disturbed areas that will remain exposed for over 30 days.

(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, 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. 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 1 meter 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) Blankets and mats. Use erosion control mulch blankets, erosion control mats, turf reinforcement mats, erosion control and revegetation mats, fiberglass roving, and synthetic or organic mulch control netting 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 kg/ha
Seed	40
Fertilizer	375
Mulch, 40±10 mm depth	1500

157.12 Inspection and Reporting. Inspect all erosion control facilities at least every 7 days, within 24 hours after more than 10 millimeters 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
(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 turf 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 following items for payment when ordered by the CO and installed. Do not measure replacement items for payment.

Measure silt fence, brush barriers, slope drains, earth berms, and temporary culvert pipe by the meter.

Measure bales, check dams, sandbags, sediment traps, and riser pipe assemblies by the each.

Measure plastic lining by the square meter excluding overlaps.

Measure temporary turf establishment by the hectare on the ground surface or by the kilogram. When measurement is by the kilogram, weigh the seed in kilograms.

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 matting under Section 629.

Payment

157.16 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown 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 for each item will be paid upon installation.

(b) 25 percent of the unit bid price for each item will be paid following completion of 50 percent of the contract amount.

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

Payment will be made under:

Pay Item		**Pay Unit**
15701	Temporary turf establishment	Kilogram
15702	Temporary turf establishment	Hectare
15703	Silt fence	Meter
15704	Brush barriers	Meter
15705	Slope drains	Meter
15706	Earth berms	Meter
15707	Temporary culvert pipe	Meter
15708	Bales *(description)*	Each
15709	Check dams	Each
15710	Sandbags	Each
15711	Sediment traps	Each
15712	Riser pipe assembly	Each
15713	Plastic lining	Square meter

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 When applied according to Subsection 158.03(a), measure watering for dust control by the cubic meter in the hauling vehicle or by metering. Do not measure water applied according to Subsection 158.03(b) for payment.

Payment

158.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
15801 Watering for dust control	Cubic meter

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 150 millimeters of the ground.

(d) Trim tree branches that extend over the road surface and shoulders to attain a clear height of 6 meters. 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, except that undisturbed stumps protruding less than 150 millimeters above the original ground and covered with a minimum of 1 meter of embankment may be left in place.

(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 for 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 clearing and grubbing by the hectare or by the lump sum. 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 for payment.

Payment

201.09 The accepted quantity, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
20101	Clearing and grubbing	Hectare
20102	Clearing and grubbing	Lump sum

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/or other vegetation is designated to remain.

(b) Selective clearing and grubbing. Clearing and grubbing where some trees and/or vegetation is designated to remain.

(c) Special clearing and grubbing. Clearing and grubbing where all trees and/or 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 selective clearing, selective clearing and grubbing, and special clearing and grubbing by the hectare.

Measure removal of individual trees by the square meter based on the average diameter at the cutoff. Do not measure trees less than 150 millimeters in diameter at the cutoff for payment.

Measure removal of individual stumps by the each.

Payment

202.10 The accepted quantity, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
20201	Selective clearing	Hectare
20202	Selective clearing and grubbing	Hectare
20203	Special clearing and grubbing	Hectare
20204	Removal of individual trees	Square meter
20205	Removal of individual stumps	Each

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.

Matchmark members of salvaged structures. Furnish one set of drawings identifying the members and their respective matchmarks.

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 all of the culvert upstream from the removal. The remaining downstream culvert may be left in place if no portion of the culvert is within 1 meter 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 1 meter below subgrade elevation. Remove structures and obstructions outside the roadbed to 0.5 meter 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. Where economically and practically feasible, the Contractor is urged to recycle 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 with earth material. Alternating layers consist of 1 meter of debris covered with 0.5 meter of earth. Distribute stumps, logs, and other large pieces to form a dense mass and minimize air voids. Fill all voids. Cover the top layer of buried debris with at least 0.5 meter of compacted earth. Grade and shape the area.

(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 removal of structures and obstructions by the each, by the meter, by the square meter, or by the lump sum. Measure removal by the meter and by the square meter before removal.

Payment

203.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
20301 Removal *(description)*	Each
20302 Removal *(description)*	Meter
20303 Removal *(description)*	Square meter
20304 Removal *(description)*	Lump sum
20305 Removal of structures and obstructions	Lump sum

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 the placement and compaction of 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
(5) Backfilling subexcavated areas, holes, pits, and other depressions

(c) Embankment material. Material for embankment construction are:

(1) Rock. Rock is material containing 25 percent or more, by volume, rock particles greater than 100 millimeters in diameter.

(2) Earth. Earth is material containing less than 25 percent, by volume, rock particles greater than 100 millimeters in diameter.

(d) 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. A material reasonably free from hard soil, rock, clay, toxic substances, litter, or other deleterious material.

(e) 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.

Excavate material suitable for backfill, roadbed finishing, topping, or other purposes in a sequence that permits the placement of the excavation directly into its final position or in stockpiles for subsequent placing.

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 150 millimeters 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 150 millimeters 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. Where applicable, survey 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. Excess borrow excavation will be deducted 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 1 meter high over natural ground. Completely break up the cleared ground surface to a minimum depth of 150 millimeters by plowing or scarifying. Compact the ground surface according to Subsection 204.11.

(b) Embankment less than 0.5 meter high over an existing asphalt, concrete, or gravel road surface. Scarify gravel roads to a minimum depth of 150 millimeters. Scarify or pulverize asphalt and concrete roads to 150 millimeters below the pavement. Reduce all particles to a maximum size of 150 millimeters 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 1:3 (1 unit vertical to 3 units horizontal). 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 type roller or by walking with a dozer. For slopes 1:1.75 or steeper, compact the slopes as construction of the embankment progresses.

(b) Rock. Place rock in horizontal layers not exceeding 300 millimeters in compacted thickness. Material composed predominantly of boulders or rock fragments too large for 300-millimeter layers may be placed in layers of up to 600 millimeters thick. Incorporate oversize boulders or rock fragments into a 600-millimeter layer by reducing them in size or placing them individually according to (c) below. Place rock layers with sufficient earth and smaller rocks to fill the voids. Compact each layer according to Subsection 204.11 before placing the next layer.

Construct the top 300 millimeters of the embankment with topping or other suitable material.

(c) Individual rock fragments and boulders. Place individual rock fragments and boulders greater than 600 millimeters in diameter as follows:

(1) Reduce rock to less than 1200 millimeters in the largest dimension.

(2) Distribute rock within the embankment to prevent nesting and fill the voids between them with finer material.

(3) Compact each layer according to Subsection 204.11.

(d) Earth. Place earth in horizontal layers not exceeding 300 millimeters in compacted thickness. Incorporate oversize boulders or rock fragments into the 300-millimeter layers by reducing them in size or placing them individually as required in (c) above.

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

(e) Embankment outside of roadway prism. Where placing embankment outside the staked roadway prism, place material in horizontal layers not exceeding 600 millimeters in compacted thickness. Compact each layer according to Subsection 204.11(a).

(f) Other Embankments. 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 100 millimeters.

204.11 Compaction. Compact as follows:

(a) Rock embankment. Adjust the moisture content of the material to a moisture content suitable for compaction. Compact each layer of material full width with one of the following:

(1) Four roller passes of a 45-metric ton compression-type roller
(2) Four roller passes of a vibratory roller having a minimum dynamic force of 180 kilonewtons impact per vibration and a minimum frequency of 16 hertz
(3) Eight roller passes of a 20-metric ton compression-type roller
(4) Eight roller passes of a vibratory roller having a minimum dynamic force of 130 kilonewtons impact per vibration and a minimum frequency of 16 hertz

Proportion the compactive effort for layers deeper than 300 millimeters as follows.

- For each additional 150 millimeters or fraction thereof, increase the number of roller passes in (1) and (2) above by four.
- For each additional 150 millimeters or fraction thereof, increase the number of roller passes in (3) and (4) above, by eight.

Operate compression-type rollers at speeds less than 2 meters per second and vibratory rollers at speeds less than 1 meter per second.

(b) Earth embankment. 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.

Compact material placed in all embankment layers and the material scarified in cut sections to at least 95 percent of the maximum density. Determine the inplace density and moisture content according to AASHTO T 238 and AASHTO T 239 or other approved test procedures.

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 0.5 meter 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 1.3:1 to 1:2. Construct the steps approximately 0.5 meter 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 150 millimeters from the top 150 millimeters of the roadbed. Remove unsuitable material from the roadbed and replace it with suitable material. Finish earth roadbeds to within ±15 millimeters and rock roadbeds to within ±30 millimeters of the staked line and grade. Finish ditch cross-sections to within ±30 millimeters 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. Material for embankment and conserved topsoil will be evaluated under Subsections 106.02 and 106.04. See Table 204-1 for minimum sampling and testing requirements.

Excavation and embankment construction will be evaluated under Subsections 106.02 and 106.04. See Table 204-1 for minimum sampling and testing requirements.

Clearing will be evaluated under Sections 201 and 203.

Placing of conserved topsoil will be evaluated under Section 624.

Measurement

204.16 Measure as follows:

(a) Roadway excavation. When a roadway excavation pay item is shown in the bid schedule and there is no pay item for embankment construction, measure by the cubic meter in place 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
(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 stockpiled at the option of the Contractor
(l) Material excavated outside the established slope limits

(b) Subexcavation. When a subexcavation pay item is shown in the bid schedule, measure by the cubic meter in place in its original position.

(c) Unclassified borrow, select borrow, and select topping. When a borrow excavation pay item (unclassified borrow, select borrow, and select topping) is shown in the bid schedule, measure by the cubic meter in original position or by the metric ton. Do not measure borrow excavation used instead of excess roadway excavation. If borrow excavation is measured by the cubic meter, 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.

(d) Embankment construction. When an embankment construction pay item is shown in the bid schedule, measure by the cubic meter in final position. Do not measure roadway excavation except as described in (3) below. 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
(d) Material used for dikes, ramps, mounds, and berms

(2) Do not include the following in embankment construction:

(a) Preparing foundations for embankment construction
*(b)*Adjustments for subsidence or settlement of the embankment or of the foundation on which the embankment is placed
(c) Material used to round fill slopes

(3) When embankment construction and roadway excavation pay items are shown in the bid schedule, measure roadway excavation by the cubic meter in place in its original position and include only 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.
(c) Drainage ditches, channel changes, and diversion ditches.

(e) Furrow ditches. Measure furrow ditches by the meter.

(f) Rounding cut slopes. Measure rounding cut slopes by the meter horizontally along the centerline of the roadway for each side of the roadway.

(g) Waste. Measure waste by the cubic meter in 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.

(h) Slope scaling. Measure slope scaling by the cubic meter in the hauling vehicle.

Payment

204.17 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
20401	Roadway excavation	Cubic meter
20402	Subexcavation	Cubic meter
20403	Unclassified borrow	Cubic meter
20404	Unclassified borrow	Metric ton
20405	Select borrow	Cubic meter
20406	Select borrow	Metric ton
20407	Select topping	Cubic meter
20408	Select topping	Metric ton
20409	Embankment construction	Cubic meter
20410	Furrow ditches	Meter
20411	Rounding cut slopes	Meter
20412	Waste	Cubic meter
20413	Slope scaling	Cubic meter

Table 204-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Earth (roadway excavation, backfill material, and unclassified borrow)	Classification	AASHTO M 145	1 for each material type	Source of material
	Moisture-Density	AASHTO T 99 method C or AASHTO T 180 method D (1)	1 for each material type	Source of material
	In-place density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 4000 m^2 but not less than 1 for each layer	Roadway embankment
Select borrow Select topping	Classification	AASHTO M 145	1 for each material type	Source of material
	Moisture-Density	AASHTO T 99 method C or AASHTO T 180 method D (1)	1 for each material type	Processed material before incorporated into the work
	Gradation Liquid limit	AASHTO T 27 and AASHTO T 11 AASHTO T 89	1 for each 5000 m^3	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 300 m^3 (500 t) but not less than 1 for each layer	Roadway embankment

(1) See Subsection 204.11(b)

continued

Table 204-1 (continued)
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Topping	Classification	AASHTO M 145	1 for each material type	Processed material before incorporated into the work
	Moisture-Density	AASHTO T 99 method C or AASHTO T 180 method D (1)	1 for each material type	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 300 m^3 (500 t) but not less than 1 for each layer	Roadway embankment

(1) See Subsection 204.11(b)

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.

205.04 Blasting Plan. Submit a blasting plan at least 14 days before drilling operations begin or whenever a change in drilling and blasting procedures is proposed. Include full details of drilling and blasting patterns and the techniques proposed for controlled and production blasting including provisions for loading wet holes.

As a minimum, the blasting plan shall contain the following:

(a) Maximum dimensions for width, length, and depth of shot.

(b) Typical plan and section view of the drill pattern for controlled blast holes and production blast holes. Show the free face, burden, hole diameters, depths, spacings, inclinations, and depth of subdrilling if any.

(c) Loading pattern diagram showing:

(1) Location of each hole
(2) Location and amount of each type of explosive in each hole including primer and initiators
(3) Location, type, and depth of stemming

(d) Initiation and delay methods, delay times, and overall powder factor.

(e) Manufacturer's data sheets for all explosives, primers, initiators, and other blasting devices.

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

(g) Working procedures and safety precautions for blasting.

The blasting plan is for quality control and record keeping purposes. The review of the blasting plan does not relieve the Contractor of the responsibility for using existing drilling and blasting technology and for obtaining the required results.

205.05 Blaster-In-Charge. At least 10 days before delivery or use of explosive material, designate in writing a blaster-in-charge. Submit evidence that the blaster-in-charge has a valid state blaster's license or other license issued by an equivalent licensing body for the type of blasting required.

205.06 Test Blasting. Drill, blast, and excavate one or more short 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 controlled blasting 750 millimeters 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.

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

205.07 Controlled Blasting.

(a) General. Drill and blast according to the blasting plan. Use controlled blasting methods to form the final rock cut faces when the rock height is more than 3 meters above ditch grade and slopes are staked 2:1 or steeper.

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 established for controlled blasting and a hole spacing not exceeding 750 millimeters.

(b) Drilling. Remove overburden soil and loose rock along the top of the excavation for at least 10 meters beyond the production hole drilling limits or to the end of the cut.

Drill 75±25-millimeter diameter controlled blast holes along the final rock face line. Drill controlled blast holes within 75 millimeters of the proposed surface location. Drill controlled blast holes at least 10 meters 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 down-hole alignment does not vary more than 225 millimeters 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 limited to 15 meters.

A 300-millimeter 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 0.5 meter below the ditch bottom is allowed for removing the toe.

(c) Blasting. Free blast holes of obstructions for their entire depth. Place charges without caving the blast hole walls.

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

Stem the upper portion of all blast holes with dry sand or other granular material passing a 9.5 millimeter sieve.

Where presplitting, delay the nearest production blast row at least 25 milliseconds after blasting the presplit line. Presplit a minimum of 10 meters 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.

205.08 Production Blasting.

(a) General. Drill production holes and blast according to the blasting plan. Take all necessary precautions to minimize blast damage to the final rock face.

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

Remove or stabilize all cut face rock that is loose, hanging, or potentially dangerous. Scale by hand methods using a standard steel mine scaling rod. Machine scale using hydraulic splitters or light blasting when necessary. 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. Repair or stabilization may include removal, rock bolting, rock dowels, or other stabilization techniques.

Halt blasting operations if any of the following occur:

(1) Slopes are unstable.
(2) Slopes exceed tolerances.
(3) Backslope damage occurs.
(4) Safety of the public is jeopardized.
(5) Property or natural features are endangered.
(6) Fly rock is generated.

(b) Drilling. Drill the row of production blast holes closest to the controlled blast line parallel and no closer than 2 meters to the controlled blast line. Do not drill production blast holes lower than the bottom of the controlled blast holes.

(c) Blasting. Use the types of explosives and blasting accessories that will obtain the desired fragmentation. Clean the blast holes, place the charges, and stem the holes according to Subsection 205.07(c). Detonate production holes on a delay sequence toward a free face.

205.09 Blasting Log. Submit a blasting log for each blast. The blasting log shall include the following:

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

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

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 controlled blast hole by the meter based on the actual length of drilling as recorded in the blasting log.

Do not measure production blasting for payment.

Payment

205.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
20501 Controlled blast hole	Meter

Section 206 Reserved

Section 207.) EARTHWORK GEOTEXTILES

Description

207.01 This work consists of furnishing and placing a geotextile as a permeable separator 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 1 meter beyond the damaged area.

207.04 Separation and Stabilization Applications. Where placing a geotextile on a subgrade, prepare 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 0.5 meter 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 geotextile 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 300 millimeters. 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 300 millimeters 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 1.5 meters. Pins may be used to hold the geotextile sheets in place. Space pins along the overlaps at approximately 1-meter 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 300 millimeters. Place slope protection rock or aggregate backfill onto the geotextile from a height less than 1 meter. 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 earthwork geotextile by the square meter excluding overlaps.

Payment

207.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	**Pay Unit**
20701 Earthwork geotextile type ____	Square meter

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
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. Submit working drawings and construction details according to Subsection 104.03 where support systems, shield systems, or other protective systems are used. Drawings shall demonstrate conformity with regulations.

Remove safety features when no longer necessary. Remove shoring and bracing to at least 0.5 meter 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 0.6 meter 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.
(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. Shore and construct cofferdams according to OSHA standards. 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.
(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 0.5 meter 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, either level or 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 neat lines of the footing and compact the foundation. Where material does not stand vertically, fill all space between the neat lines 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 150 millimeters 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 150 millimeters 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 90 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 A-ASHTO T 238 and AASHTO T 239 or other approved test procedures.

208.12 Acceptance. Material for structural backfill and foundation fill will be evaluated under Subsections 106.02 and 106.04. See Table 208-1 for minimum sampling and testing requirements.

Structure excavation and backfill work will be evaluated under Subsections 106.02 and 106.04. See Table 208-1 for minimum sampling and testing requirements.

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

Clearing will be evaluated under Sections 201 and 203.

Seal concrete will be evaluated under Section 552.

Measurement

208.13 Measure structure excavation by the cubic meter in place in its original position. Do not include the following volumes:

(a) Material excavated outside vertical planes located 450 millimeters outside and parallel to the neat lines of footings or foundations. Use these vertical planes to determine pay quantities regardless of the amount of material excavated inside or outside these planes.

(b) Any material included within the staked limits of the roadway excavation, such as contiguous channel changes and ditches, for which payment is otherwise provided in the contract.

(c) Water or other liquid material.

(d) Material excavated before the survey of elevations and measurements of the original ground.

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

Measure foundation fill by the cubic meter in place.

Measure structural backfill by the cubic meter in place. Limit the volume of structural backfill measured to that placed inside vertical planes located 450 - millimeters outside and parallel to the neat lines of footings or foundations. Use these vertical planes to determine pay quantities regardless of the amount of backfill material placed outside these planes.

Measure shoring and bracing, and cofferdams by the lump sum.

Measure seal concrete under Section 552.

Payment

208.14 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown 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 2 meters below the lowest elevation shown on the plans for each foundation structure. When the excavation exceeds 2 meters, either the Contractor or the CO may request an equitable price adjustment for the depth in excess of 2 meters.

Payment will be made under:

Pay Item		Pay Unit
20801	Structure excavation	Cubic meter
20802	Foundation fill	Cubic meter
20803	Structural backfill	Cubic meter
20804	Shoring and bracing	Lump sum
20805	Cofferdams	Lump sum

Table 208-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Structural backfill	Gradation Liquid limit	AASHTO T 27 and AASHTO T 11 AASHTO T 89	1 for each material type	Source of material or stockpile
	Moisture-Density	AASHTO T 99 method C	1 for each material type	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 200 m^3 but not less than 2 for each installation	Compacted material
Foundation fill	Classification	AASHTO M 145	1 for each material type	Source of material or stockpile
	Moisture-Density	AASHTO T 99 method C	1 for each material type	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 200 m^3 but not less than 2 for each installation	Compacted material

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
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 material as follows:

(a) Structures other than culverts. Construct bedding when required by the contract. Place and shape bedding material in layers that when compacted do not exceed 150 millimeters in depth. Compact each layer according to Subsection 209.11. When no bedding material class is specified, use class B bedding material.

(b) Culverts. Bed culverts on a prepared foundation. Use one of the following classes. When no class is specified, use class C.

(1) Class A. Place a continuous cradle of class A bedding material. Place the culvert while the concrete is still plastic. Do not backfill until the concrete reaches initial set.

(2) Class B. Loosely place a 150-millimeter thick layer of class B bedding material. Place and shape additional bedding material to fit at least 10 percent of the culvert height. Where applicable, recess the shaped bedding to receive the culvert joints. Place the culvert in the bedding. Extend the bedding material up the sides of the culvert to cover 30 percent of the culvert height.

(3) Class C. Loosely place a layer of class C bedding material to a thickness equal to at least 10 percent of the culvert height. Place and shape additional bedding material to fit at least 10 percent of the culvert height. Where applicable, recess the shaped bedding to receive the culvert joints. Place the culvert in the bedding.

209.10 Backfill. Backfill as follows:

(a) General. Place backfill in horizontal layers that when compacted do not exceed 150 millimeters 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 90 percent of the design strength is achieved.

(b) Culvert. Where installing plastic pipe, use backfill material conforming to AASHTO M 145 classification group A-1, A-2, or A-3.

Place and compact backfill material under exposed portions of the haunch. Extend each layer to the sides of the excavation, the natural groundline, or 3 times the span of the pipe, whichever is less. Repeat the layering process to a minimum of 300 millimeters 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 150 millimeters in depth. Compact each layer according to Subsection 209.11.

For multiple installations, place and compact backfill material layers evenly on each side of each culvert.

(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 375 millimeters with 300 millimeters of crushed aggregate according to Section 301 and 75 millimeters of asphalt concrete according to Section 402 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 238 and AASHTO T 239 or other approved test procedures.

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

Structural excavation and backfill work will be evaluated under Subsections 106.02 and 106.04. See Table 209-1 for minimum sampling and testing requirements.

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

Clearing 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 concrete for class A bedding material under Section 601.

Measure foundation fill under Section 208.

Measure seal concrete under Section 552.

Table 209-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Backfill material Unclassified borrow Class C bedding material Foundation fill	Classification	AASHTO M 145	1 for each material type	Source of material
	Moisture-Density	AASHTO T 99 method C	1 for each material type	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 0.5 m of vertical depth but not less than 2 for each installation	Compacted material
Class B bedding material	Gradation	AASHTO T 27 and AASHTO T 11	1 for each material type	Source of material
Structural backfill Select granular backfill Crib wall backfill	Gradation Liquid limit	AASHTO T 27 and AASHTO T 11 AASHTO T 89	1 for each material type	Source of material or stockpile
	Moisture-Density	AASHTO T 99 method C	1 for each material type	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 0.5 m of vertical depth but not less than 2 for each installation	Compacted material

Section 210.) PERMEABLE BACKFILL

Description

210.01 This work consists of furnishing and placing permeable backfill against the backfilled faces of retaining walls, wing walls, and abutments.

Material

210.02 Conform to the following Subsections:

Geotextile type I	714.01
Permeable backfill	703.04
Structural backfill	704.04

Construction Requirements

210.03 General. Do not place permeable backfill against a mortar course less than 4 days old.

Cover the inlet end of each weep hole and drain with a geotextile extending at least 0.5 meter beyond the weep hole or drain. Place permeable backfill against the surface to be backfilled. Place structural backfill according to Subsection 208.10 using methods which prevent the structural backfill from mixing with the permeable backfill.

210.04 Acceptance. Material for permeable backfill will be evaluated under Subsections 106.02 and 106.04. See Table 210-1 for minimum sampling and testing requirements.

Placement of permeable backfill will evaluated under Subsections 106.02 and 106.04.

Geotextile will be evaluated under Section 207.

Structural backfill will be evaluated under Section 208.

Measurement

210.05 Measure permeable backfill by the cubic meter in the structure.

Payment

210.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	**Pay Unit**
21001 Permeable backfill	Cubic meter

Table 210-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Permeable backfill	Gradation	AASHTO T 27 and AASHTO T 11	1 for each 500 t	Source of material or stockpile

Section 211.) ROADWAY OBLITERATION

Description

211.01 This work consists of obliterating and recontouring roadways, turnouts, parking areas, and other widened areas.

Construction Requirements

211.02 General. Scarify and bury or remove the existing pavement structure. Break down and bury or remove old structures. Fill ditches and restore the obliterated roadway to the approximate original ground contour or shape to blend with the terrain.

211.03 Rigid Material.

(a) Nonasphalt material. Break concrete pavements, curbs, gutters, sidewalks, and other nonasphalt rigid material into pieces with maximum dimension of 300 millimeters. Bury under a minimum of 0.5 meters of soil. As an alternative to breaking and burying, remove the rigid material from the project and dispose of it according to Subsection 203.05(a).

(b) 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 (a) above.

211.04 Nonrigid Material.

(a) 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 300 millimeters of soil.

(b) Asphalt contaminated material. Dispose of asphalt contaminated material according to Subsection 211.03(b).

211.05 Shaping. Shape to blend with the existing terrain.

211.06 Acceptance. Roadway obliteration will be evaluated under Sub-section 106.02.

Measurement

211.07 Measure roadway obliteration by the square meter before obliteration or by the lump sum.

Measure the square meter area on a horizontal plane. Measure to the intersection of roadway with natural ground (approximate slope stake location). Do not measure isolated areas less than 20 square meters for payment.

Measure material obtained from obliterating roadways and used elsewhere in the work, or material obtained elsewhere in the work and used to obliterate roadways under Section 204.

Payment

211.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
21101	Roadway obliteration	Square meter
21102	Roadway obliteration	Lump sum

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 300-millimeter 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 3 meters 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 30 meters. Compound curves are permitted.

(b) Profile grade. Profile grade may be shifted a maximum of 1.5 meters 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 will be evaluated under Sections 201 and 203.

Measurement

212.06 Measure linear grading by the kilometer based on the plan alignment.

Payment

212.07 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
21201 Linear grading	Kilometer

Section 213.) SUBGRADE STABILIZATION

Description

213.01 This work consists of processing and incorporating lime, lime/fly ash, or portland 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
Lime	725.03
Portland cement	701.01
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	Compressive Strength (minimum)
Lime/Soil	ASTM D 5102	0.70 MPa (1)
Lime/Fly ash/Soil	ASTM C 593	2.75 MPa (2)
Cement/Soil	ASTM D 1633	2.75 MPa (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) 90-kilogram sample of the subgrade soil
(d) 25-kilogram sample of the fly ash
(e) 10-kilogram sample of the lime
(f) 10-kilogram sample of the cement
(g) 2-kilogram 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 150 millimeters. 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 4 °C. Do not apply when excessive additive is lost to washing or blowing or when the air temperature is expected to fall below 4 °C 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 45 millimeter sieve and at least 50 percent of the mixture passes a 4.75 millimeter 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 238 and AASHTO T 239 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 producing 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 1.1 liters per square meter 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. Material for blotter, chemical admixtures (retarder), fly ash, lime, portland 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. See Table 213-2 for minimum sampling and testing requirements.

Reconditioning of subgrade will be evaluated under Section 303.

Emulsified asphalt seal will be evaluated under Section 409.

Measurement

213.10 Measure subgrade stabilization by the square meter. 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 lime, cement, and fly ash by the metric ton.

Measure emulsified asphalt under Section 409.

Measure blotter under Section 411.

Payment

213.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
21301	Subgrade stabilization with ____________, __ millimeter depth	Square meter
21302	Lime	Metric ton
21303	Cement	Metric ton
21304	Fly ash	Metric ton

Table 213-2
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Remixed material	Gradation	AASHTO T 27	1 for each 5000 m^2	Processed material before final compaction
	Moisture-Density	AASHTO T 99 method C	1 for each mixture or change in material	Processed material before final compaction
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 2500 m^2	Compacted subgrade

DIVISION 250
Structural Embankments

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
Mortar	712.05
Riprap rock	705.02

Construction Requirements

251.03 General. Perform the work under Section 209. Dress the slope to produce a smooth surface. Place geotextile required by the contract 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 keyed into place by striking with a flat-faced weight.

Place rock for keyed riprap according to Subsection 251.04. Key the riprap into place by striking the surface with a 1.2 meter by 1.5 meter flat-faced weight with a mass of approximately 2000 kilograms. Do not strike riprap below the water surface.

251.06 Mortared Riprap. Mortared riprap is rock placed on a prepared surface and with the voids filled with portland cement mortar.

Place rock for mortared riprap according to Section 251.04. Thoroughly moisten the rocks and wash excess fines to the underside of the riprap. Place mortar only when the temperature is above 2 °C and rising. Place the mortar in a manner to prevent segregation. Fill all voids without unseating the rocks. Provide weep holes through the riprap as required. Protect the mortared riprap from freezing and keep it moist for 3 days after the work is completed.

251.07 Acceptance. Rock for riprap will be evaluated under Subsection 106.02.

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 mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsections 106.02 and 106.04. Mortar placement will be evaluated under Subsection 106.02. See Table 251-1 for minimum sampling and testing requirements.

Measurement

251.08 Measure riprap by the metric ton or by the cubic meter in place.

Payment

251.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
25101	Placed riprap class ______	Cubic meter
25102	Placed riprap class ______	Metric ton
25103	Keyed riprap class ______	Cubic meter
25104	Keyed riprap class ______	Metric ton
25105	Mortared riprap class _____	Cubic meter

Table 251-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Mortar	Making test specimens Compressive strength [(2)]	AASHTO T 23 AASHTO T 22	1 sample per installation [(1)]	Job site

(1) Sample consists of 2 test specimens.
(2) The compressive strength will be the average of two test specimens.

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 neat line of the slope that are more than 300 millimeters for mechanically-placed rock or 150 millimeters 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 special rock embankment and rock buttress by the cubic meter in place or by the metric ton.

Payment

252.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
25201 Special rock embankment, ________	Cubic meter
25202 Special rock embankment, ________	Metric ton
25203 Rock buttress, ________	Cubic meter
25204 Rock buttress, ________	Metric ton

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 150 millimeters 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 150 millimeters 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 0.3 meter 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 0.3 meter 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 one meter 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 30 to 50 millimeters.

253.09 Acceptance. Material for gabion structures and revet mattresses will be evaluated under Subsections 106.02 and 106.03.

Construction of gabion structures and revet mattresses will be evaluated under Subsections 106.02 and 106.04.

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. See Table 209-1 for minimum sampling and testing requirements.

Measurement

253.10 Measure gabions by the square meter of front wall face or by the cubic meter in the structure.

Measure revet mattresses by the square meter.

Measure foundation fill under Section 208.

Payment

253.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
25301	Gabions, galvanized or aluminized coated	Square meter
25302	Gabions, polyvinyl chloride coated	Square meter
25303	Gabions, galvanized or aluminized coated	Cubic meter
25304	Gabions, polyvinyl chloride coated	Cubic meter
25305	Revet mattress, galvanized or aluminized coated	Square meter
25306	Revet mattress, polyvinyl chloride coated	Square meter

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
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 200 millimeters 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 25 millimeters in 3 meters from the lines and elevations shown on the plans.

(a) Concrete crib wall. Remove and replace all concrete members which are cracked or damaged.

(b) Metal crib wall. Torque bolts for metal crib walls to at least 34 newton meters.

(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 one meter 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
(d) Treated structural timber and lumber

Construction of 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. See Table 209-1 for minimum sampling and testing requirements.

Concrete crib walls will be evaluated under Section 601.

Timber cribs walls will be evaluated under Section 557

Measurement

254.07 Measure crib walls by the square meter of front wall face.

Measure crib wall backfill placed within the cribs by the cubic meter.

Measure foundation fill under Section 208.

Payment

254.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	**Pay Unit**
25401	Reinforced concrete crib retaining wall	Square meter
25402	Metal crib retaining wall	Square meter
25403	Treated timber crib retaining wall	Square meter
25404	Crib wall backfill	Cubic meter

Section 255.) MECHANICALLY STABILIZED 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 mesh or strips plus 0.5 meter. Where the wall is set on a rocky foundation, place 150 millimeters 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 19 millimeters vertically and horizontally when measured with a 3-meter straightedge.

Make the joint openings 19±6 millimeters wide. Install joint material according to the drawings. Cover all joints on the backside of the panels with a 300-millimeter wide strip of geotextile. Overlap geotextile splices a minimum of 100 millimeters.

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 13 millimeters per 3 meters of wall height.

(b) Wire-faced walls. Place backing mats and 6-millimeter 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 25 millimeters per 3 meters of wall height. Place reinforcement elements within 25 millimeters 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 25 millimeters per 3 meters of wall height. Do not deviate more than 50 millimeters at any point in the wall from a 3-meter 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 100-millimeter 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 one meter of the wall face. Where the stabilized volume supports spread footings for bridges or other structural loads, compact the top 1.5 meters to at least 100 percent of the maximum density.

Do not damage or disturb the facing, reinforcing mesh, or strips. 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. See Table 209-1 for minimum sampling and testing requirements.

Gabions will be evaluated under Section 253.

Concrete leveling pad will be evaluated under Section 601.

Measurement

255.07 Measure mechanically stabilized earth walls by the square meter of front wall face.

Measure select granular backfill within the stabilized volume by the cubic meter in place.

Measure concrete leveling pad by the meter.

Measure foundation fill under Section 208.

Payment

255.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
25501	Mechanically stabilized earth wall	Square meter
25502	Select granular backfill	Cubic meter
25503	Concrete leveling pad, ___ meter width	Meter

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

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 an 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 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
(7) Minimum unbonded length

(b) Ground anchor system drawings shall include the following details:

(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
(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 3 meters in rock and 4.5 meters 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 2.5 millimeter 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 insure a minimum of 13 millimeters 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 3 meters.

Locate the upper centralizer a maximum of 1.5 meters from the top of the tendon bond length. Locate the lower centralizer a maximum of 300 millimeters 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 1 megapascal.

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 225 millimeters.

(d) Unbonded length. Provide minimum unbonded length of 4.5 meters.

(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 multielement 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 300-millimeter 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 300 millimeters 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 1 megapascal 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 150 millimeters 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 0.3 megapascal 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 300 millimeters 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 multielement tendons.

(a) Testing equipment. The testing equipment shall consist of:

(1) A dial gauge or vernier scale capable of measuring to 0.025 millimeter. 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 1 megapascal 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 0.025 millimeter 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 and 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 1 millimeter, 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 which 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 0.025 millimeter 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 1 millimeter, 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 and 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. 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.

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 1 millimeter 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 2-millimeter/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 ground anchors by the each.

Measure performance tests that indicate acceptable installations by the each.

Payment

256.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
25601	Ground anchor	Each
25602	Performance test	Each

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 licensed professional engineer.

Include all details, dimensions, quantities, ground profiles, and cross-sections necessary to construct the wall. Submit design calculations on sheets about 200 by 300 millimeters 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 shall 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
(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 10 meters 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
(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/or 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

(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 alternate retaining walls by the lump sum.

Measure foundation fill under Section 208.

Payment

257.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown 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 meter cost adjustment factor to the added or decreased wall front face area resulting from the change.

The adjustment factor will be determined by dividing the lump sum price bid for each wall by its estimated area shown in the pay item.

The alternate retaining wall lump sum will be paid based on the progress of the work under this Section.

Payment will be made under:

Pay Item	Pay Unit
25701 Alternate retaining wall *(location)* , (*(estimated)* m^2)	Lump sum

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 one meter 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 reinforced concrete retaining walls by the cubic meter in the structure, by the square meter, or by the meter. Include the volume of footings in the cubic meter measurement. Determine the square meter area from the length of the front wall face and the height excluding footings. Determine the meter length along the top of the wall.

Measure foundation fill under Section 208.

Payment

258.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the pay items listed below that are shown on 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 (*PFa*) determined as follows:

$PFa = 1 - 0.5\,(1 - PF)$

Where

PF = Pay factor for concrete as determined under Section 552.

Payment will be made under:

Pay Item		**Pay Unit**
25801	Reinforced concrete retaining wall	Square meter
25802	Reinforced concrete retaining wall	Meter
25803	Reinforced concrete retaining wall	Cubic meter

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 150-kilogram 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 150 millimeters 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 238 and AASHTO T 239 or other approved test procedures.

301.06 Surface Tolerance. If grade finishing stakes are required, finish the surface to within ±10 millimeters 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 3-meter straightedge. Defective areas are surface deviations in excess of 15 millimeters in 3 meters 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. 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. See Table 301-1 for minimum sampling and testing requirements.

(a) Aggregate gradation. The upper and lower specification limits are the approved target values plus or minus the allowable deviations shown in Tables 703-2 and 703-3. See Table 301-1 for the acceptance quality characteristic categories.

(b) Plasticity index. The upper and lower specification limits for surface courses are shown in Table 703-3. See Table 301-1 for the acceptance quality characteristic category.

Construction of untreated aggregate courses will be evaluated under Subsections 106.02 and 106.04. See Table 301-1 for minimum sampling and testing requirements.

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 aggregate by the metric ton, by the square meter, or by the cubic meter in the hauling vehicle. Measure square meter width horizontally to include the top of aggregate width and allowable curve widening. Measure the square meter length horizontally along the centerline of the roadway.

Payment

301.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement adjusted according to Subsection 106.05 for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	**Pay Unit**
30101	Aggregate base grading ___	Metric ton
30102	Aggregate base grading ___, ___ millimeter depth	Square meter
30103	Aggregate base grading ___	Cubic meter
30104	Subbase grading ___	Metric ton
30105	Subbase grading ___, ___ millimeter depth	Square meter
30106	Subbase grading ___	Cubic meter
30107	Aggregate surface course	Metric ton
30108	Aggregate surface course, ___ millimeter depth	Square meter
30109	Aggregate surface course	Cubic meter

Table 301-1
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Subbase and Base courses	Gradation [(1)]) 9.5 mm 4.75 mm 75 µm Other specified sieves	 I I I II	AASHTO T 11 and AASHTO T 27	1 sample per 1000 t	From the windrow or road-bed after processing
	Liquid limit	—	AASHTO T 89	1 sample per 3000 t	From the windrow or road-bed after processing
	Moisture-Density (maximum density)	—	AASHTO T 180 method D	1 for each aggregate grad-ing produced	Production output or stock-pile
	Inplace density and moisture content	—	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 500 t	Inplace completed compacted layer

(1) Use only sieves indicated for the specified gradation.

continued

Table 301-1 (continued)
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Surface course aggregate	Gradation [(1)]) 4.75 mm 425 µm 75 µm Other specified sieves	 I I I II	AASHTO T 11 and AASHTO T 27	1 sample per 1000 t	From the windrow or roadbed after processing
	Plasticity index	I	AASHTO T 90	1 sample per 1000 t	From the windrow or roadbed after processing
	Moisture-Density (maximum density)	—	AASHTO T 180 method D	1 for each aggregate grading produced	Production output or stockpile
	Inplace density and moisture content	—	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 500 t	Inplace completed compacted layer

(1) Use only sieves indicated for the specified gradation.

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/or 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
Lime	725.03
Portland cement	701.01
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 3.45 megapascals with no single test lower than 2.75 megapascals. 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 38±2 °C.

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
Portland 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/or portland 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) 90-kilogram sample of aggregate
(e) 25-kilogram sample of fly ash
(f) 10-kilogram sample of lime
(g) 10-kilogram sample of portland cement
(h) 2-kilogram 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 4 °C 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 0.5 meters 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 1.1 liters per square meter 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. 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.

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. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04. See Table 302-3 for the acceptance quality characteristic categories and minimum sampling and testing requirements.

Construction of treated aggregate courses will be evaluated under Subsections 106.02 and 106.04. See Table 302-3 for minimum sampling and testing requirements.

Preparation of the surface on which the treated aggregate course is placed will be evaluated under to 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 treated aggregate course by the metric ton or by the square meter. Measure square meter width horizontally to include the top of aggregate width and allowable curve widening. Measure the square meter length horizontally along the centerline of the roadway.

Measure fly ash, lime, and cement by the metric ton.

Measure emulsified asphalt under Section 409.

Measure blotter under Section 411.

Payment

302.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement adjusted in according to Subsection 106.05 for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
30201	______ treated aggregate course grading ___	Metric ton
30202	______ treated aggregate course grading ___, ___ millimeter depth	Square meter
30203	Cement	Metric ton
30204	Fly ash	Metric ton
30205	Lime	Metric ton

Table 302-3
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Aggregate	Gradation (1) 9.5 mm 4.75 mm 75 µm Other specified sieves	 I I I II	AASHTO T 11 and AASHTO T 27	1 sample per 1000 t	From the windrow or road-bed after processing
	Liquid limit	—	AASHTO T 89	1 sample per 3000 t	From the windrow or road-bed after processing
Mixture	Moisture-Density (maximum density)	—	AASHTO T 180 method D	1 for each aggregate grading produced	Processed material before incorporated into the work
	Inplace density and moisture content	—	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 500 t	Inplace completed compacted layer

(1) Use only sieves indicated for the specified gradation.

Section 303.) ROAD RECONDITIONING

Description

303.01 This work consists of reconditioning graded roadbeds, aggregate surfaces, or asphalt surfaces. This work also includes cleaning and reshaping shoulders, ditches, and culvert inlets and outlets.

Material

303.02 Conform to the following Sections and Subsection:

Crack sealant	414
Crushed aggregate	308
Minor cold asphalt mix	417
Minor crushed aggregate	308
Minor hot asphalt concrete	402
Water	725.01

Construction Requirements

303.03 General. Remove all slide material, vegetation, and other debris from the existing roadbed or surface including parking areas, turnouts, other widened areas, shoulders, ditches, and culvert inlets and outlets. Clean and reshape ditches and culvert inlets and outlets as required. Dispose of material removed according to Section 203.05.

303.04 Graded Roadbed. Cut to grade any high areas in the roadbed and haul and deposit the resulting material in low areas. Construct embankments to bring the width and surface of the roadbed to finished subgrade according to Subsection 204.10. Remove all organic, deleterious, or oversize material larger than 150 millimeters from the top 150 millimeters of the roadbed.

Repair soft and unstable areas according to Subsection 204.07. Dispose of excess material according to Subsection 204.14.

303.05 Aggregate Surfaces. Repair soft and unstable areas according to Subsection 204.07. Repair the aggregate surface according to Subsection 301.07.

303.06 Asphalt Surfaces. Recondition asphalt surfaces as follows:

(a) Patching. Remove and dispose of unsuitable material that shows evidence of distress, excess asphalt material, or settlement in the subgrade. Patch the areas with approved material that conforms to and is compatible with the adjacent pavement structure. Perform the patch work according to Section 308, 402, 417, or other sections as applicable for the layer or courses being repaired.

(b) Crack sealing. Clean and seal cracks in the existing asphalt surface according to Subsection 414.05.

(c) Preleveling. Correct surface irregularities exceeding 150 millimeters in depth with a specified aggregate. Place and compact the aggregate according to Subsections 301.04 and 301.05.

Prelevel other dips, depressions, sags, excessive or nonexistent crown, or other surface irregularities with asphalt concrete according to Section 402. Spread and compact the asphalt concrete in layers parallel to the grade line not to exceed 50 millimeters in compacted depth.

303.07 Finishing Road Surfaces.

(a) Graded roadbeds. Blade, shape, compact, and finish the roadbed, including parking areas, turnouts, and other widened areas. Correct irregularities in the surface by scarifying the defective area and reworking. Compact according to Subsection 204.11. Finish the roadbed to the required line, grade, elevation, and cross-section.

(b) Aggregate surfaces. Perform the work under Subsection 303.07(a). Finish the surface according to Subsection 301.06. Compact the surface according to Subsection 301.05.

(c) Asphalt surfaces. Clean the existing surface of all loose material, dirt, or other deleterious substances by approved methods.

303.08 Scarification. When required by the contract, scarify the material to the designated depth and width. Pulverize all lumps to a size one and one half times the maximum sized aggregate or to 40 millimeters, whichever is greater. Mix, spread, compact, and finish the material according to Section 301.

303.09 Acceptance. Material for road reconditioning will be evaluated under the applicable section furnished.

Road reconditioning will be evaluated under Subsection 106.02 and 106.04.

Roadbed finishing will be evaluated under Section 204.

Aggregate surfaces will be evaluated under Section 301 or 308.

Asphalt surfaces will be evaluated under Section 402 or 417.

Crack sealing will be evaluated under Section 414.

Measurement

303.10 Measure road reconditioning by the kilometer or by the square meter. Measure the square meter area on a horizontal plane. Measure to the intersection of the roadway with natural ground (approximate slope stake location). Do not measure isolated areas less than 20 square meters for payment.

Measure removal and disposal of unsuitable material under Section 203.

Measure crack sealing under Section 414.

Measure aggregate for patching and leveling under Section 308.

Measure asphalt material for patching and leveling under Section 402 or 417.

Payment

303.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
30301	Road reconditioning	Kilometer
30302	Road reconditioning	Square meter
30303	Road reconditioning, scarify ____ millimeter depth	Kilometer
30304	Road reconditioning, scarify ____ millimeter depth	Square meter

Section 304.) AGGREGATE STABILIZATION

Description

304.01 This work consists of processing and incorporating fly ash, lime, or portland cement into the upper layer of a previously constructed aggregate course.

Material

304.02 Conform to the following Subsections:

Blotter	703.13
Chemical admixtures (set-retarding)	711.03
Emulsified asphalt	702.03
Fly ash	725.04
Lime	725.03
Portland cement	701.01
Water	725.01

Construction Requirements

304.03 General. Store chemical additives and admixtures in closed, weatherproof containers. Recondition the aggregate course according to Subsections 303.03 and 303.05. Scarify the aggregate course to a depth of 100 millimeters according to Subsection 303.08. Size and shape the scarified aggregate to a windrow or blanket that is suitable for mixing. Determine the optimum moisture content and maximum density according to AASHTO T 180 method D.

304.04 Application. Apply additives when the scarified aggregate is at least 3 percent below optimum moisture content and at least 4 °C. Do not apply when excessive additive is lost to washing or blowing or when the air temperature is expected to fall below 4 °C within 48 hours.

Apply additives at the required rates by one of the following methods:

(a) Dry method. Uniformly apply the additives with 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.

304.05 Mixing. Mix material to obtain a homogeneous friable mixture.

(a) Lime and 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 1.5 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 45 millimeter sieve and at least 50 percent of the mixture passes a 4.75 millimeter 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.

304.06 Compaction 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 238 and AASHTO T 239 or other approved test procedures. Finish the stabilized aggregate so it is smooth and suitable for placing another course.

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.

304.07 Curing. Do not allow traffic on the stabilized aggregate. Keep the aggregate continuously moist until the next course is placed. Apply water under pressure through a spray bar equipped with nozzles producing a fine, uniform spray. Place the next course within 7 days after compacting and finishing the stabilized aggregate.

Placement of the next course may be deferred up to 21 days by sealing the surface with a 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 1.1 liters per square meter 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 stabilized aggregate looses stability, density, or finish before placement of the next course, 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.

304.08 Acceptance. Material for blotter, chemical admixtures (retarder), fly ash, lime, portland 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.

Aggregate stabilization work will be evaluated under Subsections 106.02 and 106.04. See Table 304-1 for minimum sampling and testing requirements.

Reconditioning of the aggregate course will be evaluated under Section 303.

Emulsified asphalt seal will be evaluated under Section 409.

Blotter will be evaluated under Section 411.

Measurement

304.09 Measure aggregate stabilization by the kilometer or by the square meter. Measure square meter width horizontally to include the top of aggregate width and allowable curve widening. Measure the square meter length horizontally along the centerline of the roadway.

Measure lime, cement, and fly ash by the metric ton.

Measure emulsified asphalt under Section 409.

Measure blotter under Section 411.

Payment

304.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	**Pay Unit**
30401	Aggregate stabilization	Kilometer
30402	Aggregate stabilization	Square meter
30403	Lime	Metric ton
30404	Cement	Metric ton
30405	Fly ash	Metric ton

Table 304-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Mixture	Moisture-Density	AASHTO T 180 method D	1 for each mixture or change in material	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 2500 m^2	Compacted material

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 75 millimeters. Reduce all clods and sod to a maximum size of 100 millimeters.

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 50 millimeters in diameter. Before compaction, dry seed the mixture surface at a rate of 85 kilograms per hectare according to Section 625.

Determine maximum density of the mixture according to AASHTO T 99 method C. Compact the mixture to at least 90 percent of maximum density. Determine the inplace density according to AASHTO T 238 or other approved test procedures. After compaction, dry seed the surface again at a rate of 85 kilograms per hectare.

305.05 Acceptance. Aggregate for aggregate-topsoil will be evaluated under Subsections 106.02 and 106.04. See Table 305-1 for minimum sampling and testing requirements. Seed and topsoil will be evaluated under Subsections 106.02 and 106.03.

Construction of the aggregate-topsoil course will be evaluated under Subsections 106.02 and 106.04. See Table 305-1 for minimum sampling and testing requirements.

Measurement

305.06 Measure aggregate-topsoil course by the metric ton, by the square meter, or by the cubic meter in the hauling vehicle.

Payment

305.07 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown on the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
30501	Aggregate-topsoil course	Metric ton
30502	Aggregate-topsoil course, ___ millimeter depth	Square meter
30503	Aggregate-topsoil course	Cubic meter

Table 305-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Aggregate for aggregate-topsoil	Gradation	AASHTO T 27 and AASHTO T 11	1 for each 1500 t	Source of material or stockpile
Aggregate-topsoil mixture	Moisture-Density	AASHTO T 99 method C	1 for each mixture or change in material	Processed material before incorporated into the work
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 2500 m^2	Compacted material

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:

Calcium chloride	725.02
Emulsified asphalt	702.03
Lignin sulfonate	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 rainy or when rain is anticipated within 24 hours of application. Apply when the ambient air temperature is 4 °C or above.

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.

(a) Emulsified asphalt. Prepare the surface according to Subsection 303.07.

When a slow setting emulsified asphalt is used, dilute it with water until the emulsion contains 25±10 percent residual asphalt. Before application, approval of the exact proportions is required. Thoroughly blend the emulsified asphalt with the added water before application. Apply according to Subsection 409.08.

(b) Lignin sulfonate, calcium chloride, or magnesium chloride. Prepare the roadbed by blading and shaping to leave 25 to 50 millimeters of relatively loose material on the surface. Water the loose material so it is visibly moist.

When lignin sulfonate is used, dilute it with water until the mixture contains 40±10 percent lignin sulfonate by volume. When calcium chloride is used, make a water solution that contains 32±5 percent chloride by mass. Before application, approval of the exact proportions is required. Thoroughly mix the components before application.

When magnesium chloride is used, apply the brine when the ambient air temperature is 15 °C or above.

Apply at a rate of 1.4 to 2.7 liters per square meter as approved. Compact the surface.

306.05 Acceptance. Dust palliative material (emulsified asphalt, lignin sulfonate, calcium chloride, and magnesium chloride) will be evaluated under Subsection 106.03.

When lignin sulfonate is furnished, the commercial certification shall include the following information for each shipment: date, identification number (truck, trailer, etc.), net mass, net volume at 15 °C, specific gravity at 15 °C, percent solids by weight, pH, base cation, and brand name.

Application of dust palliative will be evaluated under Subsections 106.02 and 106.04.

Measurement

306.06 Measure dust palliative application by the kilometer or by the square meter.

Measure dust palliative material (emulsified asphalt, lignin sulfonate, calcium chloride, and magnesium chloride) by the metric ton.

Payment

306.07 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
30601	Dust palliative application	Kilometer
30602	Dust palliative application	Square meter
30603	Emulsified asphalt	Metric ton
30604	Lignin sulfonate	Metric ton
30605	Calcium chloride	Metric ton
30606	Magnesium chloride	Metric ton

Section 307.) STOCKPILED AGGREGATES

Description

307.01 This work consists of furnishing and placing aggregate in a stockpile at an existing site or at a new site constructed by the Contractor.

Material

307.02 Conform to the following Section:

Aggregate	703

Provide the gradation and quality requirements specified in the Section identified in the pay item.

Construction Requirements

307.03 Stockpile Site. Prepare existing sites as necessary to accommodate the quantity of aggregate to be stockpiled.

Prepare new sites as follows:

(a) Clear and grub according to Section 201.
(b) Grade and shape the site to a uniform cross-section that drains.
(c) Compact the floor of the site with at least three passes using compaction equipment conforming to Subsection 204.11.
(d) Place, compact, and maintain a minimum 150-millimeter layer of crushed aggregate over the stockpile site and access roads for stabilization and to prevent contamination of the stockpiles.

307.04 Stockpile. Obtain site approval before stockpiling aggregates. Make the stockpiles neat and regular in shape. Make the side slopes no flatter than 1:1.5.

Build the stockpiles in layers not to exceed 1 meter in thickness. Complete each layer before depositing aggregates in the next layer.

Construct stockpile layers by spreading aggregates with trucks or other approved pneumatic-tired equipment. Do not push aggregates into piles.

Do not dump the aggregate so any part of it runs down and over the lower layers in the stockpile. Do not drop aggregates from a bucket or spout in one location to form a cone-shaped pile.

Do not stockpile aggregate where traffic runs through the piles. When operating trucks on stockpiles, use plank runways, where required, to avoid tracking dirt or other foreign matter onto the stockpiled material.

Space stockpiles far enough apart or separate stockpiles by suitable walls or partitions to prevent the mixing of the different aggregate gradations.

After the stockpiled aggregate is measured and accepted and if the stockpile is for future use, cover the stockpile with an approved covering for protection from the weather.

307.05 Acceptance. Aggregate for stockpiling will be evaluated under the Section identified in the pay item.

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.

Preparation of stockpile sites and construction of stockpiles will be evaluated under Subsections 106.02 and 106.04.

Clearing will be evaluated under Section 201.

Measurement

307.06 Measure stockpiled aggregate by the metric ton or by the cubic meter in place.

Measure preparation of stockpile sites by the hectare.

Payment

307.07 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the stockpiled aggregate 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 will be made under:

Pay Item		Pay Unit
30701	Stockpiled aggregate, Section ___ grading ___	Metric ton
30702	Stockpiled aggregate, Section ___ grading ___	Cubic meter
30703	Preparation of stockpile site	Hectare

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 150 millimeters 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 150 millimeters 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(a). 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. 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. See Table 308-1 for sampling and testing requirements.

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 crushed aggregate by the cubic meter in the hauling vehicle, by the metric ton, or by the square meter.

Payment

308.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	**Pay Unit**
30801	Roadway aggregate method ___	Cubic meter
30802	Roadway aggregate method ___	Metric ton
30803	Roadway aggregate method ___	Square meter
30804	Bedding and backfill aggregate	Cubic meter
30805	Bedding and backfill aggregate	Metric ton
30806	Bedding and backfill aggregate	Square meter

Table 308-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Crushed aggregate [(1)]	Moisture-Density	AASHTO T 180 method D	1 for each aggregate supplied	Production output or stockpile.
	Inplace density and moisture content	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 500 t (300 m^3)	Inplace completed compacted layer

(1) Sampling and testing required for roadway aggregate method 2.

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 150-kilogram 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.

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 238 and AASHTO T 239 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. 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 and minimum sampling and testing requirements. 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. See Table 309-1 for minimum sampling and testing requirements.

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 aggregate for the emulsified asphalt treated base course by the metric ton, by the square meter, or by the cubic meter in the hauling vehicle. Measure square meter width horizontally to include the top of base width and allowable curve widening. Measure the square meter length horizontally along the centerline of the roadway.

Measure emulsified asphalt by the metric ton.

Payment

309.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the emulsified asphalt treated aggregate base 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 will be made under:

Pay Item		**Pay Unit**
30901	Emulsified asphalt treated aggregate base grading ___	Metric ton
30902	Emulsified asphalt treated aggregate base grading ___, ___ millimeter depth	Square meter
30903	Emulsified asphalt treated aggregate base grading ___	Cubic meter
30904	Emulsified asphalt grade ______	Metric ton

Table 309-1
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Aggregate	Gradation [(1)]		AASHTO T 11 and AASHTO T 27	1 sample per 1000 t	From the conveyor belt just before mixing
	9.5 mm	I			
	4.75 mm	I			
	75 µm	I			
	Other specified sieves	II			
	Liquid limit	—	AASHTO T 89	1 sample per 3000 t	From the conveyor belt just before mixing
Mixture	Moisture-Density (maximum density)	—	AASHTO T 180 method D	1 for each aggregate grading produced	Production output or stockpile before processing
	Inplace density and moisture content	—	AASHTO T 238 and AASHTO T 239 or other approved procedures	1 for each 500 t	Inplace completed compacted layer

(1) Use only sieves indicated for the specified gradation.

DIVISION 400
Asphalt Pavements and Surface Treatments

Section 401.) HOT ASPHALT CONCRETE PAVEMENT

Description

401.01 This work consists of constructing one or more courses of hot asphalt concrete pavement.

Hot asphalt concrete pavement class is designated as shown in Table 401-1. Aggregate grading is designated as shown in Table 703-4. Smoothness type is designated as shown in Table 401-7.

Superpave asphalt concrete pavement ESALs is designated as shown in Tables 703-10 through 703-13. Nominal maximum size aggregate is designated as shown in Tables 703-14 through 703-16. Smoothness type is designated as shown in Table 401-7.

Asphalt cement grade is designated as shown in AASHTO M 20, AASHTO M 226, or AASHTO MP 1.

Antistrip additive is designated as shown in Subsection 702.08. Where no type is designated, use any type if needed.

Material

401.02 Conform to the following Subsections:

Aggregate (class A, B, or C mix)	703.07
Aggregate (Superpave mix)	703.17
Antistrip additive	702.08
Asphalt cement	702.01
Mineral filler	725.05

Construction Requirements

401.03 Composition of Mix (Job-Mix Formula). For all but the final surface course, recycled material may be used according to Section 403. Recycled material may be used in the final surface course subject to approval of a Contractor quality control plan and submission of test data demonstrating that the mix will meet the requirements of this Section.

Furnish mixes as follows:

•**Class A, B, or C mix.** Furnish aggregate, asphalt, and additives that meet the applicable aggregate gradation in Table 703-4 and design parameters (a) or (b); (c) or (d); and (e) in Table 401-1.

Table 401-1
Asphalt Concrete Mix Requirements

Design Parameters (1)	Class of Mix		
	A	B	C
(a) Hveem (AASHTO T 246 and AASHTO T 247)			
(1) Stabilometer, minimum	37	35	30
(2) Percent air voids (1)	3-5	3-5	3-5
(3) Voids in mineral aggregate, min. %	See Table 401-2		
(b) Marshall (AASHTO T 245)			
(1) Stability, kN min.	8.00	5.34	4.45
(2) Flow, 0.25 mm	8-14	8-16	8-20
(3) Percent air voids (1)	3-5	3-5	3-5
(4) Voids in mineral aggregate, min. %	See Table 401-2		
(5) Compaction, number of blows each end of test specimen	75	50	50
(c) Immersion - Compression (AASHTO T 165 and AASHTO T 167)			
(1) Compressive strength, MPa min.	2.1	1.7	1.4
(2) Retained strength, min. %	70	70	70
(d) Root-Tunnicliff (ASTM D 4867)			
(1) Tensile strength ratio, min. %	70	70	70
(e) Dust-asphalt ratio (2)	0.6-1.3	0.6-1.3	0.6-1.3

(1) The percent of air voids are based on AASHTO T 166, AASHTO T 209, AASHTO 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 75-micrometer sieve divided by the percent of asphalt (calculated by mass of mix).

Table 401-2
Voids in Mineral Aggregate (VMA)
Marshall, Hveem, or Superpave Mix Design

Sieve Size (1)	Minimum Voids (2)(3) Percent		
	Marshall	Hveem	Superpave
2.36 mm	21	19	-
4.75 mm	18	16	-
9.5 mm	16	14	15
12.5 mm	15	13	14
19 mm	14	12	13
25 mm	13	11	12
37.5 mm	12	10	11
50 mm	11.5	9.5	10.5

(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.

•**Superpave level 1 mix.** Furnish mixes of aggregate, asphalt, and additives that meet applicable gradation and material requirements in Subsection 703.17 and the appropriate design parameters in Tables 401-2, 401-3, and 401-4. Compact specimens with the gyratory compactive effort specified in Table 401-5 for the corresponding traffic and air temperature.

Table 401-3
Superpave Asphalt Concrete Mix Requirements

Design Parameters	Requirement
Percent air voids at design gyrations, N_{des}	4.0
Percent maximum density at initial gyrations, N_{init}	89% maximum
Percent maximum density at maximum gyrations, N_{max}	98% maximum
Tensile strength ratio, min (AASHTO T 283)	80
Dust-asphalt ratio(1)	0.6-1.2

(1) Dust-asphalt ratio is defined as the percent of material passing the 75-micrometer sieve divided by the effective asphalt content as calculated by mass of mix.

Table 401-4
Superpave Voids Filled with Asphalt (VFA)

Traffic, million ESALs	Design VFA, %
≤ 0.3	70 - 80
> 0.3 - 3	65 - 78
> 3	65 - 75

Table 401-5
Gyratory Compactive Effort

Design ESAL's millions	Average Design High Air Temperature											
	<39°C			39 - 40°C			41 - 42°C			43 - 44°C		
	N_{init}	N_{des}	N_{max}	N_{init}	N_{des}	N_{max}	N_{init}	N_{des}	N_{max}	N_{init}	N_{des}	N_{max}
≤ 0.3	7	68	104	7	74	114	7	78	121	7	82	127
> 0.3 - 1	7	76	117	7	83	129	7	88	138	8	93	146
> 1 - 3	7	86	134	8	95	150	8	100	158	8	105	167
> 3 - 10	8	96	152	8	106	169	8	113	181	9	119	192
> 10 - 30	8	109	174	9	121	195	9	128	208	9	135	220
> 30 - 100	9	126	204	9	139	228	9	146	240	10	153	253
> 100	9	142	233	10	158	262	10	165	275	10	172	288

Submit written job-mix formulas for approval at least 21 days before production. For each job-mix formula, submit the following:

(a) Aggregate and mineral filler.

(1) Target value for percent passing each sieve size for the aggregate blend. Designate target values within the gradation band in the specified grading. Designate target values outside the restricted zone of Table 703-14, 703-15, or 703-16 for the appropriate nominal maximum size aggregate.

(2) Source and percentage of each aggregate stockpile to be used.

(3) Average gradation of each aggregate stockpile.

(4) Representative samples for each aggregate stockpile:

(a) 100 kilograms of each coarse aggregate
(b) 70 kilograms of each intermediate and fine aggregate
(c) 10 kilograms of mineral filler such as lime stone or filler earth if proposed to improve gradation characteristics or mix performance.
*(d)*10 kilograms of bag house fines if proposed for the mix. See Subsection 401.04.

Aggregate samples when combined according to the Contractor's recommended stockpile percentages shall be within the gradation band defined by the target values plus or minus the allowable deviation for each sieve or the samples will not be considered representative.

(5) Results of aggregate quality tests.

(b) Asphalt cement.

(1) Five 4-liter samples of the asphalt cement to be used in the mix.

(2) Recent quality test results from the manufacturer for the asphalt cement including a temperature-viscosity curve.

(3) Material safety data sheets.

(c) Antistrip additives. When an antistrip additive is needed to meet the mix requirements, furnish the following:

(1) Sample
(a) 0.5 liter of liquid heat-stable antistrip additive or
(b) 5 kilograms of dry antistrip additive such as lime or portland cement
(2) Name of product
(3) Manufacturer
(4) Material safety data sheet

(d) Asphalt mixes. When applicable, the location of all commercial mixing plants to be used. A job-mix formula is needed for each plant.

The CO will evaluate the suitability of the material and the proposed job-mix formula. If approved, the CO will develop a target value for the asphalt cement content, determine the need for antistrip additive, determine the maximum specific gravity (density) according to AASHTO T 209, and determine the discharge temperature range.

If a job-mix formula is rejected, submit a new job-mix formula as described above.

Changes to an approved job-mix formula require approval before production. Up to 14 days will 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 incurred as a result of any of the following:

- Contractor-requested changes to the approved job-mix formula

- Contractor requests for additional job-mix formula evaluations

- Additional testing necessary due to the failure of a submitted job-mix formula

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.

When baghouse fines are used in batch plants or continuous mix plants, deposit the material that is returned from the baghouse at the bottom of the hot elevator or meter it by volume or mass into the mixing chamber. Direct return from the baghouse to the hot elevator will be permitted only when the flow can be controlled at a uniform rate. In drum dryer-mixer plants, return the material to the drum at the same location as the asphalt.

(3) Aggregate storage. Store aggregate according to Section 307.

(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, one stockpile shall contain mostly coarse material, and one stockpile shall contain mostly fine material. Stockpile the material according to Section 307.

(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.

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 300 millimeters 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.

(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 303.07, 413, 502, or 503 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 2 °C and rising and the temperature of the road surface in the shade conforms to Table 401-6.

Table 401-6
Asphalt Concrete Mix Placement Temperature

Compacted Lift Thickness →	**< 50 mm**	**50 - 75 mm**	**> 75 mm**
Road Surface Temperature °C	**Minimum Lay-Down Temperature (1) °C**		
< 2	(2)	(2)	(2)
2 - 3.9	(2)	(2)	138
4 - 9.9	(2)	141	135
10 - 14.9	146	138	132
15 - 19.9	141	135	129
20 - 24.9	138	132	129
25 - 29.9	132	129	127
≥ 30	129	127	124

(1) In no case shall the asphalt concrete mix be heated above the temperature specified in the approved mix design.
(2) Paving not allowed.

401.08 Asphalt Preparation. Uniformly heat the asphalt cement to provide a continuous supply of the heated asphalt cement from storage to the mixer. Do not heat asphalt cement above 175 °C.

If the job-mix formula requires a liquid heat stable antistrip additive, meter it into the asphalt cement 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. Use calibrated weighing or metering devices to measure the amount of antistrip and moisture added to the aggregate.

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 damage to and contamination of the aggregate.

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 which contaminate or alter 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. Provide 7 days notice before beginning production of an asphalt concrete mix.

On the first day of production, produce sufficient mix to construct a 300-meter 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.

(a) Asphalt content and aggregate gradation. Take 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 and aggregate gradation.

(b) Compaction. Take nuclear density readings behind each roller pass to determine the roller pattern necessary to achieve required density without damaging the mix.

At a minimum of 4 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. 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 401-6. 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 6 meters.

On 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 150 millimeters 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 75-millimeter lifts. Complete the wedge and leveling before starting normal paving operations.

401.14 Compacting. Furnish at least 3 rollers. Furnish one roller each for breakdown, intermediate, and finish rolling. At least one roller shall be pneumatic-tired. Size the rollers to achieve the required results. Operate rollers according to the recommendation of the manufacturer.

Thoroughly and uniformly compact the asphalt surface by rolling. Do not cause undue displacement, cracking, or shoving. Continue rolling until all roller marks are eliminated and the required density is obtained. Do not roll the mix after the surface cools below 80 °C.

Monitor the compaction process with nuclear density gauges calibrated to the control strip compaction test results. Compact to a pavement specific gravity (density) that is no less than 90 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.

401.15 Joints, Trimming Edges, and Cleanup. Complete 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 50 millimeters with *"Uneven Lane"* warning signs and provide a 1:3 fillet for drop offs in excess of 100 millimeters.

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 on previous run to expose the full-depth course.

Apply an asphalt tack coat to the edge of the joint for both transverse and longitudinal joints 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 211.03(b).

401.16 Pavement Smoothness. After final rolling, measure the smoothness of the final surface course or the surface immediately under an open-graded asphalt friction course.

(a) Profilograph measurements. Measure the traveled way parallel to the centerline according to FLH T 504 after mainline paving is completed. The CO will furnish a California type profilograph and direct and observe its operation. Furnish workers to operate the profilograph. Furnish the trace to the CO.

Exclude the following areas from the profile index and profilograph bump determination: bridge decks, cattle guards, traveled way lanes with horizontal curvature less than 150-meter radius, transverse joints with existing pavements, turning or passing lanes less than 100 meters in length, driveways, parking areas, and side roads less than 100 meters in length. Measure excluded areas and type IV pavements according to (b) below.

A profile index will be calculated for each 0.1 kilometer lane of traveled way using a 5-millimeter wide blanking-band. The profile index will be determined according to FLH T 504. Bumps will be located using a 10 millimeter bump template. Defective areas are bumps in excess of 10 millimeters in 7.62 meters, 0.1-kilometer profile indexes greater than the defective limit in Table 401-7, and surfaces with a pay factor less than 0.75 as determined under Subsection 106.05.

(b) Straightedge measurement. Use a 3-meter metal straightedge to measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 6 millimeters in 3 meters between any two contacts of the straightedge with the surface.

(c) Defective area correction. Correct defective areas from (a) and (b) above. Obtain approval for the proposed method of correction.

Remeasure corrected areas according to (a) and (b) above. The smoothness pay factor will be recomputed after measurement.

Table 401-7
Maximum Profile Index

Pavement Smoothness Type	Profile Index - millimeters/kilometer	
	Upper Specification Limit	Defective Limit
I	80	160
II	125	190
III	160	240
IV	Subject to straightedge measurement only. See Subsection 401.16(b).	

401.17 Acceptance. Mineral filler and antistrip additive will be evaluated under Subsections 106.02 and 106.03.

Asphalt will be evaluated under Subsections 106.04 and 702.09.

Construction of the 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 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04. See Table 401-8 for minimum sampling and testing requirements.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value ±0.5 percent. See Table 401-8 for the acceptance quality characteristic category.

(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 401-8 for the acceptance quality characteristic categories.

(c) Density. The lower specification limit is 90 percent of the maximum specific gravity (density) determined according to AASHTO T 209 as part of the job-mix formula evaluation specified in Subsection 401.03. See Table 401-8 for the acceptance quality characteristic category.

(d) Pavement smoothness. See Subsection 401.16. The evaluation will be made after all defective areas are corrected. A sublot is a 0.1-kilometer section of the traveled way and a lot is the surface course of the entire project. The upper specification limit is shown in Table 401-7. See Table 401-8 for the acceptance quality characteristic category.

Measurement

401.18 Measure hot asphalt concrete pavement, asphalt cement, mineral filler, and antistrip additive by the metric ton.

Payment

401.19 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the hot asphalt concrete pavement 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 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, II, or III pavement smoothness, a separate adjustment will be made for pavement smoothness according to the following formula:

$$A = 12\,000(PF - 1.00)(L)$$

Where:

A = Adjustment to contract payment in dollars for pavement smoothness.
L = Total project length in lane kilometers of traveled way. Measure project length to 3 decimal places.
PF = Pay factor for smoothness with respect to the upper specification limit determined according to Subsection 106.05 after completion of corrective work.

Payment will be made under:

Pay Item		Pay Unit
40101	Hot asphalt concrete pavement class ___, grading ___, type ___ pavement smoothness	Metric ton
40102	Hot asphalt concrete pavement class ___, grading ___, wedge and leveling course	Metric ton
40103	Asphalt cement grade ___	Metric ton
40104	Mineral filler	Metric ton
40105	Antistrip additive type ___	Metric ton
40106	Superpave asphalt concrete pavement, ___ nominal maximum size aggregate, ___ ESALs, type ___ pavement smoothness	Metric ton

Table 401-8
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Hot asphalt concrete pavement	Asphalt content	I	FLH T 516, FLH T 517, or AASHTO T 164	1 per 500 t	Behind laydown machine before rolling
	Gradation [1] — 4.75 mm 600 µm 75 µm Other specified sieves	 I I I II	FLH T 514 and AASHTO T 30 [4]	1 per 500 t	Behind laydown machine before rolling
	Core density [2]	I	AASHTO T 166 and AASHTO T 209	1 per 500 t	In place after compaction
	Smoothness [3]	I	FLH T 504	See Subsection 401.16	See Subsection 401.16

(1) Use only sieves indicated for the specified gradation.
(2) Cut core samples from the compacted pavement according to AASHTO T 230 method B. Fill and compact the sample holes with asphalt concrete mixture.
(3) Applies only to an item used as a final surface course constructed under the contract.
(4) Do not use FLH T 514 if AASHTO T 164 is used to determine asphalt content.

Section 402.) MINOR HOT ASPHALT CONCRETE

Description

402.01 This work consists of constructing minor hot asphalt concrete for sidewalks, paved waterways, curbs, and roadways.

Construction Requirements

402.02 Composition of Mix (Job-Mix Formula). Provide a hot asphalt concrete mix composed of crushed stone or gravel and asphalt cement mixed in an approved plant. Use an aggregate gradation and quality and an asphalt cement grade and quality conforming to those normally used locally in the construction of highways by either Federal or state agencies.

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 cement, 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.

402.03 Surface Preparation. Prepare the surface according to Section 209 or Subsection 303.07 as applicable.

402.04 Weather Limitations. Place asphalt concrete on a dry, unfrozen surface when the air temperature in the shade is at least 2 °C and rising.

402.05 Hauling. Haul the asphalt mix using vehicles conforming to Subsection 401.11.

402.06 Placing. Place the mix with a mechanical paver. For roadway paving, do not place lifts thicker than 100 millimeters. 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.

402.07 Compacting.

(a) Roadway paving. Compact the mix to a minimum of 90 percent of maximum specific gravity (density). Determine density by nuclear gauge.

(b) Non-roadway paving. Compact by rolling with a hand-operated roller weighing at least 130 kilograms or with a small power roller.

Compact areas that are not accessible to rollers by other approved methods.

402.08 Pavement Smoothness. Use a 3-meter metal straightedge to measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 7 millimeters in 3 meters between any two contacts of the straightedge with the surface. Correct defective areas using approved methods.

402.09 Acceptance. 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. See Table 402-1 for minimum sampling and testing requirements.

Measurement

402.10 Measure asphalt concrete by the metric ton.

Payment

402.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
40201 Minor hot asphalt concrete	Metric ton

Table 402-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Roadway paving	Inplace density	Nuclear gauge	1 for each 1000 m^2 (1)	In place after compaction

(1) When directed, verify density by taking core samples from the compacted pavement according AASHTO T 230 method B. Fill and compact the sample holes with asphalt concrete mixture.

Section 403.) HOT RECYCLED ASPHALT CONCRETE PAVEMENT

Description

403.01 This work consists of constructing one or more courses of hot recycled asphalt concrete pavement using reclaimed asphalt pavement material and/or reclaimed aggregate material combined with new aggregate, asphalt cement, and/or recycling agents.

Hot recycled asphalt concrete pavement class, aggregate grading, pavement smoothness type, asphalt cement grade, and antistrip additive type are designated according to Subsection 401.01.

Material

403.02 Conform to the following Subsections:

Aggregate (new)	703.07
Antistrip additive	702.08
Asphalt cement	702.01
Mineral filler	725.05
Recycling agent	702.06

Construction Requirements

403.03 Composition of Mix (Job-Mix Formula). Prepare hot recycled asphalt concrete mixes using reclaimed aggregate material, reclaimed asphalt pavement material, new aggregate, asphalt cement, recycling agent, and additives that meet the applicable aggregate gradation requirements in Table 703-4 and design parameters (a) or (b); (c) or (d); and (e) in Table 401-1. Use a maximum of 50 percent reclaimed asphalt pavement material in the mix.

Submit written job-mix formulas for approval at least 30 days before production. For each job-mix formula, submit information and samples according to Subsection 401.03 and the following:

(a) Samples of the actual reclaimed asphalt pavement material, reclaimed aggregate material, and recycling agents to be incorporated in the work.

Where it is necessary to obtain a sample of existing pavement, mill the existing pavement to the pavement removal depth in an approved area. Replace the removed pavement with an approved asphalt concrete mix. Do not use the replacement material in the recycled mix.

(b) Sources of all stockpiled recyclable material.

(c) Laboratory test data on the reclaimed asphalt, new asphalt cement, and recycling agent demonstrating the combined asphalt grade.

The job-mix formula will be evaluated and approved according to Subsection 401.03.

403.04 Mixing Plant. Modify plants conforming to Subsection 401.04 according to the plant manufacturer's recommendations to process reclaimed material.

(a) Batch plants. Modify batch plants to allow the introduction of reclaimed asphalt pavement material into the mix using methods that by-pass 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 reclaimed asphalt pavement material.

Heat the new aggregate and/or reclaimed aggregate material to a temperature that will transfer sufficient heat to the reclaimed asphalt pavement material to produce a mix of uniform temperature within the range specified in the approved job-mix formula.

(b) Drum dryer-mixer plants. Modify drum dryer-mixer plants to prevent direct contact of the reclaimed asphalt pavement material with the burner flame and to prevent overheating of the reclaimed asphalt pavement material.

403.05 Construction. Construct hot recycled asphalt concrete pavement according to Subsections 401.05 through 401.16. Dispose of reclaimed material not incorporated into the work according to Subsection 211.03.

403.06 Acceptance. Recycling agent and antistrip additive will be evaluated under Subsections 106.02 and 106.03.

Asphalt cement will be evaluated under Subsections 106.04 and 702.09.

Construction of hot recycled 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 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04. See Table 403-1 for minimum sampling and testing requirements.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value plus or minus 0.5 multiplied by (one plus the ratio of the reclaimed asphalt pavement material to the total mixture rounded to the nearest 0.10 percent). See Table 403-1 for acceptance quality characteristic category.

Example: If 30 percent of the mixture is reclaimed asphalt pavement material, then the allowable deviation from target value for percent asphalt content is 0.5(1.30) = 0.65 percent. Use plus 0.7 percent and minus 0.7 percent from approved job-mix formula target value for asphalt content.

(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 multiplied by (one plus the ratio of reclaimed asphalt pavement material to the total mixture). Round to the nearest percent except for the 75-micrometer sieve that is rounded to the nearest tenth of a percent. See Table 403-1 for acceptance quality characteristic categories.

Example: If 30 percent of the mixture is reclaimed asphalt pavement material, then the allowable deviation from target value for percent of aggregate passing the 75-micrometer sieve is 2(1.30) or 2.6 percent. Use ±2.6 percent from the approved job-mix formula target value for percent passing the 75-micrometer sieve.

(c) Density. The lower specification limit is 90 percent of the maximum specific gravity (density) determined according to AASHTO T 209 as part of the job-mix formula evaluation specified in Subsection 401.03. See Table 403-1 for acceptance quality characteristic category.

(d) Pavement smoothness. See Subsection 401.16. The evaluation will be made after all defective areas are corrected. A sublot is a 0.1-kilometer section of the traveled way and a lot is the surface course of the entire project. The upper specification limit is shown in Table 401-7. See Table 403-1 for acceptance quality characteristic category.

Measurement

403.07 Measure hot recycled asphalt concrete pavement, asphalt cement, mineral filler, recycling agent, and antistrip additive by the metric ton.

Measure milling under Section 413.

Payment

403.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the hot recycled asphalt concrete pavement 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 hot recycled 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 recycled asphalt concrete pavement type I, II, or III pavement smoothness, a separate adjustment will be made for pavement smoothness according to the following formula:

$$A = 12\,000(PF - 1.00)(L)$$

Where:

A = Adjustment to contract payment in dollars for pavement smoothness.
L = Total project length in lane kilometers of traveled way. Measure project length to 3 decimal places.
PF = Pay factor for smoothness with respect to the upper specification limit determined according to Subsection 106.05 after completion of corrective work.

Payment will be made under:

Pay Item		**Pay Unit**
40301	Hot recycled asphalt concrete pavement class ___, grading ___, type ___ pavement smoothness	Metric ton
40302	Hot recycled asphalt concrete pavement class ___, grading ___, wedge and leveling course	Metric ton
40303	Asphalt cement grade ___	Metric ton
40304	Mineral filler	Metric ton
40305	Recycling agent	Metric ton
40306	Antistrip additive type ___	Metric ton

Table 403-1
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Hot recycled asphalt concrete pavement	Asphalt content	I	FLH T 516, FLH T 517, or AASHTO T 164	1 per 500 t	Behind laydown machine before rolling
	Gradation [1] — 4.75 mm 600 µm 75 µm Other specified sieves	 I I I II	FLH T 514 and AASHTO T 30 [4]	1 per 500 t	Behind laydown machine before rolling
	Core density [2]	I	AASHTO T 166 and AASHTO T 209	1 per 500 t	In place after compaction
	Smoothness [3]	I	FLH T 504	See Subsection 401.16	See Subsection 401.16

(1) Use only sieves indicated for the specified gradation.
(2) Cut core samples from the compacted pavement according to AASHTO T 230 method B. Fill and compact the sample holes with asphalt concrete mixture.
(3) Applies only to an item used as a final surface course constructed under the contract.
(4) Do not use FLH T 514 if AASHTO T 164 is used to determine asphalt content.

Section 404.) OPEN-GRADED ASPHALT FRICTION COURSE

Description

404.01 This work consists of constructing an open-graded asphalt friction course.

Asphalt cement grade and antistrip additive type are designated according to Subsection 401.01.

Material

404.02 Conform to the following Subsections:

Aggregate	703.08
Antistrip additive	702.08
Asphalt cement	702.01

Construction Requirements

404.03 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 method. 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.

404.04 Mixing Plant and Pavers. Use a mixing plant conforming to Subsection 401.04. Use pavers conforming to Subsection 401.05.

404.05 Surface Preparation. Prepare the surface according to Subsection 401.06.

404.06 Weather Limitations. Place open-graded asphalt friction course on a dry asphalt surface only when the air temperature in the shade is above 13 °C and the road surface temperature at least 16 °C. Stop placement if either temperature falls below these minimums.

404.07 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.

404.08 Hauling, Placing, and Finishing. Construct the open-graded asphalt friction course according to Subsections 401.11 through 401.13, except the temperature of the mix when placed shall be within the approved temperature range.

To minimize asphalt cement 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.

404.09 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 402.08.

404.10 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 ravelling.

404.11 Acceptance. 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. See Table 404-1 for minimum sampling and testing requirements.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value ±0.5 percent. See Table 404-1 for the acceptance quality characteristic category.

(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. See Table 404-1 for the acceptance quality characteristic categories.

Measurement

404.12 Measure open-graded asphalt friction course, asphalt cement, and antistrip additive by the metric ton.

Payment

404.13 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the open-graded asphalt friction course 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 open-graded asphalt friction course 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 or any individual sieve of the aggregate gradation.

Payment will be made under:

Pay Item		Pay Unit
40401	Open-graded asphalt friction course	Metric ton
40402	Asphalt cement grade ___	Metric ton
40403	Antistrip additive type ___	Metric ton

Table 404-1
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Open-graded asphalt friction course	Asphalt content	I	FLH T 516, FLH T 517, or AASHTO T 164	1 per 100 t	Hopper of laydown machine after discharge from plant
	Gradation (1) —		FLH T 514 and AASHTO T 30 (2)	1 per 100 t	Hopper of laydown machine after discharge from plant
	4.75 mm	I			
	75 µm	I			
	Other specified sieves	II			

(1) Use only sieves indicated for the specified gradation.
(2) Do not use FLH T 514 if AASHTO T 164 is used to determine asphalt content.

Section 405.) HOT ASPHALT TREATED BASE COURSE

Description

405.01 This work consists of constructing one or more courses of hot asphalt treated base.

Hot asphalt treated base course aggregate grading is designated as shown in Table 703-2.

Asphalt cement grade and antistrip additive type are designated according to Subsection 401.01.

Material

405.02 Conform to the following Subsections:

Aggregate	703.05
Antistrip additive	702.08
Asphalt cement	702.01
Mineral filler	725.05

Construction Requirements

405.03 Composition of Mix (Job-Mix Formula). Furnish a mixture of aggregate, asphalt cement, and additives that meets the applicable aggregate gradation in Table 703-2 and the class C design parameters (a)(1), (b)(1), or (c)(1); and (c)(2) or (d)(1) in Table 401-1.

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. Use a plant conforming to Subsection 401.04, except:

(a) For pugmill type mixers, plant screens are not required, except to remove oversize material.

(b) Bins do not need to be divided.

(c) For drum dryer mixers, two separate stockpiles are not required.

405.05 Construction. Prepare the surface according to Subsection 303.07. Construct the base course according to Subsections 401.05 through 401.15. Provide a smooth surface according to Subsection 402.08.

405.06 Acceptance. Mineral filler and antistrip additive will be evaluated under Subsections 106.02 and 106.03.

Asphalt will be evaluated under Subsections 106.04 and 702.09.

Construction of the hot asphalt treated base course will be evaluated under Subsections 106.02 and 106.04.

Asphalt content, aggregate gradation, and density will be evaluated under Subsection 106.05. Other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04. See Table 405-1 for minimum sampling and testing requirements.

(a) Asphalt content. The upper and lower specification limits are the approved job-mix formula target value ±0.5 percent. See Table 405-1 for the acceptance quality characteristic category.

(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 703-2. See Table 405-1 for the acceptance quality characteristic categories.

(c) Density. The lower specification limit is 90 percent of the maximum specific gravity (density) determined according to AASHTO T 209 as part of the job-mix formula evaluation specified in Subsection 401.03. See Table 405-1 for the acceptance quality characteristic category.

Measurement

405.07 Measure hot asphalt treated base course, asphalt cement, mineral filler, and antistrip additive by the metric ton.

Payment

405.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the hot asphalt treated base course 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 hot asphalt treated base course will be made at a price determined by multiplying the contract unit bid price by the material pay factor. The pay material factor is the lowest single pay factor determined for asphalt content, specific gravity (density), or any individual sieve of the aggregate gradation.

Payment will be made under:

	Pay Item	**Pay Unit**
40501	Hot asphalt treated base course grading ___	Metric ton
40502	Asphalt cement grade ___	Metric ton
40503	Mineral filler	Metric ton
40504	Antistrip additive type ___	Metric ton

Table 405-1
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Hot asphalt treated base course	Asphalt content	I	FLH T 516, FLH T 517, or AASHTO T 164	1 per 500 t	Behind laydown machine before rolling
	Gradation [(1)] — 9.5 mm 4.75 mm 75 µm Other specified sieves	 I I I II	FLH T 514 and AASHTO T 30 [(3)]	1 per 500 t	Behind laydown machine before rolling
	Core density [(2)]	I	AASHTO T 166 and AASHTO T 209	1 per 500 t	In place after compaction

(1) Use only sieves indicated for the specified gradation.
(2) Cut core samples from the compacted pavement according to AASHTO T 230 method B. Fill and compact the sample holes with treated base course mixture.
(3) Do not use FLH T 514 if AASHTO T 164 is used to determine asphalt content.

Section 406.) DENSE-GRADED EMULSIFIED ASPHALT PAVEMENT

Description

406.01 This work consists of constructing one or more courses of dense-graded emulsified asphalt mix.

Dense-graded emulsified asphalt pavement aggregate grading is designated as shown in Table 703-5.

Emulsified asphalt grade is designated as shown in AASHTO M 140 or AASHTO M 208.

Material

406.02 Conform to the following Subsections:

Aggregate	703.09
Blotter	703.13
Emulsified asphalt	702.03
Mineral filler	725.05
Water	725.01

Construction Requirements

406.03 Composition of Mix (Job-Mix Formula). Furnish a mixture of aggregate, emulsified asphalt, additives, and/or water that meets the applicable aggregate gradation in Table 703-5 and the design parameters (a); and (b) or (c) in Table 406-1.

Submit a written job-mix formula for approval at least 21 days before production. Submit the following:

(a) Aggregate.

(1) Target value for each sieve size for the aggregate blend.
(2) Percentage of each aggregate stockpile to be used.
(3) Average gradation of each aggregate stockpile.
(4) Proportional samples representing each aggregate stockpile, about 300 kilograms total.

(b) Emulsified asphalt.

(1) Percentage of emulsified asphalt to be added based on the total mass of the mix and corresponding residual asphalt content.
(2) Emulsified asphalt application temperature range conforming to Table 702-1.
(3) Source of the emulsified asphalt and a 20-liter sample. Furnish the sample in plastic containers.

(c) Additives. 25-kilogram sample of each solid additive (lime, portland cement, mineral filler, fly ash, etc.)

(d) Water. Percentage of water to be added based on the total mass of the mix.

The job-mix formula will be evaluated and approved according to Subsection 401.03.

Table 406-1
Dense-Graded Emulsified Asphalt Mix

Design Parameters[1]	Specification	Test Procedure
(a) Coating, % minimum		
Base	50	Visual[2]
Surface	75	
(b) Resistance[3]) R_t at 22.8±3 °C		
Early cure[4], minimum	70	[3]
Fully cured and water soak[5], minimum	78	
(c) Marshall stability, kN minimum at 22.2±1 °C	2.22	AASHTO T 245
Marshall stability loss[6], % maximum	50	

(1) Reference - *AI Manual Series No. 19 (MS-19)*.
(2) Evaluate the mix after surface dry for the percent of particle surface coated.
(3) $R_t = R + 0.05C$.
Where: R = Resistance value (AASHTO T 190).
C = Cohesiometer value (AASHTO T 246).
(4) Cured in mold for total of 24 hours at specified temperature.
(5) Cured in mold for total of 72 hours at specified temperature plus vacuum desiccation.
(6) After vacuum saturation and immersion.

406.04 Mixing Plant. Use a pugmill or drum dryer-mixer plant equipped with weighing or volumetric gauging equipment capable of providing accurate control of the material entering the mixer.

Interlock the aggregate feed controls with the emulsified asphalt, additive, and water controls to ensure uniform introduction of the material into the mixer. Use equipment conforming to AASHTO M 156 for handling emulsified asphalt. Use positive displacement pumps to control the flow of emulsified asphalt. Provide dry storage facilities for additives.

406.05 Surface Preparation. Prepare the surface according to Subsection 401.06.

406.06 Weather Limitations. Place the emulsified asphalt pavement on a dry, unfrozen surface only when the air temperature in the shade is above 10 °C and the pavement surface temperature is above 4 °C.

Do not place emulsified asphalt mix when fog, showers, rain, frost, or temperatures below 2 °C are anticipated within 24 hours following the placement of the mix.

406.07 Mixing, Hauling, Placing, Finishing, and Compacting. Construct the dense-graded emulsified asphalt pavement according to Subsections 401.10 through 401.15, except:

(a) Add the following to Subsection 401.10:

(1) Where combining with the emulsified asphalt, maintain the aggregate temperature between 16 and 80 °C.

(2) Maintain emulsified asphalt temperature within the approved range.

(3) Combine and dry mix the aggregate according to the approved job-mix formula for a period sufficient to provide a uniform batch gradation. Add additives and water before the emulsified asphalt. Mix the material until particles are uniformly coated and a mixture of uniform color and even distribution of coarse and fine particles is obtained.

(b) Delete the reference to Table 401-6 in Subsection 401.13.

(c) Add the following to Subsection 401.14:

Compact when the fluid content (emulsified asphalt and water) is within 2 percent of the optimum fluid content determined by the CO and the residual asphalt content is within 0.75 percent of the percent in the job-mix formula. Use a steel-wheeled roller having a minimum mass of 8 metric tons for breakdown rolling and a pneumatic-tired roller with maximum tire pressure of 275 kilopascals for intermediate rolling.

Provide a smooth surface according to Subsection 402.08. Correct defective areas by removing or adding material and recompacting.

Where public traffic is permitted on a compacted mix, spread blotter on areas where tracking or pickup of material occurs.

Allow the surface to cure for not less than 10 days before covering with the next course or treatment. During this period, maintain the surface and keep it free of corrugations. Patch all holes that develop with approved material. Remove all excess blotter, dirt, or other objectionable substances before placing the following course or treatment.

406.08 Acceptance. Mineral filler and blotter will be evaluated under Subsections 106.02 and 106.03.

Emulsified asphalt will be evaluated under Subsections 106.04 and 702.09.

Construction of the dense-graded emulsified asphalt pavement course will be evaluated under Subsections 106.02 and 106.04.

Residual asphalt content and aggregate gradation will be evaluated under Subsection 106.05. Density and other aggregate quality properties will be evaluated under Subsections 106.02 and 106.04. See Table 406-2 for minimum sampling and testing requirements.

(a) Residual asphalt content. The upper and lower specification limits are the approved job-mix formula target value ±0.75 percent. See Table 406-2 for the acceptance quality characteristic category.

(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 703-5. See Table 406-2 for the acceptance quality characteristic categories.

Measurement

406.09 Measure dense-graded emulsified asphalt pavement, emulsified asphalt, and mineral filler by the metric ton. Do not adjust the scale masses of the mix for the emulsified asphalt, moisture content, or additives.

Payment

406.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the dense-graded emulsified asphalt pavement 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 dense-graded emulsified asphalt 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 residual asphalt content or any individual sieve of the aggregate gradation.

Payment will be made under:

Pay Item		Pay Unit
40601	Dense-graded emulsified asphalt pavement grading ___	Metric ton
40602	Emulsified asphalt grade ___	Metric ton
40603	Mineral filler	Metric ton

Table 406-2
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Dense-graded emulsified asphalt pavement	Residual asphalt content	I	FLH T 516, FLH T 517, or AASHTO T 164	1 per 500 t	Behind laydown machine before rolling
	Gradation (1) — 4.75 mm 2.36 mm 75 µm Other specified sieves	 I II I II	FLH T 514 and AASHTO T 30 (3)	1 per 500 t	Behind laydown machine before rolling
	Core density (2)	—	AASHTO T 166 and AASHTO T 209	1 per 500 t	In place after compaction

(1) Use only sieves indicated for the specified gradation.
(2) Cut core sample from the compacted pavement according to AASHTO T 230 method B using air-cooled equipment. Fill and compact the sample holes with dense-graded emulsified asphalt mixture.
(3) Do not use FLH T 514 if AASHTO T 164 is used to determine residual asphalt content.

Section 407.) OPEN-GRADED EMULSIFIED ASPHALT PAVEMENT

Description

407.01 This work consists of constructing one or more courses of open-graded emulsified asphalt.

Open-graded emulsified asphalt pavement aggregate grading is designated as shown in Table 703-6.

Emulsified asphalt grade is designated as shown in AASHTO M 140 or AASHTO M 208.

Material

407.02 Conform to the following Subsections:

Aggregate	703.09
Choker aggregate	703.12
Emulsified asphalt	702.03
Water	725.01

Construction Requirements

407.03 Composition of Mix (Job-Mix Formula). Furnish a mixture of aggregate, emulsified asphalt, additives, and/or water that meets the aggregate gradation in Table 703-6 and design parameters in Table 407-1.

Submit a written job-mix formula for approval at least 21 days before production. Submit according to Subsection 406.03, except, if applicable, specify the percent of water to be added. Use a maximum moisture content approximately the same as the saturated surface dry condition of the aggregate as determined by AASHTO T 85.

The job-mix formula will be evaluated and approved according to Subsection 401.03.

Table 407-1
Open-Graded Emulsified Asphalt Mix

Design Parameters[1]	Specification	Test Procedure
Coating, % minimum Base Surface	 50 75	Visual[2]
Runoff, % maximum residual asphalt	0.5	
Washoff, % maximum residual asphalt	0.5	
Combined (Runoff and Washoff), % maximum	0.5	

(1) Reference - *AI Manual Series No. 19 (MS-19)*.
(2) Evaluate the mix after surface dry for the percent of particle surface coated.

407.04 Mixing Plant. Use a stationary pugmill, batch plant, drum dryer-mixer plant, or continuous mixing plant equipped with weighing or volumetric gauging equipment capable of providing accurate control of the material entering the mixer.

Use a mixing plant that permits variation in mixing times of 5 to 30 seconds and injects the emulsified asphalt into the mix as a stream and not a spray.

Locate the mixing plant as close as practical to the project.

407.05 Surface Preparation. Prepare the surface according to Subsection 401.06.

407.06 Weather Limitations. See Subsection 406.06.

407.07 Mixing. Introduce the material into the mixing plant according to the approved job-mix formula. Control the aggregate moisture content in the stockpiles so the maximum moisture determined in the job-mix formula is not exceeded. Mix until a uniform coating of between 70 percent and 95 percent is obtained upon discharge based on visual inspection.

407.08 Hauling, Spreading, and Finishing. Use hauling vehicles conforming to Subsection 401.11. Begin placement at the point farthest from the mixing plant and progress toward the plant. Minimize hauling over material already placed and do not drive on the material until it is compacted. Cleanup asphalt material dripping from the hauling vehicles onto previously constructed pavement on a daily basis.

Do not use mixes produced from different plants unless the mixes are produced according to the same job-mix formula, use the same material from the same sources, and the procedure is approved.

Place the mix using pavers conforming to Subsection 401.05. Spread, strike off, and finish the mix to the grade and elevation needed to provide the compacted thickness. Offset and locate longitudinal joints according to Subsection 401.13.

Clean the paver immediately after use. Clean only in locations where asphalt material will not be discharged into a borrow pit, ditch, gutter, or stream, or onto a completed pavement.

407.09 Compaction. Compact when the fluid content (emulsified asphalt and water) is within ±2 percent of the optimum fluid content determined by the CO and the residual asphalt content is within ±0.5 percent of the approved job-mix formula percent. Make up any deficiencies in residual asphalt content through the application of a flush coat.

Furnish the number, mass, and type of rollers to obtain density without undue displacement, cracking, or shoving. Move the rollers at a uniform speed not to exceed 5 kilometers per hour, with the drive wheels nearest the paver.

Immediately correct undue displacement resulting from the reversing of the direction of a roller, or other causes, by the use of rakes and fresh mix. Do not displace the line and grade of the edges.

Begin rolling at the sides and proceed parallel to the road centerline. Overlap each trip one-half the roller width, gradually progressing to the crown of the road. On superelevated curves, begin the rolling at the low side and progress to the high side by overlapping passes parallel to the centerline.

Make a minimum of 3 complete roller passes using a nonvibratory 2 steel-wheeled roller having a minimum mass of 8 metric tons for breakdown rolling.

Immediately after breakdown rolling, place choker aggregate using a spreader designed for the controlled spreading of sand. Spread the choker aggregate at the rate of 1.7 to 3.2 kilograms per square meter.

Make a minimum of 2 complete roller passes using a self-propelled pneumatic-tired roller with a tire pressure of approximately 275 kilopascals for intermediate rolling. Obtain a uniform textured surface with a minimum of voids.

Use a nonvibratory 2 steel-wheeled roller for finish rolling. Continue finish rolling until all roller marks are eliminated.

Provide a smooth surface according to Subsection 402.08. Correct defective areas by removing or adding material and recompacting.

Along forms, curbs, headers, walls, and other places not accessible to the rollers, thoroughly compact the mix with mechanical hand tampers. Construct joints, trim edges, and cleanup according to Subsection 401.15.

407.10 Flush Coat. Allow the surface to cure for a minimum of 2 days. Maintain the surface and keep it free of corrugations. Patch any holes that develop with approved material. Remove all excess choker aggregate, dirt, or other objectionable substances.

If the final surface will be used for the driving surface, apply a flush coat of emulsified asphalt using an asphalt distributor according to Subsection 409.04. Use the same emulsified asphalt type and grade as used for the mix. Add water to the emulsified asphalt and thoroughly mix to produce a blend containing approximately 50 percent emulsified asphalt and 50 percent added water.

When introducing water into a CMS-2, CMS-2s, or CMS-2h emulsified asphalt, heating of the water may be necessary. Spread the blend at the rate of 0.2 to 0.7 liter per square meter. The CO will determine the total number of applications.

407.11 Surface Treatment. Allow the surface to cure for a minimum of 10 days according to Subsection 407.10. When required by the contract, place a surface treatment according to Section 409.

407.12 Acceptance. Choker aggregate will be evaluated under Subsections 106.02 and 106.03.

Emulsified asphalt will be evaluated under Subsections 106.04 and 702.09.

Construction of the open-graded emulsified asphalt pavement course will be evaluated under Subsections 106.02 and 106.04.

Residual 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. See Table 407-2 for minimum sampling and testing requirements.

(a) Residual asphalt content. The upper and lower specification limits are the approved job-mix formula target value ±0.5 percent. See Table 407-2 for the acceptance quality characteristic category.

(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 703-6. See Table 407-2 for the acceptance quality characteristic categories.

Flush coat will be evaluated under Section 409.

Measurement

407.13 Measure open-graded emulsified asphalt pavement, emulsified asphalt for pavement and flush coat, and choker aggregate by the metric ton. Do not adjust the scale masses of the mix for the emulsified asphalt or moisture content.

Measure surface treatment under Section 409.

Payment

407.14 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the open-graded emulsified asphalt pavement 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 open-graded emulsified asphalt 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 residue asphalt content or any individual sieve of the aggregate gradation.

Payment will be made under:

Pay Item		**Pay Unit**
40701	Open-graded emulsified asphalt pavement grading ___	Metric ton
40702	Emulsified asphalt grade ___	Metric ton
40703	Choker aggregate	Metric ton

Table 407-2
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Open-graded emulsified asphalt pavement	Residual asphalt content	I	FLH T 516, FLH T 517, or AASHTO T 164	1 per 500 t	Hauling vehicle after discharge from plant
	Gradation (1) — 4.75 mm 2.36 mm 75 µm Other specified sieves	 I I I II	FLH T 514 and AASHTO T 30 (2)	1 per 500 t	Hauling vehicle after discharge from plant

(1) Use only sieves indicated for the specified gradation.
(2) Do not use FLH T 514 if AASHTO T 164 is used to determine residual asphalt content.

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 reclaimed asphalt pavement material and/or reclaimed aggregate material combined with new aggregates, water, emulsified asphalt, recycling agents, and/or lime.

Cold recycled asphalt base course aggregate grading is designated as shown in Table 703-5.

Emulsified asphalt grade is designated as shown in AASHTO M 140 or AASHTO M 208.

Material

408.02 Conform to the following Subsections:

Aggregate (new)	703.06
Emulsified asphalt	702.03
Lime	725.03
Recycling agent	702.06
Water	725.01

Construction Requirements

408.03 Composition of Mix (Job-Mix Formula). Furnish a mixture of reclaimed aggregate material, reclaimed asphalt pavement material, new aggregate, water, emulsified asphalt, recycling agent, and/or lime that meets the applicable aggregate gradation in Table 703-5 and the design parameters (a); and (b) or (c) in Table 406-1.

Submit a written job-mix formula for approval at least 21 days before production. Submit the following:

(a) Aggregate. Sources of and proportional samples representing the reclaimed asphalt pavement material, reclaimed aggregate material, and new aggregate, about 300 kilograms total. Obtain samples of existing pavement according to Subsection 403.03(a).

(b) Emulsified asphalt.

(1) Percentage of emulsified asphalt and/or 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 20-liter sample of the emulsified asphalt and/or 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 job-mix formula will be evaluated and approved according to Subsection 401.03.

408.04 Surface Preparation. For inplace mixing, clear, grub, and dispose of all vegetation and debris within 300 millimeters of the pavement to be recycled. Perform the work according to Section 201. Prepare the surface according to Subsection 303.07.

408.05 Weather Limitations. See Subsection 406.06.

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.

For inplace 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/or 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/or lime content will be established by the CO after evaluation of field results.

408.07 Spreading, Finishing, and Compacting. Spread, finish, and compact the mixture according to Subsection 406.07.

After the recycled mixture has been compacted, do not permit any traffic on the completed cold recycled asphalt base for at least 2 hours. Allow the pavement to cure according to Subsection 406.07 before placing the next course or sealing the surface with a fog seal according to Section 409.

408.08 Acceptance. Recycling agent and lime will be evaluated under Subsections 106.02 and 106.03.

Emulsified asphalt will be evaluated under Subsections 106.04 and 702.09.

Aggregate (new) will be evaluated under Subsections 106.02 and 106.04. See Table 408-1 for minimum sampling and testing requirements.

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. See Table 408-1 for minimum sampling and testing requirements.

Measurement

408.09 Measure cold recycled asphalt base course by the metric ton or by the square meter. When measurement is by the metric ton, do not deduct for the emulsified asphalt, recycling agent, water, and/or lime contained in the mixture. Measure square meter width horizontally to include the top of base width and allowable curve widening. Measure the square meter length horizontally along the centerline of the roadway.

Measure emulsified asphalt, lime, and recycling agent by the metric ton.

Measure fog seal under Section 409.

Payment

408.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
40801	Cold recycled asphalt base course grading ___	Metric ton
40802	Cold recycled asphalt base course grading ___, ___ millimeter depth	Square meter
40803	Emulsified asphalt grade ___	Metric ton
40804	Recycling agent	Metric ton
40805	Lime	Metric ton

Table 408-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Aggregate (new)	Gradation	AASHTO T 27 and AASHTO T 11	1 for each aggregate	Source of material or stockpile
Cold recycled asphalt pavement	Core density (1)	AASHTO T 166 and AASHTO T 209	1 for each 3500 m^2	In place after compaction

(1) Cut core sample from the compacted pavement according to AASHTO T 230 method B using air-cooled equipment. Fill and compact the sample holes with asphalt mixture.

Section 409.) ASPHALT SURFACE TREATMENT

Description

409.01 This work consists of constructing a single or multiple asphalt surface treatment course. A fog seal is an asphalt surface treatment without aggregate.

The grade of asphalt is designated as shown in AASHTO M 20 or AASHTO M 226 for asphalt cement, AASHTO M 140 or AASHTO M 208 for emulsified asphalt, and AASHTO M 81 or AASHTO M 82 for cut-back asphalt.

Surface treatment aggregate designation is designated as shown in Tables 409-1, 409-2, and 409-3.

Material

409.02 Conform to the following Subsections:

Aggregate	703.10
Asphalt cement	702.01
Blotter	703.13
Cut-back asphalt	702.02
Emulsified asphalt	702.03

Construction Requirements

409.03 Composition of Mix. For surface treatments, submit the following information and samples for approval at least 21 days before production:

(a) Aggregate samples. 35 kilograms 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. 2 liters of 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.

409.04 Equipment. Furnish equipment as follows:

(a) Asphalt distributor.

(1) Capable of heating asphalt evenly.
(2) Adjustable full circulation spray bar to 4.6-meter width.
(3) Positive controls including tachometer, pressure gauge, volume measuring device, or calibrated tank to uniformly deposit asphalt over the full width within 0.08 liter per square meter of the required rate.
(4) Thermometer for measuring the asphalt temperature in the tank.

(b) Rotary power broom.

(c) Pneumatic-tire rollers.

(1) Minimum compacting width) 1.5 meters.
(2) Minimum ground contact pressure) 550 kilopascals.

(d) Aggregate spreader.

(1) Self-propelled.
(2) Minimum of 4 pneumatic tires on 2 axles.
(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.

409.05 Surface Preparation. Prepare surface according to Subsection 303.07.

409.06 Weather Limitations. Place asphalt seal coats when the air temperature in the shade and the pavement surface temperature are at least 16 °C and rising and when the weather is not foggy or rainy.

409.07 Production Start-Up Procedures for Surface Treatment. 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 production, construct a 150-meter control strip that is one-lane wide. Locate the control strip on the project as designated.

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 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.

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 emulsified asphalt, moisten the aggregate to remove its dust coating.

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 150 millimeters 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.

Make first roller pass to seat the aggregate immediately after the aggregate is applied. Operate rollers at a maximum speed of 10 kilometers per hour.

409.10 Fog Seal. A fog seal consists of applying a 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 0.45 to 0.70 liters per square meter 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 an asphalt onto an existing asphalt 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 rolling, limit the traffic speeds to 15 kilometers per hour. Limit traffic speeds to 30 kilometers per hour for 24 hours.

Lightly broom the aggregate surface on the morning after construction. Maintain the surface 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. Do not displace embedded material.

Table 409-1
Approximate Quantities of Material for Single-Course Surface Treatment

Sequence of Operations	Treatment Designation and Aggregate Gradation [(1)]				
	B	C	D	E	F
Apply asphalt material (L/m²)					
Emulsified asphalt	2.00	1.70	1.25	0.90	0.90
Cut-back asphalt or asphalt cement	1.80	1.15	0.90	0.70	0.70
Spread aggregate[(1)(2)] (kg/m²)	24	16	12	8	11

(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 AASHTO T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.

409.12 Multiple-Course Surface Treatment. A multiple-course surface treatment consists 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.

For multiple-course surface treatment designations AT-61 and E-61, wait at least 24 hours between application of the third and fourth layers.

Table 409-2
Approximate Quantities of Material for
Multiple-Course Surface Treatment
(Using Cut-back Asphalt or Asphalt Cement)

Aggregate Grading [1][2] and Sequence of Operations	**Treatment Designation**				
	AT-19	**AT-27**	**AT-33**	**AT-38**	**AT-61**
First Course)					
Apply asphalt material (L/m²)	1.00	1.15	0.70	1.35	0.90
Spread aggregate (kg/m²)					
Grading D	13				
Grading C		19			
Grading B			21	27	
Grading A					38
Second Course)					
Apply asphalt material (L/m²)	0.60	1.15	1.35	1.55	1.80
Spread aggregate (kg/m²)					
Grading E	6	8			
Grading D			7	11	
Grading C					11
Third Course)					
Apply asphalt material (L/m²)			0.70		0.90
Spread aggregate (kg/m²)					
Grading E			5		7
Fourth Course)					
Apply asphalt material (L/m²)					0.90
Spread aggregate (kg/m²) [3]					
Grading F					5
TOTALS)					
Asphalt material (L/m²)	1.60	2.30	2.75	2.90	4.56
Aggregate (kg/m²)	19	27	33	38	61

(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 AASHTO T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.
(3) After final aggregate spread, apply additional cover aggregate, grading F, to all areas with unabsorbed asphalt materials.

Table 409-3
Approximate Quantities of Material for Multiple-Course Surface Treatment (Using Emulsified Asphalt)

Aggregate Grading [1][2] and Sequence of Operations	Treatment Designation				
	E-19	E-27	E-33	E-38	E-61
First Course)					
Apply asphalt material (L/m²)	2.00	1.55	2.00	2.25	1.80
Spread aggregate (kg/m²)					
Grading D	13				
Grading C		17			
Grading B			19	21	
Grading A					38
Second Course)					
Apply asphalt material (L/m²)	1.15	1.15	1.15	1.15	2.00
Spread aggregate (kg/m²)					
Grading E	6	5			
Grading D			9	11	11
Third Course)					
Apply asphalt material (L/m²)		1.15	1.15	1.15	1.15
Spread aggregate (kg/m²)					
Grading E		5	5	6	7
Fourth Course)					
Apply asphalt material (L/m²)					1.15
Spread aggregate (kg/m²) [3]					
Grading F					5
TOTALS)					
Asphalt material (L/m²)	3.15	3.85	4.30	4.55	6.10
Aggregate (kg/m²)	19	27	33	38	61

(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 AASHTO T 85. Make proportionate corrections when the aggregate furnished has a bulk specific gravity above 2.75 or below 2.55.
(3) After final aggregate spread, apply additional cover aggregate, grading F, to all areas with unabsorbed asphalt materials.

409.13 Acceptance. Asphalt cement, emulsified asphalt, and cut-back asphalt will be evaluated under Subsections 106.04 and 702.09.

Aggregate for asphalt surface treatment will be evaluated under Subsections 106.02 and 106.04. See Table 409-4 for minimum sampling and testing requirements.

Construction of asphalt surface treatment course will be evaluated under Subsections 106.02 and 106.04.

Blotter will be evaluated under Section 411.

Measurement

409.14 Measure surface treatment aggregate by the metric ton or by the cubic meter in the hauling vehicle.

Measure asphalt cement and emulsified asphalt by the metric ton.

Measure blotter under Section 411.

Payment

409.15 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
40901	Surface treatment aggregates designation ___	Metric ton
40902	Surface treatment aggregates designation ___	Cubic meter
40903	Asphalt cement grade ___	Metric ton
40904	Emulsified asphalt grade ___	Metric ton

Table 409-4
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Aggregate surface treatment aggregate	Gradation [(1)]	AASHTO T 27 and AASHTO T 11	1 for each 500 t	Spreader discharge
	Fractured faces [(1)]	FLH T 507	1 for each 500 t	Spreader discharge
	Flakiness index [(1)]	FLH T 508	1 for each 500 t	Spreader discharge

(1) Applies to each aggregate grade furnished.

Section 410.) SLURRY SEAL

Description

410.01 This work consists of applying an asphalt slurry seal mix.

Slurry seal type is designated as shown in Table 703-8.

Emulsified asphalt grade is designated as shown in AASHTO M 140 or AASHTO M 208.

Material

410.02 Conform to the following Subsections:

Aggregate	703.11
Emulsified asphalt	702.03
Mineral filler	725.05
Water	725.01

Construction Requirements

410.03 Composition of Mix (Job-Mix Formula). Furnish a slurry seal mixture of aggregate, water, emulsified asphalt, and additives according to ASTM D 3910 and ISSA T 114. Conform to the applicable aggregate gradation in Table 703-8 and the following residual asphalt contents:

Type I - Residual asphalt between 10.0% and 16.0%

Type II - Residual asphalt between 7.5% and 13.5%

Type III - Residual asphalt between 6.5% and 12.0%

Submit a written job-mix formula for approval at least 21 days before production. 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. 45-kilogram sample of each aggregate.

(d) Emulsified asphalt sample. Source of and 20-liter sample of the emulsified asphalt to be used in the mix. Furnish the sample in plastic containers.

(e) Mineral filler samples. 25-kilogram 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) Slurry seal mixer.

(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 0.13 to 0.27 liters per square meter.
(9) Proportioning system that is accurate for measuring all material independent of the engine speed.
(10) Minimum speed of 20 meters per minute and maximum speed of 55 meters per minute.
(11) Minimum storage capacity of 6 metric tons.
(12) Capable according to ISSA Performance Guidelines A 105.

(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 assure a uniform spread over varying grades and crowns.
(4) Adjustable in width with a flexible strike-off.
(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. Prepare the surface to be sealed according to Subsection 303.07.

410.06 Weather Limitations. Apply slurry seal when the air temperature in the shade and the surface temperature are at least 15 °C and rising and when the weather is not foggy, rainy, or overcast.

410.07 Slurry Seal Application. Mix the slurry seal 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 slurry seal a maximum of 4 minutes. Ensure the slurry seal 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 slurry seal 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 slurry seal mix.

Allow treated areas to completely cure before opening to traffic. Cure is complete when clear water can be pressed out of the slurry mix with a piece of paper without discoloring the paper.

410.08 Acceptance. Emulsified asphalt will be evaluated under Subsections 106.04 and 702.09.

Aggregate for slurry seal will be evaluated under Subsections 106.02 and 106.04. See Table 410-1 for minimum sampling and testing requirements.

Construction of the slurry seal will be evaluated under Subsections 106.02 and 106.04.

Measurement

410.09 Measure slurry seal by the square meter. Measure square meter width horizontally to include the top of surface width and allowable curve widening. Measure the square meter length horizontally along the centerline of the roadway.

Measure emulsified asphalt and slurry seal aggregate by the metric ton.

Payment

410.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	Pay Unit
41001	Slurry seal type ___	Square meter
41002	Emulsified asphalt grade ___	Metric ton
41003	Slurry seal aggregate	Metric ton

Table 410-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Slurry seal aggregate	Gradation	AASHTO T 27 and AASHTO T 11	1 for each 500 t	Production output or stockpile
	Fineness modulus [(1)]	AASHTO T 27	1 for each 500 t	Production output or stockpile
	Sand equivalent	AASHTO T 176 alternate method no. 2	1 for each 500 t	Production output or stockpile

(1) See AASHTO M 29.

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 AASHTO M 208 for emulsified asphalt and AASHTO M 81 or AASHTO 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

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 303.07.

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 10 °C 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 0.45 to 2.25 liters per square meter for optimum penetration.

Where using an emulsified asphalt that is not formulated as a penetrating prime coat material, dampen the roadway surface and scarify 25 to 50 millimeters deep. When required, dilute a slow-setting emulsified asphalt by adding an equal amount of water. Apply the emulsified asphalt at a rate of 0.45 to 1.35 liters per square meter. 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 303.

Measurement

411.08 Measure prime coat asphalt by the metric ton or by the liter including water added for dilution.

Measure blotter by the metric ton or by the cubic meter in the hauling vehicle.

Payment

411.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will made under:

Pay Item		Pay Unit
41101	Prime coat grade ___	Metric ton
41102	Prime coat grade ___	Liter
41103	Blotter	Metric ton
41104	Blotter	Cubic meter

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 AASHTO 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. Prepare the surface for a tack coat according to Subsection 303.07. 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 2 °C 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 0.15 to 0.70 liters per square meter. 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 tack coat by the metric ton or by the liter including water added for dilution.

Payment

412.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	**Pay Unit**
41201 Tack coat grade ___	Metric ton
41202 Tack coat grade ___	Liter

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.
(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 6 millimeters in 3 meters 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 17 millimeters of depth per 10 meters . 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 156.06(b).

Mill the surface to a smoothness conforming to Subsection 402.08.

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 211.03(b).

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 402.

Measurement

413.05 Measure asphalt pavement milling by the square meter or by the kilometer. Measure square meter width horizontally. Measure the length horizontally along the centerline of the roadway.

Payment

413.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
41301	Asphalt pavement milling, ___ millimeter depth	Square meter
41302	Asphalt pavement milling, ___ millimeter depth	Kilometer

Section 414.) ASPHALT PAVEMENT CRACK AND JOINT SEALING

Description

414.01 This work consists of saw cutting, when required in the contract, and cleaning and filling cracks and joints in asphalt pavement.

Material

414.02 Conform to the following Section and Subsections:

Asphalt cement	702.01
Blotter	703.13
Emulsified asphalt	702.03
Fine aggregate	703.01
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 2.8 cubic meters per minute at a pressure of 830 kilopascals and at a temperature of 1000 °C.

(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 100 to 300 °C in 2 °C 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, 350 kilopascals 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 4 °C 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.

Fill each joint such that, after cooling, the level of the sealant is no more than 3 millimeters below the pavement surface.

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. Rout and clean all cracks with an average opening of 6 millimeters or more to make a sealant reservoir to the depth of the routed crack or at least 20 millimeters 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 13 millimeter width or less, seal with hot-poured elastic sealant according to Subsection 414.04.

For cracks with a width greater than 13 millimeters, seal with an approved slurry seal mix, fine aggregate-asphalt cement 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 75-millimeter wide band is centered on the finished sealed crack. Cover the sealed crack with a light application of blotter.

414.06 Resealing Defective Joints or Cracks. Reseal areas exhibiting adhesion failure, damage, missed areas, foreign objects in the sealant, or other problems which will 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 joint sealant by the liter or by the kilogram.

Measure saw cutting and joint sealing, and crack cleaning and sealing by the meter.

Payment

414.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
41401	Joint sealant	Liter
41402	Joint sealant	Kilogram
41403	Saw cutting and joint sealing	Meter
41404	Crack cleaning and sealing	Meter

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 cement	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 303.07.

415.04 Weather Limitations. Apply asphalt sealant and paving geotextile on a dry surface when the pavement surface temperature is at least 13 °C and rising.

415.05 Asphalt Sealant Application. Use asphalt cements within a temperature range of 140 to 165 °C. Use emulsified asphalts within a temperature range of 55 to 70 °C.

Apply the asphalt sealant to the pavement surface according to Subsection 409.08 at a rate of 0.90 to 1.35 liters per square meter.

Spray the asphalt sealant 150 millimeters 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 cement 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 25 millimeters. Broom and/or roll the paving geotextile to maximize fabric contact with the pavement surface.

At geotextile joints, overlap the geotextile 6 inches (150 millimeters 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 165 $^\circ$C except when the paving geotextile is composed of polypropylene fibers, limit the lay-down temperature of the mix to a maximum of 150 $^\circ$C.

415.07 Acceptance. Asphalt cement 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 303.

Measurement

415.08 Measure paving geotextile by the square meter excluding overlaps.

Measure asphalt sealant by the metric ton.

Measure blotter under Section 411.

Payment

415.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payments will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
41501 Paving geotextile	Square meter
41502 Asphalt sealant	Metric ton

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 AASHTO M 208.

Material

416.02 Conform to the following Subsections:

Emulsified binder agent	702.03
Quicklime	725.03
Recycling agent	702.06
Sealing emulsion	702.03
Water	725.01

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 150 millimeters in diameter from randomly selected sites
(2) Source of and 7 liters of emulsified binder agent
(3) One kilogram of quicklime if quicklime is included in the bid schedule
(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. Prepare the surface according to Subsection 303.07(c). Clear, grub, and remove all vegetation and debris within 0.5 meter of the pavement to be recycled.

416.05 Weather Limitations. See Subsection 406.06.

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, half the existing pavement width or one lane width, whichever is greater

(e) Capable of screening and crushing material

Do not disturb underlying material.

Reduce oversize particles to a maximum size of 25.0 millimeters.

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 which allows the addition of emulsified binder agent and/or 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/or 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 metric 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 60 °C. Measure the density of the laboratory specimen according to AASHTO T 166. Measure the density of the inplace recycled mix according to AASHTO T 238.

(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 metric tons and equipped with frequency and amplitude controls.

(b) 8 to 12 roller passes with a pneumatic-tired roller having a minimum mass of 900 kilograms per wheel and a contact pressure of 550 kilopascals.

(c) 4 to 6 roller passes with a static steel-wheel roller with a minimum pressure of 1.7 megapascals.

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(b), except defective areas are surface deviations in excess of 10 millimeters in 3 meters. Correct defective areas according to Subsection 401.16(c).

(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 22 °C. 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 239 or until 21 days after recycling.

416.09 Sealing Emulsion. When there is a pay item for sealing emulsion in the bid schedule and when directed by the CO, place a sealing emulsion on the surface of the recycled base after final compaction. Dilute the sealing emulsion 50 percent by volume with water and apply it at a rate of 0.20 to 0.90 liters per square meter. Place blotter according to Section 411.

416.10 Acceptance. 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. See Table 416-1 for minimum sampling and testing requirements.

Pavement smoothness will be evaluated under Subsections 106.02 and 106.04.

Blotter material will be evaluated under Section 411.

Measurement

416.11 Measure cold recycled asphalt base course by the kilometer or by the square meter. Measure square meter width horizontally to include the top of base width and allowable curve widening. Measure the square meter length horizontally along the centerline of the roadway.

Measure emulsified binder agent by the metric ton.

Measure sealing emulsion by the metric ton including water used for dilution.

Payment

416.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
41601	Continuous cold recycled asphalt base course type ___	Kilometer
41602	Continuous cold recycled asphalt base course type ___	Square meter
41603	Emulsified binder agent grade ___	Metric ton
41604	Sealing emulsion grade ___	Metric ton
41605	Quicklime	Metric ton

Table 416-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Recycled mix [(1)]	Inplace density	AASHTO T 238	1 for each 1000 m	In place after compaction [(2)]

2

(1) Testing required when cold recycled asphalt base course 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 cement, additives, and mix meet Federal or state agency specifications.

417.04 Surface Preparation. Prepare the surface according to Section 209 or Subsection 303.07 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 100 millimeters. 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 metric tons.

(b) Non-roadway paving and patching. Compact by rolling with a hand-operated roller weighing at least 130 kilograms 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 minor cold asphalt mix by the metric ton.

Payment

417.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
41701 Minor cold asphalt mix	Metric ton

DIVISION 500
Portland Cement Concrete Pavement

Section 501.) PORTLAND CEMENT CONCRETE PAVEMENT

Description

501.01 This work consists of constructing portland cement concrete pavement on a prepared surface. This work also includes pavement rehabilitation consisting of full-depth, full-width removal and reconstruction of portland cement concrete pavement.

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 resin adhesives	725.21
Fine aggregate	703.01
Fly ash	725.04
Grout	725.22
Joint fillers and sealants	712.01
Portland cement	701.01
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 60 meters, furnish flexible or curved forms. Conform to all the following:

(1) Depth equal to edge of pavement thickness
(2) 3-meter minimum length
(3) Stabilizing devices to withstand paving operations
(4) Joint locks to join form lengths tightly together
(5) Cleaned and oiled before each use

Table 501-1
Portland Cement Concrete Pavement Composition

Water/Cement Ratio (maximum)	Temperature of Concrete	Slump	Air Content (%)	Aggregate Size[1] (AASHTO M 43)	28-Day Compressive Strength (minimum)
0.49	20±10 °C	40±20 mm	4½ min.	No. 57 or 67	25 MPa

(1) Other AASHTO M 43 aggregate sizes smaller than no. 57 or 67 may be used in the concrete mix design. However if the nominal-maximum-sized aggregate is 12.5 millimeters or smaller, provide at least 5 percent air content. Furnish type I or II portland cement.

(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 450-millimeter 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 which displaces the side forms will not be permitted.

(3) Vibrators. Furnish internal immersed tube or multiple spud type vibrators for all paving more than 200 millimeters thick. Surface pan type vibrators are acceptable for full-width concrete consolidation of slabs 200 millimeters 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 stand-by 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. 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 3.8 megapascals according to AASHTO T 97 or compressive strength of 24 megapascals 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 13 millimeters and transverse joints more than 6 millimeters 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 13-millimeter 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 4.5 meters. 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 3-meter 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 3 meters of any parallel joint.

If sufficient concrete has not been mixed to form a slab at least 3 meters 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 3-meter s-traightedge. Remove high areas indicated by the straightedge. Lap each successive check with the straightedge 1.5 meters over the previous check path.

Correct pavement edge slump in excess of 6 millimeters in 3 meters before the concrete has hardened. If edge slump exceeds 25 millimeters on any 0.3 meter 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 6-millimeter continuous radius and a smooth, dense mortar finish. Do not use mortar buildup to round edges.

Groove 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. Entirely cover the surface with a waterproof cover. Lap the cover at least 0.5 meter. 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 2 °C, furnish a sufficient supply of insulating material. Insulate the pavement surface and sides to a depth to maintain a temperature above 4 °C 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 4 °C. 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 6 millimeters below the pavement surface.

Remove and replace seals that are damaged, twisted, improperly positioned, or stretched more than 3 percent.

501.12 Pavement Smoothness. After the concrete has sufficiently hardened, measure the smoothness of the surface.

(a) Profilograph measurements. Measure the traveled way parallel to the centerline according to Subsection 401.16(a). Measure the excluded areas according to (b) below. Defective areas are bumps in excess of 10 millimeters in 7.62 meters, 0.1-kilometer profile indexes greater than 160 millimeters per kilometer, and surfaces with a pay factor less than 0.75 as determined under Subsection 106.05.

(b) Straightedge measurement. Use a 3-meter metal straightedge to measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 6 millimeters in 3 meters between any two contacts of the straightedge with the surface.

(c) Defective area correction. Correct defective areas from (a) and (b) above. Obtain approval for the proposed method of correction. Remeasure corrected areas according to (a) and (b) above. The smoothness pay factor will be recomputed after measurement.

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 45±5 millimeters. 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 will be welded, cut the existing reinforcing steel and leave 200 millimeters of steel exposed. If replacement steel will be tied, cut the existing steel to leave the lap length plus 50 millimeters. Lap lengths are shown in Table 501-2.

Table 501-2
Reinforcing Steel Splices

Bar Size	Length of Overlap millimeters
10M	375
15M	450
20M	550

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 300 millimeters 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 75-millimeter 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 460 millimeters 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 300 millimeters.

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 4 megapascals according to AASHTO T 97
(b) Compressive strength of 25 megapascals 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 portland cement concrete pavement will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification for the portland 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 minimum sampling and testing.

Concrete compressive strength, pavement thickness, and pavement smoothness will be evaluated under Subsection 106.05. See Table 501-3 for minimum sampling and testing.

(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 6 millimeters. See Table 501-3 for the acceptance quality characteristic category.

(c) Pavement smoothness. See Subsection 501.12. A sublot is a 0.1-kilometer section of traveled way and a lot is the surface of the entire project. The upper specification limit is 80 millimeters per kilometer. See Table 501-3 for the acceptance quality characteristic category.

Construction (including batching, placing, finishing, and curing concrete) of the portland cement concrete pavement will be evaluated under Subsections 106.02 and 106.04.

Reinforcing steel will be evaluated under Section 554.

Measurement

501.16 Measure portland cement concrete pavement by the square meter. Measure square meter width horizontally including allowable curve widening. Measure the square meter 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, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the portland cement concrete pavement 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 portland cement 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 either compressive strength or pavement thickness.

In addition, a separate adjustment will be made for pavement smoothness according to the following formula:

$$A = 12\,000(PF - 1.00)(L)$$

Where:

A	=	Adjustment to contract payment in dollars for pavement smoothness.
L	=	Total project length in lane kilometers of traveled way. Measure project length to 3 decimal places.
PF	=	Pay factor for smoothness with respect to the upper specification limit determined according to Subsection 106.05 after completion of corrective work.

Payment will be made under:

Pay Item		Pay Unit
50101	Reinforced portland cement concrete pavement, ___ millimeter depth	Square meter
50102	Plain portland cement concrete pavement, ___ millimeter depth	Square meter

Table 501-3
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Concrete	Slump	—	AASHTO T 119	1 per load [2]	Discharge stream at point of placement [1]
	Air content	—	AASHTO T 152 or AASHTO T 196	1 per load [2]	Discharge stream at point of placement [1]
	Unit weight	—	AASHTO T 121	1 per load [2]	Discharge stream at point of placement [1]
	Temperature	—	Thermometer	First load	Discharge stream at point of placement [1]
	Making test specimens Compressive strength [4]	— II	AASHTO T 23 AASHTO T 22	1 set per 2000 m^2 but not less than 1 per day [3]	Discharge stream at point of placement [1]
Concrete pavement	Pavement thickness	II [5]	AASHTO T 24	1 core per 2000 m^2	In place after sufficient hardening
	Smoothness [6]	I	FLH T 504	See Subsection 501.12	See Subsection 501.12

(1) Sample according to AASHTO T 141 except composite samples are not required.
(2) See Subsection 552.09(b)(3).
(3) Cast at least 4 compressive strength test cylinders and carefully transport the cylinders to the job site curing facility.
(4) A single compressive strength test result is the average result from 2 cylinders cast from the same load and tested at 28 days.
(5) Thickness is not a statistically evaluated parameter unless concrete pavement payment is by the square meter.
(6) Applies only to an item used as a final surface course constructed under the contract.

Section 502.) PORTLAND CEMENT CONCRETE PAVEMENT RESTORATION

Description

502.01 This work consists of the restoration of portland cement concrete 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 resin adhesives	725.21
Joint fillers and sealants	712.01
Polymer grout, mortar, and concrete	725.22
Portland cement concrete 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.

Design a hydraulic cement grout mix according to Subsection 725.22.

502.04 Equipment. Furnish equipment conforming to Section 501 and the following:

(a) Portland cement concrete pavement removal. Furnish removal equipment that will not fracture the concrete below the necessary patch depth.

(b) Routing. Furnish routers which will 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 690 kilopascals 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 1900±170 kilopascals when pumping a grout slurry mixed to a 12-second flow cone time and that will continuously pump at a minimum rate of 6.0 liters 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 38-millimeter holes through the concrete slab, steel reinforcement, and base material.

Furnish rock drills weighing less than 27 kilograms that are capable of drilling with a downward pressure of less than 90 kilograms. 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 80 kilonewtons 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.
(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 portland cement concrete pavement with diamond blades. Furnish equipment that will do each of the following:

(1) Cut or plane at least 1 meter in width.
(2) Not encroach on traffic movement outside of the work area.
(3) Grind 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 32-metric 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 portland cement 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 mortar or polymer concrete patch material for patches less than or equal to 40 millimeters deep. Use portland cement concrete for patches greater than 40 millimeters deep.

(b) Patch area preparation. Extend the limits of repair areas a minimum of 100 millimeters outside the area of delamination. Saw cut the perimeter of the patch area, parallel to the existing joint, to a minimum depth of 40 millimeters 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 40 millimeters to expose sound and clean concrete. If the depth of the repair exceeds 100 millimeters, 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 300 millimeters, to facilitate placing form work. Patch and compact shoulders with material similar to the existing shoulder. Dispose of the concrete according to Section 203.

(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 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. Use procedures that will 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 20 millimeters.

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 will not properly clean the joint. Limit sawing to exposing clean, new, concrete faces in the joint with a minimum allowable cut of 2 millimeters 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 hydraulic cement grout.

(a) Drilling holes. Determine a pattern for grout injection holes and submit for approval. Drill holes vertically, round, and less than 50 millimeters 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 3 millimeters of the string line grade. When jacking jointed pavement and bridge approach slabs, allow pumping to raise the pavement to within 6 millimeters of the transverse and longitudinal grades.

Continuous pressures to 1.4 megapascals are permitted. Use pressures to 2 megapascals only for short periods (30 seconds or less). If the pavement is bonded to the subbase, brief pressure rises (10 seconds or less) to 4.1 megapascals 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 25 millimeters, 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 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 300 millimeters behind the joint and the outside test wheel 300 millimeters from the pavement edge. Read the back gauge.

(4) Move the test truck across the joint to a similar position 300 millimeters 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 0.8 millimeter.

(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 75 millimeters 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 700 kilopascals and slab lift greater than 1.3 millimeters 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 3±0.5 millimeters wide. Provide an area between the grooves 2.2±0.5 millimeters, and a difference between the peaks of the ridges and the bottom of the grooves of approximately 2 millimeters.

Test the ground pavement surfaces for pavement smoothness according to Subsection 501.12(b). Check transverse joints and random cracks with a 3-meter straightedge. Misalignment of surface planes on adjacent sides of the joints or cracks and between each grinding pass shall be less than 1.6 millimeters. The transverse slope of the pavement shall have no depressions or slope misalignment greater than 6 millimeters in 3 meters 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 0.5 to 1.0 meters 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 0.4 to 0.6 meters 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 0.05 to 0.15 meters 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 150-millimeter 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/or striking height based on check sections.

Seating consists of rolling the rigid pavement, 2 passes minimum with a 45-metric ton roller or 4 to 7 passes with a 32-metric ton roller, until the concrete pieces are firmly seated. Compacting consists of rolling the rigid pavement, 2 passes minimum with a 9-metric ton vibratory roller. The CO will determine the maximum number of roller passes on the test section to assure seating or compacting without damaging the pavement. Remove all loose pieces of broken concrete that are not firmly seated.

Tack, according to Section 412, the near vertical sides where full-depth broken concrete is removed. Fill the hole with asphalt concrete according to Section 402.

Prevent the formation of continuous longitudinal cracks. Do not fracture pavement within 3 meters of existing box or pipe culverts.

Fill 25-millimeter 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 15 millimeters 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 portland cement concrete has a compressive strength of 25 megapascals when tested according to AASHTO T 22 or until the grout used for jacking or undersealing the pavement has attained 4.2 megapascals when tested with a 160-square millimeter 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. Material for portland cement concrete pavement restoration will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification for the portland cement.

The concrete mixture's slump, air content, unit mass, and temperature will be evaluated under Subsections 106.02 and 106.04. See Table 502-1 for minimum sampling and testing.

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. See Table 502-1 for minimum sampling and testing.

Construction (including batching, placing, finishing, and curing concrete) of the portland cement concrete will be evaluated under Subsections 106.02 and 106.04.

Grout will be evaluated under Subsection 106.04. See Table 502-1 for minimum sampling and testing requirements.

Portland cement concrete 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 concrete pavement patch by the square meter for all repairs with an average depth between 40 and 100 millimeters.

Measure sealing joints and cracks by the meter along the alignment of the joint or crack.

Measure grout for pavement jacking and undersealing by the cubic meter at the pump.

Measure undersealing holes by the each.

Measure surface diamond grinding, breaking and seating, cracking and seating, or rubblizing and compacting concrete pavement by the square meter.

Measure slabs ordered replaced after undersealing twice under Section 501.

Measure aggregate base under Section 301.

Payment

502.14 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05

Payment will be made under:

	Pay Item	**Pay Unit**
50201	Concrete pavement patch	Square meter
50202	Sealing joints and cracks	Meter
50203	Grout	Cubic meter
50204	Undersealing holes	Each
50205	Surface diamond grinding	Square meter
50206	Breaking and seating concrete pavement	Square meter
50207	Cracking and seating concrete pavement	Square meter
50208	Rubblizing and compacting concrete pavement	Square meter

Table 502-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Concrete	Slump	AASHTO T 119	1 per load [2]	Discharge stream at point of placement [1]
	Air content	AASHTO T 152 or AASHTO T 196	1 per load [2]	Discharge stream at point of placement [1]
	Unit weight	AASHTO T 121	1 per load [2]	Discharge stream at point of placement [1]
	Temperature	Thermometer	First load	Discharge stream at point of placement [1]
	Making test specimens Compressive strength [4]	AASHTO T 23 AASHTO T 22	1 set per 2000 m^2 but not less than 1 per day [3]	Discharge stream at point of placement [1]
Grout	Compressive strength	AASHTO T 106	Each mixture	Each source
	Time of setting of concrete	AASHTO T 197	AASHTO T 197	Each source

(1) Sample according to AASHTO T 141 except composite samples are not required.
(2) See Subsection 552.09(b)(3).
(3) Cast at least 4 compressive strength test cylinders, and carefully transport the cylinders to the job site curing facility.
(4) A single compressive strength test result is the average result from 2 cylinders cast from the same load and tested at 28 days.

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, 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
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 can only be used to drive timber piles. Furnish a hammer with a ram weighing between 900 and 1600 kilograms and limit the drop height to 4.5 meters. 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 1250 kilograms.

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. Do not use nonimpact hammers, such as vibratory hammers, unless 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 will 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.

(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.

The Government will evaluate the suitability of the equipment and will accept or reject the driving system within 14 days of receipt of the pile and driving equipment information. Approval of pile driving equipment will be based on a wave equation analysis when dynamic load testing is required, when ultimate pile capacities exceed 2400 kilonewtons, or when precast or prestressed concrete piles are used. When the wave equation analysis is not used, approval of the pile driving equipment will be based on minimum hammer energy in Table 551-1. Approval of a pile hammer relative to driving stress damage does not relieve the Contractor of responsibility for damaged piles.

Approval of the pile driving system is specific to the equipment data submitted. If the proposed equipment is modified or replaced, resubmit the revised data for approval before using. The revised driving system will be accepted or rejected within 14 days of receipt of the revised pile, equipment, and wave equation analysis (if required) information. Use only the approved equipment during pile driving operations.

(1) Equipment submittal. Submit the following pile driving equipment information at least 30 days before driving piles. When dynamic load tests are required by the contract, submit a wave equation analysis performed by a pile specialty consultant meeting the requirements of Subsection 551.11. If dynamic load testing is not required by the contract, the Government will perform the wave equation analysis.

(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 drive-head 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 meter, 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 15 per 25 millimeters. 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
EPV = The effective prestress value

(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 (kilonewtons)	Minimum Rated Hammer Energy (kilojoules)
≤800	14.0
1330	21.2
1600	28.1
1870	36.0
2140	44.9
2400	54.4
>2400	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 it will prevent transfer of torsional forces during driving while maintaining proper alignment of hammer and pile.

(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, 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 700 kilopascals at two 20-millimeter 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 1.5 meters 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.

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 0.5 meter 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 dynamic formula to determine ultimate pile capacity of the inplace pile unless the wave equation is required according to Subsection 551.03(b).

(a) Wave equation. Adequate penetration will be considered to be obtained when the specified wave equation resistance criteria is achieved within 1.5 meters 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:

$$Ru = (7\sqrt{E}\log(10N)) - 550$$

Where:

Ru = Ultimate pile capacity in kilonewtons
E = Manufacturer's rated hammer energy in joules at the ram stroke *observed or measured in the field*
$\log(10N)$ = logarithm to the base 10 of the quantity 10 multiplied by N
N = Number of hammer blows per 25 millimeters at final penetration

Solving for N:

$$N = 10^x$$

$$x = \left(\frac{Ru + 550}{7\sqrt{E}}\right) - 1$$

Factor of safety = 3.0

(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.
(d) The head of the pile is not broomed or crushed.

551.07 Preboring. Prebore holes to natural ground when piles are driven through compacted embankments more than 1.5 meters in depth. Use augering, wet rotary drilling, or other approved methods of preboring. Except for piles end-bearing on rock or hardpan, stop preboring at least 1.5 meters above the estimated pile tip elevation and drive the pile with an impact hammer to a penetration which achieves the required ultimate pile capacity. Preboring may extend to the surface of the rock or hardpan where piles are to be end-bearing on rock or hardpan. Seat the piles into the end-bearing strata.

Prebore holes smaller than the diameter or diagonal of the pile cross-section while allowing penetration of the pile to the specified depth. If subsurface obstructions such as boulders or rock layers are encountered, the hole diameter may be increased to the least dimension adequate for pile installation. Fill any void space remaining around the pile after completion of driving 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 so as not to damage other parts of the completed work.

Drive piles to within 50 millimeters of plan location at cutoff elevation for bent caps and within 150 millimeters of plan location for piles capped below finished ground. The pile shall not be closer than 100 millimeters to any cap face. Drive piles so that the axial alignment is within 20 millimeters per meter 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 1.5 meters 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 15 millimeters. Drive treated timber piles within 6 months after treatment. Handle and care for pressure-treated piles according to AWPA Standard M 4.

Carefully shape the pile tip to secure an even uniform bearing for the pile shoe. Fasten the shoe securely to the pile. Treat all holes, cuts, or caps in treated piles with 2-brush applications of creosote-coal tar solution.

(b) Steel piles. Furnish full-length, unspliced piles for lengths up to 18 meters. 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 3 meters 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. Load tests performed will be 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.

Protect the heads of concrete piles with a pile cushion at least 100 millimeters thick. Cut the pile cushion to match the cross-section of the pile top. Replace the pile cushion if it is either compressed more than one-half its original thickness or begins to burn. Provide a new pile cushion for each pile.

A concrete pile is rejected if it contains any defect that will affect the strength or long-term performance of the pile.

(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 prior to placing concrete in any of the shells or pipes. Do not drive pile shells or pipes within 5 meters 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. Submit drawings of proposed splices for acceptance. Use dowels or other acceptable mechanical means to splice precast concrete or precast prestressed concrete piles. 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 5 meters are driven. Re-drive all piles that heave more than 5 millimeters. 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 a shelter to protect the dynamic test equipment from the elements. Locate the shelter within 15 meters of the test location. Provide a shelter with a minimum floor size of 6 square meters and minimum ceiling height of 2 meters. Maintain the inside temperature between 10 and 35 °C.

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 1.2 by 1.2 meter rigid platform with a 1.1 meter safety rail that can be raised to the top of the pile.

Provide a suitable electrical power supply for the test equipment. If field generators are used as the power source, provide functioning meters for monitoring power voltage and frequency.

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 150 millimeters, a maximum of 50 blows, or to practical driving refusal, whichever occurs first. Practical driving refusal is defined as 15 blows per 25 millimeters for steel piles, 8 blows per 25 millimeters for concrete piles, and 5 blows per 25 millimeters 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 licensed professional engineer prepare the drawings.

(2) Furnish a loading system capable of applying 150 percent of the ultimate pile capacity or 9000 kilonewtons, 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 600 millimeters or less in diameter or diagonal width, the load that produces a settlement at failure of the pile head equal to:

$$S_f = S + (3.8 + 0.008D)$$

- For piles greater than 600 millimeters in diameter or diagonal width:

$$S_f = S + \frac{D}{30}$$

Where:

S_f = Settlement at failure in millimeters
D = Pile diameter or diagonal width in millimeters
S = Elastic deformation of pile in millimeters

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. Prior to testing, re-drive or jack to the original elevation any pile that heaves more than 6 millimeters.

After completion of the load testing, remove or cut off any test or anchor piling not a part of the finished structure at least 0.5 meter 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 will inhibit paint adhesion. Use aluminum colored paint system 2 according to Section 563. Paint portions of completed trestle or other exposed piling to a point not less than 1 meter below finished groundline or waterline with one shop prime coat and 2 shop finish coats. Shop coats applied in the field shall be applied before driving the pile. 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 150 millimeters 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 3-millimeter minimum diameter 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.
(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 3 meters 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 50 millimeters 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 3 meters 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
(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 piles by the meter or by the each. When measurement is by the meter, measure the length of pile from the cutoff elevation to the tip.

Measure pile load tests by the each or by the lump sum.

Measure preboring by the meter.

Measure splices required to drive piles in excess of the contract estimated tip elevation by the each.

Measure test piles by the meter or by the each.

Payment

551.17 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the concrete-filled pipe or steel shell pile 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 concrete-filled pipe or steel shell piles will be made at a price determined by multiplying the contract 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.

Payment will be made under:

Pay Item		Pay Unit
55101	____________ piles, in place	Meter
55102	____________ piles, in place	Each
55103	____________ pile load test	Each
55104	____________ pile load test	Lump sum
55105	Preboring	Meter
55106	Splices	Each
55107	Test piles	Meter
55108	Test piles	Each

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
Joint fillers and sealants	712.01
Latex modifier	711.04
Linseed oil	725.14
Portland cement	701.01
Silica fume (microsilica)	725.04
Water	725.01

Construction Requirements

552.03 Composition (Concrete Mix Design). Design and produce concrete mixtures that conform to Table 552-1 for the class of concrete specified. Determine design strength values according to ACI 214. Structural concrete shall also conform to the following ACI specifications.

- ACI 211.1 for normal and heavy mass concrete.
- ACI 211.2 for lightweight concrete.
- ACI 211.3 for no-slump concrete.

Table 552-1
Composition of Concrete

Class of Concrete	Minimum Cement Content (kg/m^3)	Maximum W/C Ratio	Slump(1) (mm)	Minimum Air Content(2) %	Coarse Aggregate AASHTO M 43
A	360	0.49	50 to 100		No. 57
A(AE)	360	0.44	25 to 100	5.0	No. 57
B	310	0.58	50 to 100		No. 357
B(AE)	310	0.58	50 to 100	4.0	No. 357
C	390	0.49	50 to 100		No. 7
C(AE)	390	0.44	25 to 75	6.0	No. 7
D(AE)(3)	360	0.40	25 to 75	4.0	No. 57
E(AE)(4)	360	0.40	100 to 150(5)	3.0	No. 7
P	390	0.44	0 to 100		No. 67
Seal	390	0.54	100 to 200		No. 57

(1) Maximum slump is 200 millimeters if approved mix design includes a high-range water reducer.
(2) See Subsection 552.03(t) for maximum air content.
(3) Concrete with a water reducing and retarding admixture conforming to AASHTO M 194 type D.
(4) A latex modified concrete with 0.31 liters of modifier per kilogram of cement.
(5) Measure the slump 4 to 5 minutes after the concrete is discharged from the mixer.

Submit concrete mix designs on FHWA Form 1608.

Verify mix designs with trial mixes prepared from the same source(s) proposed for use. 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.

(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 as follows in any mix design except for prestressed concrete:

(1) Fly ash.

(1) 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 cement.

(2) 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 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 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 cement.

The water/cement ratio for modified concrete is the ratio of the mass of water to the combined masses of portland cement and cement substitute.

(h) Cement content in kilograms per cubic meter of concrete.

(i) The saturated surface dry batch mass of the coarse and fine aggregate in kilograms per cubic meter of concrete.

(j) Water content (including free moisture in the aggregate plus water in the drum, exclusive of absorbed moisture in the aggregate) in kilograms per cubic meter of concrete.

(k) Target water/cement ratio.

(l) Dosage of admixtures. Entrained air may be obtained either by the use of an air-entraining portland cement or by the use of an air entraining admixture. Do not use set accelerating admixtures with class P (prestressed) concrete. Do not mix chemical admixtures from different manufacturers. Do not use high range water reducers for bridge decks.

(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 kilograms per cubic meter.

(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. In the absence of such acceptable documentation, the maximum air content shall be 10 percent.

(u) Concrete unit mass.

(v) Compressive strengths of 7 and 28-day concrete. Pending 28-day strength results, a mix design may be approved on the basis that the 7-day compressive strength results equal or exceed 85 percent of the minimum strength requirements when no accelerators or early strength cements are used.

(w) 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 25 millimeters 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 not less than 70 nor more than 100 revolutions of the drum or blades at mixing speed. Begin the count of mixing revolutions as soon as all material, including water, is in the mixer drum.

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. Use methods of delivering, handling, and placing that will 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.

(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.

Water and admixtures (if in the approved mix design) may be added at the project to obtain the required slump or air content, providing the total of all water in the mix does not exceed the maximum water/cement ratio and the concrete has not obtained an initial set. If additional water is necessary, add only once and remix with 30 revolutions at mixing speed. Complete the remixing within 45 minutes (75 minutes for type I, IA, II, or IIA cements with water reducing/retarding admixture) after the initial introduction of mixing water to cement or cement to aggregates.

After the beginning of the addition of the cement, complete the discharge of the concrete within the time specified in Table 552-2.

Table 552-2
Concrete Discharge Time Limits

Cement Type With and Without Admixtures	Time Limit (hour)
Type I, IA, II, or IIA	1.00
Type I, IA, II, or IIA with water reducing or retarding admixture	1.50
Type III	0.75
Type III with water reducing or retarding admixture	1.25

(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.

(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

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.

Sample every batch after at least 0.2 cubic meters are discharged and before placing any of the batch in the forms. When continuous mixing is used, sample approximately every 7.5 cubic meters. Test the air content according to AASHTO T 152 or AASHTO 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 of 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 10 and 30 °C, except maintain the concrete for bridge decks between 10 and 25 °C.

(a) Cold weather. Cold weather is defined as any time during the concrete placement or curing period the ambient temperature at the work site drops below 2 °C or the ambient temperature at the site drops below 10 °C for a period of 12 hours or more.

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. 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 will come into contact with fresh concrete shall be at least 2 °C and shall be maintained at a temperature of 2 °C 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 40 °C. 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 the concrete for at least 7 days at or above the minimum temperatures in Table 552-3.

Furnish and place continuously recording surface temperature measuring devices that are accurate within ±1 °C.

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 552-3. All protection may be removed when the concrete surface temperature is within 15 °C of the ambient air temperature.

Table 552-3
Cold Weather Concrete Surface Temperatures

Minimum section size dimension, mm	<300	300 - 900	900 - 1800	>1800
Minimum temperature of concrete during protection period	13 °C	10 °C	7 °C	4 °C
Maximum allowable temperature drop in any 24-hour period after end of protection	28 °C	22 °C	17 °C	11 °C

(b) Hot weather. Hot weather is any time during the concrete placement that the ambient temperature at the work site is above 35 °C.

In hot weather, cool all surfaces that will come in contact with the mix to below 35 °C. 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.

(3) Cool aggregate and/or water by refrigeration or replacing a portion or all of the mix water with flaked or crushed ice to the extent that the ice will completely melt during mixing of the concrete.

(c) Evaporation. When placing concrete in bridge decks or other exposed slabs, limit expected evaporation rate to less than 0.5 kilograms per square meter per hour as determined by Figure 552-1 or the following:

$$EVAP = \frac{1+0.2374WV}{2906} * \left[CT^2 - 4.762CT + 220.8 - RH * \left[\frac{AT^3 + 127.8AT^2 + 665.6AT + 34283}{20415} \right] \right]$$

Where:

EVAP	=	Evaporation rate (kg/m²/hr)
WV	=	Wind velocity (km/hr)
RH	=	Relative humidity (%)
AT	=	Air temperature ($^\circ$C)
CT	=	Concrete temperature ($^\circ$C)

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 will not cause segregation and will result in dense homogeneous concrete which 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.

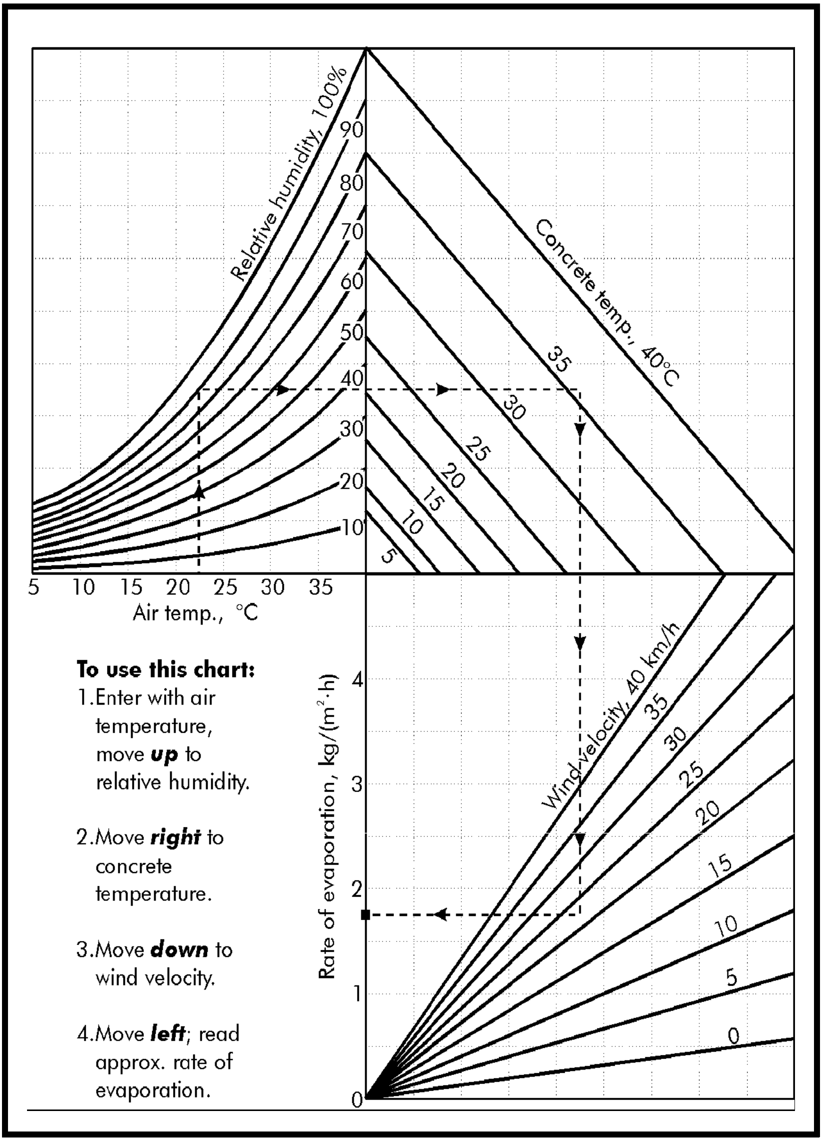

Figure 552-1
Evaporation Rate of Surface Moisture

Note: Example shown by dashed lines is for an air temperature of 22.5 °C, relative humidity of 90 percent, concrete temperature of 36 °C, and a wind velocity of 22.5 kilometers per hour. This results in a rate of evaporation of 1.75 kilograms per square meter per hour.

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.

(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 over 5 meters in height, allow the concrete to set for at least 4 hours before placing concrete for integral horizontal members. For vertical members less than 5 meters in height, allow the concrete to set for at least 30 minutes. Do not apply loads from horizontal members until the vertical member has attained its required strength.

(3) Superstructures. Do not place concrete in the superstructure until substructure forms have been stripped sufficiently to determine the acceptability of the supporting substructure concrete. Do not place concrete in the superstructure until the substructure has attained the required strength.

Place concrete for T-beams in 2 separate operations. Wait at least 5 days after stem placement before placing the top deck slab concrete.

Concrete for box girders may be placed in 2 or 3 separate operations consisting of bottom slab, girder webs, and top slab or as shown on the plans. However, place the bottom slab first and do not place the top slab until the girder webs have been in place for at least 5 days.

(4) Arches. Place concrete in arch rings so the centering is loaded uniformly and symmetrically.

(5) Box culverts. Place the base slab of box culverts and allow to set 24 hours before the remainder of the culvert is constructed. For sidewall heights of 1.5 meters or less, the sidewalls and top slab may be placed in one continuous operation. For sidewalls greater than 1.5 meters but less than 5 meters in height, allow sidewall concrete to set at least 30 minutes before placing concrete in the top slab. For sidewalls 5 meters or higher, allow sidewall concrete to set at least 12 hours before placing concrete in the top slab.

(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 0.5 meter 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 2 meters. 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 170 meters 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. The vibrators shall conform to Table 552-4. Provide rubber coated vibrators when epoxy coated reinforcement is used.

Table 552-4
Hand Held Vibratory Requirements

Head Diameter (millimeters)	Frequency (vibrations/minute)	Radius of Action (millimeters)
19 to 38	10 000 to 15 000	75 to 125
32 to 64	9 000 to 13 500	125 to 255
50 to 89	8 000 to 12 000	180 to 485

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.

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 250 millimeters 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 in accordance with Subsection 552.15(b). The curing period may be shortened, as approved, by using moist heat and/or type III 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.

At horizontal construction joints, place gauge strips inside the forms along all exposed faces to produce straight joint lines. Clean and saturate construction joints before placing fresh concrete. Keep joints saturated until adjacent fresh concrete is placed. Immediately before placing new concrete, draw forms tightly against previously placed concrete. Where accessible, thoroughly coat the existing surface with a very thin coating of cement mortar. Extend reinforcing bars across construction joints.

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 3 millimeters 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) Water stops. Construct water stops according to Section 560.

(e) 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.

(f) 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 which 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.

Finish all concrete surfaces used by traffic to a skid-resistant surface. Provide at least 2 suitable and adequate work bridges.

(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 oscillating screed. 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 50 millimeters below the finished surface and fill and finish any voids with fresh concrete. 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 3-meter metal straightedge. Overlap the straightedge at least half the length of the previous straightedge placement.

Correct deviations in excess of 3 millimeters from the testing edge of the straightedge. For deck surfaces that are to receive an overlay, correct deviations in excess of 6 millimeters.

(c) Texturing. 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 10 to 20 millimeters on centers. Make the grooves 2 to 5 millimeters wide and 3 to 5 millimeters deep. Groove perpendicular to the centerline without tearing the concrete surface or loosening surface aggregate.

If grooves are sawn, cut the grooves approximately 5 millimeters wide at a spacing of 15 to 25 millimeters.

On bridge decks, discontinue grooving 300 millimeters 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 3 millimeters 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 501.10, 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 5 millimeters of plan elevation. When a masonry plate is to be placed directly on the concrete or on filler material less than 5 millimeters 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 5 and 15 millimeters 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 2 millimeters.

When a masonry plate is to be set on filler material greater than 15 millimeters 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 portland 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 portland 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 or by applying a clear curing compound (type 1 or type 1-D) 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 150 millimeters and tightly seal all seams with pressure sensitive tape, mastic, glue, or other approved methods. Secure all material so that wind will 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 0.25 liter per square meter 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.

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.

(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 which 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 300 millimeters 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 1 meter that are visible from the traveled way. Finish for a distance inside the barrel at least equal to the height of the culvert.

(7) All surfaces of railings.

Complete a class 1 finish according to (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 set for at least 14 days. Protect adjacent surfaces that are not to be sandblasted. Sandblast the surface with hard, sharp sand to produce an even fine-grained surface in which the mortar is cut away leaving the aggregate exposed.

(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 0.5 by 1 meter 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 4 °C or higher and the air temperature in the shade is anticipated to be 4 °C 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.

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
(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 will withstand a sustained direct tension test load not less than the values shown in Table 552-5 for a period of at least 48 hours with movement not to exceed 1 millimeter. 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 552-5
Sustained Load Test Values

Anchorage Device Stud Size	Tension Test Load (kN)
M20	24.0
M16	18.3
M12	12.7
M8	7.1

Install concrete anchorage devices as recommended by the device manufacturer and so that the attached equipment or fixtures will bear firmly against the concrete. Torque installed nuts to the values specified in Table 552-6 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 to the load specified in Table 552-6 or according to the manufacturer's instructions.

Table 552-6
Torque for Anchorage Devices

Anchorage Device Stud Size	Torque (N·m)
M20	180
M16	130
M12	80
M8	30

552.18 Loads on New Concrete Structures. Do not place any loads on finished bents piers, or abutments until tests on concrete cylinders cast from the same concrete and cured under the same conditions as the substructure element indicate that the concrete has attained at least 80 percent of the specified minimum 28-day compressive strength. This restriction does not apply to placement of upper lifts for substructure elements cast in stages.

Do not allow vehicles or construction equipment on any span until concrete in the entire superstructure has attained its design compressive strength and has been in place 21 days.

For post-tensioned concrete structures, do not allow vehicles over 2000 kilograms on any span until the prestressing steel for that span is tensioned, grouted, and cured, the grout has obtained a strength of 21 megapascals, and the tie rods are tightened. Vehicles weighing less than 2000 kilograms may be permitted on a span provided the mass of the vehicle was included in the falsework design.

552.19 Acceptance. Material for concrete will be evaluated under Subsections 106.02 and 106.03. Furnish a production certification for the portland cement.

The concrete mixture's slump, air content, unit mass, and temperature will be evaluated under Subsections 106.02 and 106.04. See Table 552-1 for specification limits. See Table 552-7 for minimum sampling and testing.

Concrete compressive strength will be evaluated under Subsection 106.05. See Table 552-7 for minimum sampling and testing. 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. See Table 552-7 for the acceptance quality characteristic category.

Remove and replace concrete represented by cylinders having a compressive strength of less than 90 percent of the minimum 28-day compressive strength (f_c') and so located as to cause an intolerably detrimental effect on the structure.

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 structural concrete and seal concrete by the cubic meter in the structure.

Payment

552.21 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule except the structural concrete 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 a structural concrete will be made at a price determined by multiplying the contract unit bid price by the compressive strength pay factor.

Payment will be made under:

	Pay Item	**Pay Unit**
55201	Structural concrete class ___	Cubic meter
55202	Structural concrete class ___ for _*(description)*_	Cubic meter
55203	Structural concrete for _*(description)*_	Cubic meter
55204	Seal concrete for _*(description)*_	Cubic meter

Table 552-7
Sampling and Testing

Material or Product	Property or Characteristic	Category	Test Methods or Specifications	Frequency	Sampling Point
Concrete	Slump	—	AASHTO T 119	1 per load [2]	Discharge stream at point of placement [1]
	Air content	—	AASHTO T 152 or AASHTO T 196	1 per load [2]	Discharge stream at point of placement [1]
	Unit weight	—	AASHTO T 121	1 per load [2]	Discharge stream at point of placement [1]
	Temperature	—	Thermometer	First load	Discharge stream at point of placement [1]
	Making test specimens Compressive strength [4]	— II	AASHTO T 23 AASHTO T 22	1 set per 25 m^3 but not less than 1 set each day [3]	Discharge stream at point of placement [1]

(1) Sample according to AASHTO T 141 except composite samples are not required.
(2) See Subsection 552.09(b)(3).
(3) Cast at least 4 compressive strength test cylinders and carefully transport the cylinders to the job site curing facility.
(4) A single compressive strength test result is the average result from 2 cylinders cast from the same load and tested at 28 days.

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	725.22
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
(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 approved splice per pretensioning strand is permitted if the splice is between members in the casting bed. Splice so the strands have the same *"twist"* or *"lay."*

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.

553.05 Concrete. Construct prestressed concrete according to Section 552. Construct reinforcing steel according to Section 554.

Do not place concrete in the forms until the placement of reinforcing steel, prestressing steel, ducts, bearing plates, and other embedded material is approved. Place and vibrate concrete with care to avoid displacing the embedded material.

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.

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 ±3 °C) 150 to 200 millimeters from the top or bottom of the girder on its centerline and near its midpoint.
(c) Monitor with a recording sensor (accurate to ±3 °C) 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 38 °C during the first 2 hours after placing concrete and increase the temperature no more than 14 °C per hour to a maximum of 80 °C.
(f) Cool concrete, after curing is complete, no more than 14 °C per hour, to 38 °C.
(g) Keep the temperature of the concrete above 15 °C 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 150 millimeters in diameter.

Measure the force induced in the prestressing steel using jacking gauges and take elongation measurements of the prestressing steel. If there is a discrepancy of more than 7 percent between the measured elongation and that expected for the jacking force, check the entire operation, determine the reasons for the discrepancy, and correct before proceeding. Recalibrate jacking gauges if their readings do not agree within 5 percent of each other. 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 in prestressing steel 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 will 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, horizontal movement of abutments, and prestressing steel temperature changes between the time of tensioning and the time when the concrete takes its initial set.
Maintain the prestress bed forms, strands, and reinforcement bar temperature within 14 °C 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 will be 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 14 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 rigid, mortar tight, galvanized ferrous metal ducts fabricated with either welded or interlocked seams with sufficient strength to maintain correct alignment during concrete placement and with minimum wall thickness as follows:

(1) 0.55 millimeter for ducts $\leq$ 65 millimeter diameter
(2) 0.70 millimeter for ducts > 65 millimeter diameter
(3) 0.35 millimeter when bar tendons are preassembled with the duct

Make positive metallic joints between duct sections. Do not make angles at 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.

Provide all ducts or anchorage assemblies with metal pipes or other suitable connections for the injection of grout after prestressing.

Provide ducts with an inside diameter at least 10 millimeters larger than the nominal diameter of a single wire, bar, or strand tendon. For multiple wire, bar, or strand tendons, provide a duct cross-sectional area at least 2 times the net area of the prestressing steel. When tendons are to be placed by the pull-through method, provide a duct cross-sectional area at least 2.5 times the net area of the prestressing steel.

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. Cover the ends of ducts to prevent the entry of water or debris.

Vent all ducts for continuous structures at the high points of the duct profile. Make mortar tight vents with 13-millimeter minimum diameter standard pipe or suitable plastic pipe. Connect vents to ducts 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 50 millimeters 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 12 grams per liter. 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 a 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 6 millimeters 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 after concrete curing, stressing, and grouting are completed within 10 days after installation, 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. Bond all post-tensioned prestressing steel to the concrete by filling the void space between the duct and tendon with grout. Provide prestressing steel to be bonded to the concrete, which is free of dirt, loose rust, grease, or other deleterious substances.

Use grouting equipment capable of grouting at a pressure of at least 0.7 megapascals with a pressure gauge with a full-scale reading of not more than 2.1 megapascals. Fit grout injection pipes with positive mechanical shutoff valves. Fit vents and ejection pipes with valves, caps, or other devices capable of withstanding the pumping pressures.

Determine pumpability of the grout according to FLH T 502. The efflux time of a grout sample immediately after mixing shall not be less than 11 seconds. When hot weather conditions may cause quick setting of the grout, cool the grout by approved methods, as necessary, to prevent blockages during pumping operations. When freezing weather conditions are possible during and following placement of grout, protect the grout from damage by freezing according to PTI Post-Tensioning Manual *Recommended Practice for Grouting of Post-Tensioned Prestressed Concrete,* Section 3.3.7, 5th edition.

Provide standby flushing equipment capable of developing a pumping pressure of 1.7 megapascals 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.

Pass all grout through a screen with 2 millimeters maximum clear openings before entering the grout pump. Completely fill the duct from the low end with grout under pressure. 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 not less than 11 seconds.

Close all vents and openings and increase the grouting pressure at the injection end to at least 0.7 megapascals 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 25 millimeters below the roadway surface after grouting has been completed.

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.

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 25-millimeter 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.

Table 553-1
Prestressed Concrete Member Tolerances

Description	Tolerance
Precast Girders With Cast-In-Place Deck[1] Length	 ±10 mm/10 m, ±25 mm max.
Width (overall)	+10 mm, -5 mm
Depth (overall)	+15 mm, -5 mm
Depth (flanges)	-5 mm
Width (web)	+10 mm, -5 mm
Sweep[2]	3 mm/3 m
Variation from end squareness or skew	±15 mm/m, ±25 mm max.
Camber variation from design camber	±3 mm/3 m ±15 mm, max. ≤ 25 m length ±25 mm, max. > 25 m length
Position of strands: Individual Bundled Position from design location of deflection points for deflected strands	 ±5 mm - bundled ±15 mm ±500 mm
Position of plates other than bearing plates	±25 mm
Position of bearing plates	±15 mm
Tipping and flushness of plates	±5 mm
Tipping and flushness of bearing plates	±5 mm
Position of inserts for structural connections	±15 mm
Position of handling devices: Parallel to length Transverse to length	 ±150 mm ±25 mm
Position of stirrups: Longitudinal spacing Projection above top	 ±50 mm ±20 mm
Local smoothness[3]	±6 mm in 3 m 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	±20 mm
Width (overall)	±5 mm
Depth (overall)	±5 mm
Depth (top flange)	±15 mm
Depth (bottom flange)	+15 mm, -5 mm
Width (web)	±10 mm
Sweep [5] Up to 12 m member length 12 to 18 m member length Greater than 18 m member length	 ±5 mm ±10 mm ±15 mm
Variation from end squareness or skew Horizontal Vertical	±10 mm/m ±15 mm max. ±15 mm
Camber variation from design camber	±3 mm/3 m, ±15 mm max.
Differential camber between adjacent members of the same design	6 mm/3 m, 20 mm max.
Position of Strands: Individual Bundled Position from design location of deflection points for deflected strands	 ±5 mm ±5 mm 500 mm
Position of plates other than bearing plates	±25 mm
Tipping and flushness of plates	±5 mm
Position of inserts for structural connections	±15 mm
Position of handling devices: Parallel to length Transverse to length	 ±150 mm ±25 mm

(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	 ±25 mm +5 mm, -20 mm
Tipping of beam seat bearing area	±5 mm
Position of dowel tubes	±15 mm
Position of tie rod tubes: Parallel to length Vertical	 ±15 mm ±10 mm
Position of slab void: End of void to center of tie hole Adjacent to end block	 ±15 mm ±25 mm
Local smoothness (6)	±6 mm in 3 m any surface
Post-Tension Members	
Position of post tensioning ducts	±5 mm
Position of tendon anchorage bearing plates	±5 mm

(6) Does not apply to top surface left rough to receive a topping or to visually concealed surfaces.

553.11 Acceptance. 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 the following:

(a) Portland cement
(b) Prestressing steel
(c) Reinforcing steel

Grouting will be evaluated under Subsections 106.02 and 106.04. See Table 553-2 for sampling and testing requirements.

Concrete for precast, prestressed concrete members will be evaluated under Subsections 106.02, 106.03, and 106.04. See Tables 552-7 and 553-2 for sampling and testing requirements.

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 precast, prestressed structural concrete members by the each or by the meter. Do not measure reinforcing steel or concrete for precast, structural concrete members.

Measure prestressing system by the lump sum.

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, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
55301	Precast, prestressed concrete structural members _*(description)*_	Each
55302	Precast, prestressed concrete structural members _*(description)*_	Meter
55303	Prestressing system	Lump sum

Table 553-2
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Prestressed Concrete	Making test specimens Compressive strength	AASHTO T 23 AASHTO T 22	In addition to the test cylinders required to determine 28-day strength, cast 2 release cylinders for each concrete member. (2)	Discharge stream at point of placement (1)
Grout	Flow of grout mixture	FLH T 502	Each mixture	Each source

(1) Sample according to AASHTO T 141 except composite samples are not required.
(2) 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 millimeters or minus 6 millimeters. 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 284M. 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 50 millimeters or as recommended by the manufacturer. Provide a minimum 200-micrometer 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 0.5-meter 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 284M for patching damaged epoxy coatings.

554.08 Placing and Fastening. Support the bars on precast concrete blocks or metal supports according to the *Manual of Standard Practice of the Concrete Reinforcing Steel Institute.* 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 1.2 meters 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 38 millimeters of the required location. Do not cumulate spacing variations. The average of any two adjacent spaces shall not exceed the required spacing.

Provide 50 millimeters clear cover for all reinforcement except as otherwise shown on the plans.

Place reinforcing steel in deck slabs within 6 millimeters of the vertical plan location. Tie bridge deck reinforcing bars together at all intersections except where spacing is less than 300 millimeters 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 2 meters. 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 50 millimeters. 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 reinforcing steel by the kilogram excluding laps added for the Contractor's convenience.

Payment

554.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
55401	Reinforcing steel	Kilogram
55402	Epoxy coated reinforcing steel	Kilogram

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 270M grade 250 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 300 millimeters 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 will be correct. See Subsection 562.03 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 250 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
345	Green and Yellow
345W	Blue and Yellow
485W	Blue and Orange
690	Red
690W	Red and Orange

For other steels (except grade 250 steel) not shown in Table 555-1 or included in AASHTO M 160M, 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) which 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 0.25 millimeters. Use a tool that will make 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
3 mm	0.2 mm
5 mm	0.1 mm
6 mm	0.3 mm

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/or compressive stresses.

(2) Plate cut edges.

(a) Edge planing. Remove sheared edges on plates thicker than 15 millimeters to a depth of 5 millimeters 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 2 millimeters 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 2 millimeters.

(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 20 millimeters. Universal mill plate may be used provided its thickness does not exceed 25 millimeters. 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 10 millimeters. Bolted lateral gusset plates may be furnished with sheared edges provided the thickness is less than or equal to 20 millimeters.

(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 will be 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 2 millimeters 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 690 and 690W steels equal to about three times that for grade 250 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 650 °C, except for grades 690 and 690W. When grades 690 and 690W steel plates are heated to temperatures greater than 605 °C, requench and temper according to the producing mill's standard practice.

Table 555-3
Minimum Bending Radii

Plate Thickness - (t) (mm)	**Bending Radius** [1]
≤ 13	2(t)
Over 13 to 25	2.5(t)
Over 25 to 38	3(t)
Over 38 to 64	3.5(t)
Over 64 to 102	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 10 millimeters.

(e) Facing of bearing surfaces. Finish bearing and 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 Surface	Surface Roughness Value (μm)
Steel slabs	50
Heavy plates in contact in shoes to be welded	25
Milled ends of compression members, milled or ground ends of stiffeners and fillers	13
Bridge rollers and rockers	6
Pins and pin holes	3
Sliding bearings	3

Machine sliding bearings that have a surface roughness greater than 2 micrometers according to ANSI 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 1 millimeter. 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 will 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 485W, 690, and 690W steel members.

Table 555-5
Heat Straightening Temperatures

Material to be Straightened	Maximum Temperature
Grade 485W > 150 mm from weld	580 °C
Grade 485W < 150 mm from weld	480 °C
Grade 690 or 690W > 150 mm from weld	605 °C
Grade 690 or 690W < 150 mm from weld	510 °C

In all the other steels, do not exceed 650 °C 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 will differ by more than 60 °C at any one time.

Do not anneal or normalize members of grades 690/690W or 485W 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 690/690W and grade 485W steels is 605 °C and 580 °C, 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 2 millimeters larger than the nominal diameter of the bolts where the thickness of the material is not greater than 20 millimeters for structural steel, 15 millimeters for high-strength steel, or 15 millimeters 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 20 millimeters for structural steel, 15 millimeters for high-strength steel, or 15 millimeters 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) 5 millimeters smaller and, after assembling, ream 2 millimeters larger or drill full size to 2 millimeters larger than the nominal diameter of the bolts.

(a) Punched holes. Use a die diameter that is not more than 2 millimeters 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 millimeter 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 millimeter 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 3 millimeters 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 5 millimeters 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 millimeter.

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/or 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 225 millimeters in diameter. Pins and rollers 225 millimeters or less in diameter may be either forged and annealed or cold-finished carbonsteel shafting.

In pins larger than 225 millimeters in diameter, bore a hole not less than 50 millimeters 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 0.50 millimeter for pins 125 millimeters or less in diameter, or by 1 millimeter 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 millimeter 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 35 millimeters or more, provide six threads per 25 millimeters.

555.12 Eyebars. Pin holes may be flame cut at least 50 millimeters 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 5.25 millimeters per meter.

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 6 meters, 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 assure accurate alignment) plus 2 or more sections or panels added at the advancing end. For structures longer than 50 meters, make each assembly not less than 50 meters 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 assure proper fit in the field. Provide a diagram showing such matchmarks.

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 3 micrometers. 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 2 millimeters 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 164M or AASHTO M 253M 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 25 millimeters, 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 to protected storage fasteners not used 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 which 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)

Nominal Bolt Diameter and Tread Pitch	AASHTO M 164M (kilonewtons)	AASHTO M 253M (kilonewtons)
M16 × 2	91	114
M20 × 2.5	142	179
M22 × 2.5	176	221
M24 × 3	205	257
M27 × 3	267	334
M30 × 3.5	326	408
M36 × 4	475	595

(1) Equal to 70 percent of the specified minimum tensile strength of bolts (as specified for tests of full size ASTM A 325M and ASTM A 490M bolts) rounded to the nearest kilonewton.

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 253M fasteners and galvanized AASHTO M 164M fasteners. If approved, other AASHTO M 164M 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)

	Geometry of Outer Faces of Bolted Parts		
Bolt Length Measured from Underside of Head to End of Bolt	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 diameters(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 ±30° for bolts installed by 1/2 turn or less. The tolerance is ±45° 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 ASTM A 325M Test Methods 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 which 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:

$$\text{Torque} = \frac{PD}{4000}$$

Where:

Torque = Measured torque in newton meters
P = Measured bolt tension in newtons
D = Nominal bolt diameter in millimeters

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 bevelled 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 of the bolt diameter from the center of the washer.

Hardened washers are not required for connections using AASHTO M 164M and AASHTO M 253M 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 253M bolts are installed in material having a specified yield point less than 275 megapascals regardless of the tightening method.

(c) Use a hardened washer conforming to ASTM F 436M where AASHTO M 164M bolts of any diameter or AASHTO M 253M 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 436M, except with 8 millimeter minimum thickness, under both the head and the nut in lieu of standard thickness hardened washers where AASHTO M 253M bolts over M24 are to be installed in an oversize or shortslotted hole in an outer ply. Multiple hardened washers with a combined thickness equal to or greater than 8 millimeters do not satisfy this requirement.

(e) Where AASHTO M 164M bolts of any diameter or AASHTO M 253M bolts equal to or less than M24 are installed in a long-slotted hole in an outer ply, provide a plate washer or continuous bar of at least 8-millimeter 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 253M bolts over M24 are used in long-slotted holes in external plies, use a single hardened washer conforming to ASTM F 436M with an 8-millimeter minimum thickness in lieu of washers or bars of structural grade material. Multiple hardened washers with combined thickness equal to or greater than 8 millimeters 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 436M 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. Then tighten all fasteners systematically from the most rigid part of the connection to the free edges in a manner that will minimize 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 will minimize 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 which 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 30 millimeters at a 300-millimeter 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.

(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 will 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 will produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing as necessary during erection to provide stability and assure 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 millimeter larger than the bolts.

(e) Pin connections. Use pilot and driving nuts in driving pins. Drive the pins so that the members will 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 the following:

(a) Structural steel
(b) Steel forgings
(c) 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 structural steel by the kilogram 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.

If the quantity shown in the bid schedule is a contract quantity as defined in Subsection 109.02(a), 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, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
55501 Structural steel *(description)* furnished, fabricated, and erected	Kilogram

Section 556.) BRIDGE RAILING

Description

556.01 This work consists of furnishing and erecting and 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 alloy 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 10 millimeters 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.

If required, galvanize according to AASHTO M 111 and furnish nuts, bolts and washers galvanized according to AASHTO M 232. Repair minor abrasions with zinc rich paint.

For exposed weathering steel, use railing fasteners, railing hardware, rail post anchor bolts, nuts, washers, and shims with the same atmospheric corrosion resistance and weathering characteristics as the railing and posts. Use hand methods to clean erected steel railing of all oil, dirt, grease, mortar, and other foreign substances. Use weld metal with similar atmospheric corrosion resistance and coloring characteristics as the base metal. Clean welds by power brushing or blast cleaning to remove welding flux, slag, and spatter.

Unless a coating is required, clean all weathering steel according to SSPC-SP6 and remove all mill scale and other foreign substances so that the steel surface is uniformly exposed to the atmosphere.

556.06 Aluminum Railing. Construct according to Section 555 except as amended by the following.

(a) Cutting. Material that is 13 millimeters thick or less may be cut by shearing, sawing, or milling. Saw or mill material that is over 13 millimeters 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 200 °C 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.
(2) Fabricate anchor bolt holes up to 25 percent larger, not to exceed 15 millimeters 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.

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 bridge railing by the meter or by the lump sum.

Measure remove and reset bridge railing by the meter.

When bridge railing is measured by the meter, measure along the top of the railing.

Payment

556.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	**Pay Unit**
55601 __________ bridge railing	Meter
55602 __________ bridge railing	Lump sum
55603 Remove and reset bridge railing	Meter

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	
Treated structural timber and lumber		716.03
Untreated structural timber and lumber		716.01

Construction Requirements

557.03 General. Perform excavation and backfill work under 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 200 millimeters 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.

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.

Treat all cuts and abrasions in timber or lumber with 3 brush coats of the same type of preservative used in the original treatment.

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 Untreated Timber. Coat the following untreated timber surfaces according to AWPA Standard M4:

(a) Ends, tops, and all contact surfaces of posts, sills, and caps
(b) Ends, joints, and contact surfaces of bracing and truss members
(c) Surfaces of timber bumpers and the back faces of bulkheads
(d) Other timber that will be in contact with earth

557.06 Holes for Bolts, Dowels, Rods, and Lag Screws. Bore all holes before preservative treating the wood. Bore holes for round driftbolts and dowels 2 millimeters smaller in diameter than that of the bolt or dowel to be used. The diameter of holes for square driftbolts or dowels shall be equal to the side dimension of the bolt or dowel.

Bore holes for machine bolts with a bit of the same diameter as that of the bolt. Bore holes for lag screws with a bit not larger than the body of the screw at the base of the thread. Drill depth of lag screw bolt holes 25 millimeters less than length under screw head.

557.07 Bolts and Washers. Use washers under all bolt heads or nuts in contact with wood. Use cast-iron washers when the timber is in contact with the ground. Burr threads or check nuts with a pointed tool after final tightening.

557.08 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.

557.09 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.

557.10 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 150 millimeters 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 150 millimeters. Where possible, remove all earth in contact with sills for circulation of air around the sills.

557.11 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 230 millimeters.

557.12 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 25 millimeters out of line when bracing bolts are tightened.

Where the space between the bracing and cap or pile is less than 25 millimeters, shims need not be used. Where the space between the bracing and the cap or pile is 40±15 millimeters, place 2 ogee washers with their narrow faces together or other approved washers on each bolt which passes through the space.

Where the space between the bracing and the cap or pile is over 55 millimeters, 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 100 millimeters 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.

557.13 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 15 millimeters 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.

557.14 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 5 millimeters 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 2 millimeters.

Two-ply timber floors consist of 2 layers of flooring supported on stringers. Pressure treat the lower layer with creosote oil. 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 1 meter. Where the top layer is placed parallel to the centerline of the roadway, use special care to securely fasten the ends of the flooring. Bevel the ends of top layer members at each end of the structure.

557.15 Transversely Nail-Laminated Decks. Use 50 millimeters nominal thickness laminations, surface one edge hit or miss 3 millimeters scant (SIE-H or M 3 millimeter scant), and one side hit or miss 3 millimeter scant (SIS-H or M 3 millimeter 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 450-millimeter 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, toenail every other piece to every other stringer. Use the size spikes required. 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.

557.16 Wheel Guards and Railings. Surface (S4S) wheel guards, rails, and posts. Place wheel guards in sections not less than 4 meters in length. Squarely butt-joint all rails at posts.

557.17 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.

557.18 Drains. Hot-dip galvanize drains, including anchorages, after fabrication.

557.19 Painting. When paint is specified in the contract, paint according to Section 563.

557.20 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

557.21 Measure untreated and treated structural timber and lumber by the cubic meter 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

557.22 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	Pay Unit
55701	Untreated structural timber and lumber	Cubic meter
55702	Treated structural timber and lumber	Cubic meter

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 7 $^{\circ}$C or higher.

Apply primer to the surface and allow it to dry. Apply 2 coats of asphalt at the rate of approximately 1.25 kilograms per square meter 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 2 millimeters 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 dampproofing by the square meter or by the lump sum. When measurement is by the square meter, measure the visible surface area dampproofed.

Payment

558.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
55801 Dampproofing	Square meter
55802 Dampproofing	Lump sum

Section 559.) WATERPROOFING

Description

559.01 This work consists of waterproofing concrete surfaces with a firmly bonded membrane and when specified, protected 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 150 and 175 °C. 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 100 millimeters. Continue this process of lapping each strip of fabric at least 100 millimeters over the strip placed before the last strip until the entire surface is covered with 2 layers of fabric. Lap the ends at least 300 millimeters. 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 5 liters per square meter of finished horizontal surface and not less than 6 liters per square meter 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 300 millimeters. Seal flashing with either a metal counterflashing or by embedding the upper edges of the flashing in a groove joint filler.

Provide approved water stops for expansion joints, both horizontal and vertical, according to Section 560. Install membrane across all expansion joints as required.

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.

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 50-millimeter thick mortar course reinforced with 152-millimeter by 152 millimeter welded wire reinforcement (MW34.9 X MW34.9) 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 waterproofing by the square meter or by the lump sum. When measurement is by the square meter, measure the visible surface area waterproofed.

Payment

559.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement, for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
55901	Membrane waterproofing	Square meter
55902	Membrane waterproofing	Lump sum
55903	Membrane waterproofing with type ___ protection	Square meter
55904	Membrane waterproofing with type ___ protection	Lump sum

Section 560.) WATER STOPS

Description

560.01 This work consists of furnishing and installing water stops in expansion and construction joints.

Water stops are designated as copper, plastic, or rubber.

Material

560.02 Conform to the following Subsections:

Copper water stops	712.06
Plastic water stops	712.08
Rubber water stops	712.07

Construction Requirements

560.03 Copper Water Stops. Use copper sheet of the thickness, mass, width, and shape required. Solder joints for a continuous watertight unit.

560.04 Rubber Water Stops. Before installation, submit for approval the following:

(a) Performance test data
(b) One-meter sample of each type of water stop required
(c) At least one preliminary field splice if splices are used

Form water stops with a cross-section that is uniform in width and web thickness. Do not splice straight strips.

Full-mold all junctions in the special connection pieces. Provide well-cured, dense, homogeneous special connection pieces that are nonporous and are free from other defects.

Fabricate splices that are dense and homogeneous throughout the cross-section. Fabricate splices watertight by vulcanizing or by mechanical means. Fabricate splices so they have a tensile strength of at least 50 percent of the reported tensile strength of the unspliced rubber water stop.

560.05 Plastic Water Stops. Before installation, submit for approval at least one preliminary field splice sample. Heat splices according to the manufacturer's instructions to make them watertight. Fabricate splices so they have a tensile strength of at least 80 percent of the reported tensile strength of the unspliced plastic water stop.

560.06 Placing Water Stops. Carefully place and support water stops. Prevent water stops from being displaced or damaged by construction operations or other activities. Keep all surfaces of water stops free from oil, grease, dried mortar, or any other deleterious material until embedded in concrete. Ensure that embedded portions of the water stop are completely enclosed in dense concrete.

560.07 Acceptance. Material for water stops will be evaluated under Subsections 106.02 and 106.03.

Installing water stops will be evaluated under Subsections 106.02 and 106.04.

Measurement

560.08 Measure water stops by the meter or by the lump sum.

Payment

560.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
56001 ________ water stop, _____ width	Meter
56002 ________ water stop	Lump sum

Section 561.) STRUCTURAL CONCRETE BONDING

Description

561.01 This work consists of repairing cracks in concrete structures by pressure injecting epoxy.

Material

561.02 Conform to the following Subsections:

Epoxy resin adhesives	725.21
Polymer grout	725.22

Construction Requirements

561.03 Crack Preparation. Provide notice of crack sealing at least 14 days before beginning work. The work areas will be identified and the locations of the cracks to be repaired will be marked.

Remove all dirt, laitance, and other debris from the exterior and interior of cracks. Apply a temporary surface seal material to the face of cracks. Use surface seal material with sufficient strength and adhesion to confine the injected epoxy material until cured.

Provide openings (entry ports) in the surface seal along the crack. Make the distance between entry ports at least the thickness of the concrete member being repaired.

After the injection adhesive has cured, remove the surface seal. Finish face of the crack and entry ports flush with the adjacent surface.

561.04 Injection Procedures. Begin injecting epoxy at the lowest entry port. Continue injection at the first port until epoxy begins to flow out of the next highest port. Plug the first port and inject epoxy in the second port until the epoxy flows from the next highest port. Continue this sequence until the entire crack is filled. Use a 2-component epoxy system. Maintain the mix ratio for the epoxy as prescribed by the manufacturer within 5 percent by volume at any discharge pressure not to exceed 1.4 megapascals. Do not use solvents to thin the epoxy.

Use positive inline displacement type equipment to meter, mix, and inject the epoxy at pressures not to exceed 1.4 megapascals.

(a) Test for proper ratio. Perform this test for each injection unit at the beginning and at the end of every day that the unit is used. Disconnect the mixing head of the injection equipment and pump the 2 adhesive components through a ratio check device with 2 independent valved nozzles capable of controlling flow rate and back pressure by opening or closing valves on the check device. Use a pressure gauge capable of sensing back pressure behind each valve to adjust the discharge pressure to 1.4 megapascals for both epoxy components. Simultaneously discharge both epoxy components into separate calibrated containers. Compare the discharged amounts to determine the mix ratio.

After the test is completed at 1.4 megapascals discharge pressure, repeat the procedures for zero-megapascal discharge pressure.

(b) Test for pressure check. Perform this test for each injection unit at the beginning and at the end of every day that the unit is used.

Disconnect the mixing head of the injection equipment and attach the 2 adhesive component delivery lines to a pressure check device with 2 independent valved nozzles capable of controlling flow rate and pressure by opening or closing the valves. Use a pressure gauge capable of sensing the pressure build-up behind each valve. Close the valves on the pressure-check device and operate the equipment until the gauge pressure on each line reads 1.4 megapascals. When the pumps are stopped, the gauge pressure must not drop below 1.3 megapascals within 3 minutes.

(c) Records. Maintain and make available complete and accurate records of the ratio check tests and the pressure check tests. Additional ratio and pressure check tests may be required.

561.05 Coring. Take one 50 millimeters diameter test core according to AASHTO T 24 for every 15 meters of repaired crack at designated locations. The crack repair is acceptable if the core sample indicates that 90 percent or more of the crack has been successfully bonded.

When a test core shows that the epoxy bonding has penetrated less than 90 percent of the crack volume within the core sample, redo that 15-meter crack segment or the segment that the core represents and resample. Repeat this procedure until acceptable crack repair is achieved.

Fill all sample core holes with polymer grout and finish the surface to match the adjacent concrete.

561.06 Acceptance. Material for structural concrete bonding will be evaluated under Subsections 106.02 and 106.03.

Structural concrete bonding work will be evaluated under Subsections 106.02 and 106.04. See Table 561-1 for sampling and testing requirements. Crack repair will be evaluated according to Subsection 561.05.

Measurement

561.07 Measure crack preparation by the meter or by the lump sum.

Measure structural concrete bonding by the meter, by the liter, or by the lump sum.

When measurement is by the meter, measure the actual meters of surface crack acceptably repaired.

When measurement is by the liter, measure the actual number of liters of bonding material injected in the marked cracks that are acceptably repaired.

Payment

561.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
56101	Structural concrete bonding	Meter
56102	Structural concrete bonding	Liter
56103	Structural concrete bonding	Lump sum
56104	Crack preparation	Meter
56105	Crack preparation	Lump sum

Table 561-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Repaired concrete	50-mm diameter test core	AASHTO T 24	1 for every 15 meters of repaired crack.	Repaired crack

Section 562.) FORMS AND FALSEWORK

Description

562.01 This work consists of designing, constructing, and removing forms and falsework to temporarily support concrete, girders, and other structural elements until the structure is completed to the point it can support itself.

Design and Construction Requirements

562.02 Drawings. When complete details for forms and falsework are not shown, prepare and submit drawings according to Subsection 104.03. Show the following, as applicable:

(a) Design and show the details for constructing safe and adequate forms and falsework that provide the necessary rigidity, support the loads imposed, and produce in the finished structure the required lines and grades. See Subsection 562.03 for design loads. See Subsection 562.04 for design stresses, loadings, and deflections. See Subsection 562.05 for manufactured assemblies.

(b) Show the maximum applied structural load on the foundation material. Include a drainage plan or description of how foundations will be protected from saturation, erosion, and/or scour. See Subsection 562.06.

(c) Precisely describe all proposed material. Describe the material that is not describable by standard nomenclature (such as AASHTO or ASTM specifications) based on manufacturer's tests and recommended working loads. Evaluate falsework material and ascertain whether the physical properties and conditions of the material is such that it can support the loads assumed in the design.

(d) Furnish design calculations and material specifications showing that the proposed system will support the imposed concrete pressures and other loads. Provide an outline of the proposed concrete placement operation listing the equipment, labor, and procedures to be used for the duration of each operation. Include proposed placement rates and design pressures for each pour. Include a superstructure placing diagram showing the concrete placing sequence and construction joint locations.

(e) Provide design calculations for proposed bridge falsework. A registered professional engineer proficient in structural design shall design, sign, and seal the drawings. The falsework design calculations shall show the stresses and deflections in load supporting members.

(f) Show anticipated total settlements of falsework and forms. Include falsework footing settlement and joint take-up. Design for anticipated settlements not to exceed 25 millimeters. Design and detail falsework supporting deck slabs and overhangs on girder bridges so there is no differential settlement between the girders and the deck forms during placement of deck concrete. Design and construct the falsework to elevations that include anticipated settlement during concrete placement and required camber to compensate for member deflections during construction.

(g) Show the support systems for form panels supporting concrete deck slabs and overhangs on girder bridges.

(h) Show details for strengthening and protecting falsework over or adjacent to roadways and railroads during each phase of erection and removal. See Subsection 562.07.

(i) Include intended steel erection procedures with calculations in sufficient detail to substantiate that the girder geometry will be correct. See Subsection 562.08.

(j) Submit details of proposed anchorage and ties for void forms. See Subsection 562.10 for void form requirements.

Submit separate falsework drawings for each structure, except for identical structures with identical falsework design and details. Do not start construction of any unit of falsework until the drawings for that unit are reviewed and accepted.

562.03 Design Loads.

(a) Vertical design loads. Dead loads include the mass of concrete, reinforcing steel, forms, and falsework. Consider the entire superstructure, or any concrete mass being supported by falsework to be a fluid dead load with no ability to support itself. If the concrete is to be prestressed, design the falsework to support any increased or readjusted loads caused by the prestressing forces.

Assume the density of concrete, reinforcing steel, and forms to be not less than 2600 kilograms per cubic meter for normal concrete and not less than 2100 kilograms per cubic meter for lightweight concrete.

Consider live loads to be the actual mass of equipment to be supported by falsework applied as concentrated loads at the point of contact plus a uniform load of not less than 1000 pascals applied over the area supported, plus 1100 newtons per meter applied at the outside edge of deck falsework overhangs.

The total vertical design load for falsework is the sum of vertical dead and live loads. Use a total vertical design load of not less than 4800 pascals.

(b) Horizontal design loads. Use an assumed horizontal design load on falsework towers, bents, frames, and other falsework structures to verify lateral stability. The assumed horizontal load is the sum of the actual horizontal loads due to equipment, construction sequence, or other causes and an allowance for wind. However, in no case is the assumed horizontal load to be less than 2 percent of the total supported dead load at the location under consideration.

The minimum wind allowance for each heavy-duty steel shoring having a vertical load carrying capacity exceeding 130 kilonewtons per leg is the sum of the products of the wind impact area, shape factor, and the applicable wind pressure value for each height zone. The wind impact area is the total projected area of all the elements in the tower face normal to the applied wind. Assume the shape factor for heavy-duty shoring to be 2.2. Determine wind pressure values from Table 562-1.

The minimum wind allowance on all other types of falsework, including falsework supported on heavy-duty shoring, is the sum of the products of the wind impact area and the applicable wind pressure value for each height zone. The wind impact area is the gross projected area of the falsework and unrestrained portion of the permanent structure, excluding the areas between falsework posts or towers where diagonal bracing is not used. Use design wind pressures from Table 562-2.

Design the falsework so it has sufficient rigidity to resist the assumed horizontal load without vertical dead load. Neglect the effects of frictional resistance.

Table 562-1
Design Wind Pressure - Heavy Duty Steel Shoring

Height Zone Above Ground meter	Wind Pressure Value - Pa	
	Adjacent To Traffic	At Other Locations
0	960	720
9 -15	1200	960
15 - 30	1450	1200
Over 30	1675	1450

Table 562-2
Design Wind Pressure - Other Types of Falsework

Height Zone Above Ground meter	Wind Pressure Value - Pa	
	For Members Over and Bents Adjacent To Traffic Openings	At Other Locations
0	320 Q	240 Q
9 - 15	400 Q	320 Q
15 - 30	480 Q	400 Q
Over 30	560 Q	480 Q

Note: $Q = 0.3 + 0.2W$, but not more than 3. W is the width of the falsework system in meters measured in the direction of the wind force being considered.

(c) Lateral fluid pressure. For concrete with retarding admixture, fly ash, or other pozzolan replacement for cement, design forms, form ties, and bracing for a lateral fluid pressure based on concrete with a density of 2400 kilograms per cubic meter. For concrete containing no pozzolans or admixtures, which affect the time to initial set, determine the lateral fluid pressure based on concrete temperature and rate of placement according to ACI standard 347R, *Guide for Formwork for Concrete.*

562.04 Design Stresses, Loads, and Deflections. The allowable maximum design stresses and loads listed in this section are based on the use of undamaged, high-quality material. If lesser quality material is used, reduce the allowable stresses and loads. Do not exceed the following maximum stresses, loads, and deflections in the falsework design:

(a) Timber.

Compression perpendicular to the grain = 3100 kilopascals

Compression parallel to the grain [(1)] = $\dfrac{3309}{(L/d)^2}$ megapascals

Note: (1) Not to exceed 11 megapascals.

Where:

L = Unsupported length
d = Least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns

Flexural stress = 12.4 megapascals

Note: Reduced to 10 megapascals for members with a nominal depth of 200 millimeters or less.

Horizontal shear = 1300 kilopascals

Axial tension = 8.3 megapascals

Deflection due to the mass of concrete may not exceed 1/500 of the span even if the deflection is compensated for by camber strips.

Modulus of elasticity (E) for timber = 11.7 gigapascals

Maximum axial loading on timber piles = 400 kilonewtons

Design timber connections according to the stresses and loads allowed in the *National Design Specification for Wood Construction*, as published by the National Forest Products Association except:

(1) Reductions in allowable loads required therein for high moisture condition of the lumber and service conditions do not apply.

(2) Use 75 percent of the tabulated design value as the design value of bolts in two member connections (single shear).

(b) Steel. For identified grades of steel, do not exceed the design stresses (other than stresses due to flexural compression) specified in the *Manual of Steel Construction* as published by the AISC.

When the grade of steel cannot be positively identified, do not exceed the design stresses, other than stresses due to flexural compression, either specified in the AISC Manual for ASTM A 36M steel or the following:

Tension, axial and flexural = 150 megapascals

Compression, axial = 110 000 - 2.6(L/r)^2 kilopascals

Note: L/r shall not exceed 120.

Shear on the web gross section of rolled shapes = 100 megapascals

Web crippling for rolled shapes = 185 megapascals

For all grades of steel, do not exceed the following design stresses and deflection:

Compression, flexural (1) = $\frac{82\ 750}{Ld/bt}$ megapascals

Note: (1) Not to exceed 150 megapascals for unidentified steel or steel conforming to ASTM A 36. Not to exceed 0.6 F_y for other identified steel.

Where:

L = Unsupported length.
d = Least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns or the depth of beams.
b = Width of the compression flange.
t = Thickness of the compression flange.
r = Radius of gyration of the member.
F_y = Specified minimum yield stress for the grade of steel used.

Deflection due to the mass of concrete may not exceed 1/500 of the span even if the deflection is compensated for by camber strips.

Modulus of elasticity (E) for steel = 210 gigapascals

(c) Other requirements. Limit falsework spans supporting T-beam girder bridges to 4.3 meters plus 8.5 times the overall depth of T-beam girder.

562.05 Manufactured Assemblies. For jacks, brackets, columns, joists and other manufactured devices, do not exceed the manufacturer's recommendations or 40 percent of the ultimate load carrying capacity of the assembly based on the manufacturer's tests or additional tests ordered. Limit maximum allowable dead load deflection of joists to 1/500 of their spans.

Furnish catalog or equivalent data showing the manufacturer's recommendations or perform tests, as necessary, to demonstrate the adequacy of any manufactured device proposed for use. Do not substitute other manufacturer's components unless the manufacturer's data encompasses such substitutions or field tests reaffirm the integrity of the system.

If a component of the falsework system consists of a steel frame tower exceeding 2 or more tiers high, the differential leg loading within the steel tower unit shall not exceed 4 to 1. An exception may be approved if the manufacturer of the steel frame certifies, based on manufacturer's tests, that the proposed differential loadings are not detrimental to the safe load carrying capacity of the steel frame.

562.06 Falsework Foundations. Field verify all ground elevations at proposed foundation locations before design.

Where spread footing type foundations are used, determine the bearing capacity of the soil. The maximum allowable bearing capacity for foundation material, other than rock, is 190 kilopascals.

Do not locate the edge of footings closer than 300 millimeters from the intersection of the bench and the top of the slope. Unless the excavation for footings is adequately supported by shoring, do not locate the edge of the footings closer than 1.2 meters or the depth of excavation, whichever is greater, from the edge of the excavation.

When a pile-type foundation is used, use according to Section 551. When falsework is supported by footings placed on paved, well-compacted slopes of berm fills, do not strut the falsework to columns unless the column is founded on rock or supported by piling.

Size spread footings to support the footing design load at the assumed bearing capacity of the soil without exceeding anticipated settlements. Provide steel reinforcement in concrete footings.

When individual steel towers have maximum leg loads exceeding 130 kilonewtons, provide for uniform settlement under all legs or each tower under all loading conditions.

Protect the foundation from adverse effects for the duration of its use. Advise the CO of actions that will be taken to protect the foundation.

562.07 Falsework Over or Adjacent to Roadways and Railroads. Design and construct the falsework to be protected from vehicle impact. This includes falsework posts that support members crossing over a roadway or railroad and other falsework posts if they are located in the row of falsework posts nearest to the roadway or railroad and if the horizontal distance from the traffic side of the falsework to the edge of pavement or to a point 3 meters from the centerline of track is less than the total height of the falsework.

Provide additional features to ensure that this falsework will remain stable if subjected to impact by vehicles. Use vertical design loads for these falsework posts, columns, and towers (but not footings) that are greater than or equal to either of the following:

(a) 150 percent of the design load calculated according to Subsection 562.03, but not including any increased or readjusted loads caused by prestressing forces

(b) the increased or readjusted loads caused by prestressing forces

Install temporary traffic barriers before erecting falsework towers or columns adjacent to an open public roadway. Locate barriers so that falsework footings or pile caps are at least 75 millimeters clear of concrete traffic barriers and all other falsework members are at least 300 millimeters clear. Do not remove barriers until approved.

Use falsework columns that are steel with a minimum section modulus about each axis of 156 000 cubic millimeters or sound timbers with a minimum section modulus about each axis of 4 100 000 cubic millimeters.

Mechanically connect the base of each column or tower frame supporting falsework over or immediately adjacent to an open public road to its supporting footing or provide other lateral restraint to withstand a force of not less than 9 kilonewtons applied to the base of the column in any direction. Mechanically connect such columns or frames to the falsework cap or stringer to resist a horizontal force of not less than 4.5 kilonewtons in any direction. Neglect the effects of frictional resistance.

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.

Mechanically connect all exterior falsework stringers and stringers adjacent to the end of discontinuous caps, the stringer or stringers over points of minimum vertical clearance and every fifth remaining stringer, to the falsework cap or framing. Provide mechanical connections capable of resisting a load in any direction, including uplift on the stringer, of not less than 2.2 kilonewtons. Install connections before traffic is allowed to pass beneath the span.

Use 16 millimeters diameter or larger bolts to connect timber members used to brace falsework bents located adjacent to roadways or railroads.

Sheath falsework bents within 6 meters of the centerline of a railroad track solid in the area between 1 and 5 meters above the track on the side facing the track. Construct sheathing of plywood not less than 16 millimeters thick or lumber not less than 25 millimeters nominal thickness. Provide adequate bracing on such bents so that the bent resists the required assumed horizontal load or 22 kilonewtons, whichever is greater, without the aid of sheathing.

Provide at least the minimum required vertical and horizontal clearances through falsework for roadways, railroads, pedestrians, and boats.

562.08 Falsework for Steel Structures.

(a) Use falsework design loads consisting of the mass of structural steel, the load of supported erection equipment, and all other loads supported by the falsework.

(b) Design falsework and forms for concrete supported on steel structures so that loads are applied to girder webs within 150 millimeters of a flange or stiffener. Distribute the loads in a manner that does not produce local distortion of the web. Do not use deck overhang forms that require holes to be drilled into the girder webs.

(c) Strut and tie exterior girders supporting overhanging deck falsework brackets to adjacent interior girders to prevent distortion and overstressing of the exterior girder web.

(d) 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.

(e) Build supporting falsework that will accommodate the proposed method of erection without overstressing the structural steel, as required, and will produce the required final structural geometry, intended continuity, and structural action.

562.09 Falsework Construction. Construct falsework to conform to the accepted drawings.

When welding is required, submit a welder certification for each welder according to Subsection 555.18.

Build camber into the falsework to compensate for falsework deflection and anticipated structure deflection. Camber shown on the plans or specified by the CO is for anticipated structure deflection only.

Attach tell-tales to soffit of concrete forms in enough systematically placed locations to be able to determine from the ground the total settlement of the structure while concrete is placed.

Do not apply dead loads, other than forms and reinforcing steel, to any falsework until authorized.

Discontinue concrete placement and take corrective action, if unanticipated events occur, including settlements that cause a deviation of more then 10 millimeters from those shown on the falsework drawings. If satisfactory corrective action is not taken before initial set, remove all unacceptable concrete.

562.10 Forms. For exposed concrete surfaces, use U.S. Product Standard PS 1 for exterior B-B (concrete form) class I plywood or other approved material that will produce a smooth and uniform concrete surface. Use only form panels in good condition free of defects on exposed surfaces. If form panel material other than plywood is used, it shall have flexural strength, modulus of elasticity, and other physical properties equal to or greater than the physical properties for the type of plywood specified.

Furnish and place form panels for exposed surfaces in uniform widths of not less than 1 meter and in uniform lengths of not less than 2 meters, except where the width of the member formed is less than 1 meter.

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. Provide 19-millimeter triangular fillets at all sharp edges of the concrete.

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. Use form ties and anchors that can be removed without damaging the concrete surface. Construct metal ties or anchorages within the forms to permit their removal to a depth of at least 25 millimeters from the face without damage to the concrete. Fill cavities with cement mortar and finish to a sound, smooth, uniform colored surface.

Construct all exposed concrete surfaces that will not be completely enclosed or hidden below the permanent ground surface so the formed surface of the concrete does not undulate more than 2.5 millimeters or 1/360 of the center to center distance between studs, joists, form stiffeners, form fasteners, or wales. Interior surfaces of underground drainage structures are considered to be completely enclosed surfaces. Form all exposed surfaces for each element of a concrete structure with the same forming material or with materials that produce similar surface textures, color, and appearance.

Support roadway slab forms of box girder type structures on wales or similar supports fastened, as nearly as possible, to the top of the web walls.

Construct concrete forms mortar-tight, true to the dimensions, lines, and grades of the structure, and of sufficient strength to prevent appreciable deflection during placement of concrete. Place all material required to be embedded in the concrete before concrete placement. Clean inside surfaces of forms of all dirt, mortar and foreign material. Remove all loose material before the completion of forming for the roadway deck slab of cast-in-place box girders or cells or voids of other members in which the forms are to either remain in place or be removed.

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:

- Chords within the panel are the same length.
- Chords do not vary from a true curve by more than 15 millimeters at any point.
- All panel points are on the true curve.

When architectural treatment is required, make the angle points for chords in wall stems fall at vertical rustication joints.

Coat forms to be removed with form oil. Use commercial quality form oil or an equivalent coating that permits release of the forms and does not discolor the concrete. Do not place concrete in forms until the forms have been inspected and approved.

(a) Stay inplace deck forms. Use permanent or stay inplace forms only when permitted by the contract.

Fabricate permanent steel bridge deck forms and supports from steel conforming to ASTM A 653M coating designation 2600, any grade except grade 340, class 3.

Install forms according to accepted fabrication and erection drawings. Do not rest form sheets directly on the top of stringer or floor beam flanges. Securely fasten sheets to form supports. Place form supports in direct contact with the stringer flange or floor beam. Make all attachments with permissible welds, bolts, or clips. Do not weld form supports to flanges of steels not considered weldable or to portions of flanges subject to tensile stresses.

Clean, wire brush, and paint with 2 coats of zinc dust zinc-oxide primer (FSS TT-P-641 type II, no color added) any permanently exposed form metal where the galvanized coating has been damaged. Minor heat discoloration in areas of welds need not be touched up.

Locate transverse construction joints in slabs at the bottom of a flute. Field drill 6-millimeter diameter weep holes at not less than 300 millimeters on center along the line of the joint.

(b) Void forms. Store void forms in a dry location to prevent distortion. Secure the forms using anchors and ties which leave a minimum of metal or other supporting material exposed at the bottom of finished slab.

Make the outside surface of the forms waterproof. Cover the ends with waterproof mortar tight caps. Use a premolded 6 millimeters thick rubber joint filler around the perimeter of the caps to permit expansion.

Provide a PVC vent near each end of each void form. Construct vents so the vent tube shall not extend more than 13 millimeters below the bottom surface of the finished concrete after form removal. Protect void forms from the weather until concrete is placed.

(c) Metal forms. The specifications for forms relative to design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and oiling also apply to metal forms.

562.11 Removal of Forms and Falsework. Remove all forms except as follows:

(a) Interior soffit forms for roadway deck slabs of cast-in-place box girders

(b) Forms for the interior voids of precast members

(c) Forms for abutments or piers when no permanent access is available into the cells or voids

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. Protect exposed concrete surfaces from damage. Cure all exposed concrete surfaces according to Subsection 552.15, if forms are removed less than 7 days after concrete placement.

Do not remove forms and falsework until the strength and time requirements of Table 562-3 are met.

Remove falsework for arch bridges uniformly and gradually. Begin at the crown and work toward the springing. Remove falsework for adjacent arch spans simultaneously.

Do not release falsework for cast-in-place prestressed portions of structures until after the prestressing steel has been tensioned.

Do not remove falsework supporting the deck of rigid frame structures, excluding box culverts, until backfill material is placed and compacted against the vertical legs of the frame.

Install a reshoring system if falsework supporting the sides of girder stems with slopes steeper than 1:1 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.

Table 562-3
Minimum Form/Support Release Criteria

Structural Element	Percent of Specified 28-Day Strength (f'_c)	Minimum Number of Days Since Last Pour
(a) Columns and wall faces (not yet supporting loads)	50	3
(b) Mass piers and mass abutments (not yet supporting loads) except pier caps	50	3
(c) Box girders	80	14
(d) Simple span girders, T-beam girders, slab bridges, cross beams, caps, pier caps not continuously supported, struts, and top slabs of concrete box culverts.	80	14
(e) Trestle slabs where supported on wood stringers	70	10
(f) Slabs and overhangs where supported on steel stringers or prestressed concrete girders	70	10
(g) Pier caps continuously supported	60	7
(h) Arches, continuous span bridges, rigid frames	90	21

Remove all falsework material. Remove falsework piling to at least 0.5 meter below the surface of the original ground or original stream bed. Where falsework piling is driven within the limits of ditch or channel excavation, remove the piling to at least 0.5 meter below the bottom and side slopes of the excavated areas.

Leave the forms for footings constructed within a cofferdam or crib in place when their removal would endanger the safety of the cofferdam or crib, and where the forms will not be exposed to view in the finished structure.

Remove all other forms whether above or below groundline or water level.

562.12 Acceptance. Forms and falsework (including design, construction, and removal) will be evaluated under Subsections 106.02, 106.03, and 106.04.

When the falsework installation is complete and before concrete placement or removal begins, have the falsework inspected by a licensed professional engineer proficient in structural design. Certify in writing that the installation conforms to the contract, the approved falsework drawings (including approved changes), and acceptable engineering practices. Provide a copy of the certification before concrete placement.

Measurement and Payment

562.13 See Subsection 109.05.

Do not measure forms and falsework for payment.

Section 563.) PAINTING

Description

563.01 This work consists of 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*
- 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 to the structure.

(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) A Competent person responsible for ensuring that all necessary health, safety, and containment measures are enacted and maintained.

After acceptance, perform work according to the 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 10 and 40 °C.
(e) Determine that the surface temperature is 3 °C or more above the dew point according to ASTM E 337.
(f) Determine that the humidity is 85 percent 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 120 millimeters. 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 3 square meters 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.

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 II 75-100 µm dry	Zinc-rich epoxy 75-100 µm dry	Moisture-cured urethane 50-75 µm dry	Acrylic latex 50-75 µm dry	Low VOC alkyd 50-75 µm dry
Intermediate	Epoxy 75-100 µm dry	Epoxy 75-100 µm dry	Moisture-cured urethane 50-75 µm dry	Acrylic latex 50-75 µm dry	Low VOC alkyd 50-75 µm dry
Top	Aliphatic urethane 50-75 µm dry	Aliphatic urethane 50-75 µm dry	Moisture-cured urethane or Aliphatic urethane 50-75 µm dry	Acrylic latex 50-75 µm dry	Low VOC alkyd 50-75 µm dry
Total Thickness	200-275 µm dry	200-275 µm dry	150-225 µm dry	150-225 µm dry	150-225 µm 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, orstructures 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 50-75 µm dry	Low VOC alkyd 50-75 µm dry	Low viscosity epoxy sealer 25-50 µm dry
Intermediate	Moisture-cured urethane 50-75 µm dry	Low VOC alkyd 50-75 µm dry	Epoxy 75-100 µm dry
Top	Moisture-cured urethane or Aliphatic urethane 50-75 µm dry	Low VOC silicone-alkyd 50-75 µm dry	Aliphatic urethane 50-75 µm dry
Total Thickness	150-225 µm dry	150-225 µm dry	150-225 µm dry

(1) System 1 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. S-ystem 2 or 3 is for use in those environments free from high concentrations of salts or pollutants that cause aggressive corrosion environments.

(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 25 to 50 micrometers, 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.

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 3.5 megapascals. 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 50 millimeters 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.

Table 563-3
Coating Systems for Other Structures

Substrate	Paint Coatings			
	Primer	**Intermediate**	**Finish**	**Total**
Smooth Wood	Exterior wood primer (1) 60-70µm dry	Exterior latex or alkyd 35-50µm dry	Exterior latex or alkyd 35-50µm dry	130-170µm dry
Rough Lumber	Exterior latex or alkyd (1) 35-50µm dry	Exterior latex or alkyd 35-50µm dry	Exterior latex or alkyd 35-50µm dry	105-150µm dry
Concrete	Epoxy single coat 80-100µm dry. For gloss finish, finish with aliphatic-polyurethane (50µm dry).			80-150µm dry
Masonry Block	Masonry block filler 50-60µm dry	Exterior latex or alkyd 35-50µm dry	Exterior latex or alkyd 35-50µm dry	120-160µm dry
Aluminum	Metal primer 30-40µm dry	Exterior latex or alkyd 35-50µm dry	Exterior latex or alkyd 35-50µm dry	100-140µm dry
Other Metals	Metal primer (2) 35-45µm dry	Exterior latex or alkyd 35-50µm dry	Exterior latex or alkyd 35-50µm dry	105-145µm dry

(1) For untreated wood, thin the primer with up to 0.1 liter of turpentine and 0.1 liter of linseed oil per liter of paint.
(2) For galvanized surfaces, use an epoxy primer (35-45 micrometers dry thickness) or a vinyl wash primer (7-13 micrometers dry thickness).

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.

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 oil-borne 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.

563.12 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 painting by the square meter or by the lump sum. When measurement is by the square meter, measure the visible surface area painted.

Payment

563.13 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
56301 Painting, ___*description*___ structure	Lump sum
56302 Painting, ___*description*___ structure	Square meter

Section 564.) BEARING DEVICES

Description

564.01 This work consists of furnishing and installing bridge bearings. Bearing devices are designated as elastomeric, rocker, roller, and sliding plate.

Material

564.02 Conform to the following Subsections:

Elastomeric bearing pads	717.10
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 according to Subsection 717.07. 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 15 millimeters thick with laminates every 15 millimeters through the entire thickness.

If not specified, use 50-durometer elastomer, capable of sustaining an average compressive stress of 7 megapascals.

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 40 millimeters of steel between the weld and elastomer. Do not expose the elastomer or elastomer bond to instantaneous temperatures greater than 200 °C.

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 270M grade 250.

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 70 megapascals 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 450-kilonewton 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 25 millimeters 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 (megapascals)	Friction Coefficient
Unfilled TFE, fabric containing TFE fibers, or TFE-perforated metal composite	3.5	0.08
	14	0.06
	24	0.04
Filled TFE	3.5	0.12
	14	0.10
	24	0.08
Interlocked bronze and filled TFE structures	3.5	0.10
	14	0.07
	24	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.

Drill holes for anchor bolts and set them in portland cement non-shrink grout or preset them before placing the concrete.

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.

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 bearing devices by the each.

Payment

564.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement, for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
56401 __________ bearing device	Each

Section 565.) DRILLED SHAFTS

Description

565.01 This work consists of constructing drilled shafts.

Material

565.02 Conform to the following Section and Subsections:

Mineral slurry	725.26
Reinforcing steel	709.01
Structural concrete	552

Construction Requirements

565.03 Contractor Qualifications and Equipment Adequacy. Use personnel with at least 3 or more years experience in the construction of drilled shafts. Provide personnel resumes of job experiences and appropriate documentation including names, addresses, and telephone numbers of organizations or associations that verify the information. Acceptance of the proposed personnel responsible for the construction of the drilled shafts is required before work begins.

Submit an installation plan for acceptance at least 30 days before constructing drilled shafts. Include the following information in the plan.

(a) List of proposed equipment to be used including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies, concrete pumps, casings, etc.

(b) Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.

(c) Details of shaft excavation methods and procedures for maintaining correct horizontal and vertical alignment of the excavation.

(d) When a mineral slurry is required, details of the methods to mix, circulate, and de-sand the slurry.

(e) Details of methods to clean the shaft excavation.

(f) Details of reinforcement placement including support and centralization methods.

(g) Details of concrete placement including proposed operational procedures for free fall, tremie, or pumping methods.

Acceptance of the Contractor's plan, personnel, and trial shafts does not relieve the Contractor of the responsibility for obtaining the required results.

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 5 meters 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 75 millimeters 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 20 millimeters per meter of depth. Do not allow the alignment of a battered shaft to vary by more than 40 millimeters per meter 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
- Elevation and approximate rate of any seepage or groundwater en countered
- Equipment used, time required to drill shaft, and all difficulties en countered
- Remarks

(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 300 millimeters 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.
(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.
(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.

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 15 millimeters or a maximum of 75 millimeters 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 10 millimeters of sediment and the maximum depth of sediment at any place on the bottom of the hole does not exceed 40 millimeters. For dry holes, reduce the depth of water to 75 millimeters or less before placing concrete.

(b) Mineral slurry . Premix the mineral slurry with clean fresh water according to the mineral manufacturer 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 1 meter 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 3 meters 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.

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.

Furnish reports of all tests, signed by an authorized representative, after completion of each drilled shaft. Dispose of slurry at approved locations.

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, kg/m^3	1030 - 1110	1030 - 1200	Density balance
Viscosity, s/L	30 - 48	30 - 48	Marsh cone
pH	8 - 11	8 - 11	pH paper or meter

Note: Density values shown are for fresh water. Increase density values 30 kilograms per cubic meter for saltwater. Perform tests when slurry temperature is above 4 °C. 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.

(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 1.5 meters 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
(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. Perform the work according to Section 554. Place the reinforcing steel cage as a unit immediately after the shaft excavation is inspected and accepted and before concrete placement. Securely wire together contact reinforcing steel lap splices. 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.

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 3 meters along the length of the cage. Use spacers of approved material at least equal in quality and durability to the shaft concrete.

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 150 millimeters above and no more than 75 millimeters 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. Place concrete immediately after all excavation is complete and the reinforcing steel cage is in place. 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 175±25 millimeters. For shafts constructed with drilling fluid, use class A structural concrete having a slump of 200±25 millimeters. 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 3 meters of the shaft concrete using acceptable vibratory equipment. Finish the top of the shaft to +25 millimeters or -75 millimeters 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 8-meter 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 8 meters. 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/or 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 250 millimeters. 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 1.5 meters 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 100-millimeter 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 1.5 meters 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.

When the top of shaft is above ground, use a removable form or other approved means to form the shaft to at least 0.5 meter below finished ground. Forms may be removed provided the requirements in Subsection 562.11 and Table 562-3(a) 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.

565.08 Acceptance. Material for mineral slurry will be evaluated under Subsections 106.02 and 106.03.

Construction of drilled shafts will be evaluated under Subsections 106.02 and 106.04.

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.

Measurement

565.09 Measure drilled shafts by the meter 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 for payment.

Measure trial drilled shafts, determined to be satisfactory, by the meter from the approved tip elevation to the ground surface at the center of the shaft.

Measure drilled shaft bells by the each.

Payment

565.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
56501	Drilled shafts	Meter
56502	Trial drilled shaft	Each
56503	Bell	Each

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
Curing material	711.01
Fine aggregate	703.01
Fly ash	725.04
Joint fillers	712.01
Portland cement	701.01
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 Portland Cement 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 meter of concrete.
(d) Gradation of fine and coarse aggregate.
(e) Mass of mixing water per cubic meter of concrete.
(f) Mass of cement per cubic meter 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 millimeters.

TABLE 601-1
Composition of Minor Structure Concrete

Property	Specification
Minimum cement content, kg/m^3)	362
Maximum water/cement ratio	0.49
Maximum slump, mm	125
Minimum air content, %	4
Size of coarse aggregate	AASHTO M 43 with 100% passing the 37.5 mm sieve
Minimum 28-day compressive strength, MPa	25

Construction Requirements

601.04 General. Perform excavation and backfill work under 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 2400 kilograms per cubic meter.

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 552-2.

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 delivery 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. Material for minor concrete structures including concrete, reinforcing steel, and structural steel for minor structures will be evaluated under Subsections 106.02 and 106.03. For confirming commercial certifications of compressive strength, AASHTO T 23 is modified to allow the 28-day cure in a waterproof mold.

Excavation and backfill will be evaluated under Section 209.

Construction or minor concrete structures will be evaluated under Subsections 106.02 and 106.04.

Measurement

601.08 Measure concrete by the cubic meter in the structure, by the square meter, by the lump sum, or by the each.

Payment

601.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown 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 paid based on the progress of the work under this Section.

Payment will be made under:

Pay Item		Pay Unit
60101	Concrete	Cubic meter
60102	Concrete	Square meter
60103	Concrete	Lump sum
60104	Concrete	Each

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 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
Special grout backfill	704.11
Watertight gaskets	712.03

Construction Requirements

602.03 General. Use the same material and coating on all contiguous pipe sections, extensions, and special sections, such as elbows and branch connections. Culvert material, sizes, and approximate locations are shown on the plans. Determine the final location, length, and special sections in the field. Perform excavation and backfill work under 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 manufacturers' 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 the sections together with coupling bands. Do not use flat bands or smooth sleeve type couplers. 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.

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 special grout 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 pipe and box culverts by the meter 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, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
60201	__ millimeter pipe culvert	Meter
60202	__ millimeter span, __ millimeter rise pipe arch culvert	Meter
60203	__ millimeter equivalent diameter arch or elliptical culvert pipe	Meter
60204	__ millimeter slotted drain pipe	Meter
60205	__ span, __ rise precast reinforced concrete box culvert	Meter
60206	End section for __ millimeter pipe culvert	Each
60207	End section for __ millimeter span, __ millimeter rise pipe arch culvert	Each
60208	End section for __ millimeter equivalent diameter arch or elliptical culvert	Each
60209	Elbow *(description)*	Each
60210	Branch connection *(description)*	Each

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. Perform excavation and backfill work under 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 135 newton meters and a maximum of 400 newton meters.

Torque steel bolts and aluminum bolts on 2.5-millimeter thick aluminum plates to a minimum of 120 newton meters and a maximum of 155 newton meters.

Torque steel bolts and aluminum bolts on 3-millimeter thick and heavier aluminum plates to a minimum of 155 newton meters and a maximum of 180 newton meters.

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 structural plate pipes, pipe arches, boxes, and underpasses by the meter along the invert.

Measure structural plate arches by the meter along the average of the springline lengths.

Payment

603.07 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
60301	*(diameter)* millimeter structural plate pipe, *(metal thickness)* millimeter	Meter
60302	___ span, ___ rise, structural plate pipe-arch, *(metal thickness)* millimeter	Meter
60303	___ span, ___ rise, structural plate underpass, *(metal thickness)* millimeter	Meter
60304	___ span, ___ rise, structural plate arch, *(metal thickness)* millimeter	Meter
60305	___ span, ___ rise, structural plate box, *(metal thickness)* millimeter	Meter

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
Reinforcing steel	709.01
Watertight gaskets	712.03

Construction Requirements

604.03 General. Perform excavation and backfill work under 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 will 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 300-millimeter 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 6 to 13 millimeters 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 12 millimeters 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 150 millimeters thick or water tight masonry not less than 200 millimeters thick. Fracture the base of concrete structure to prevent entrapment of water. Obliterate the top of the structure to an elevation at least 1 meter 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 manholes by the meter from finished grade to the flow line surface of the manhole or by the each.

Measure inlets, catch basins, manhole and inlet adjustments, capping inlets and manholes, junction boxes, and spring boxes by the each.

Measure metal frames and grates and removing and resetting metal frames and grates by the each unless included as part of the original inlet, manhole, or catch basin construction. The frame and the grate or cover used with it constitute one unit.

Payment

604.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
60401	Manhole *(description)*	Each
60402	Manhole *(description)*	Meter
60403	Inlet *(description)*	Each
60404	Catch basin *(description)*	Each
60405	Manhole adjustment	Each
60406	Inlet adjustment	Each
60407	Capping inlets and manholes	Each
60408	Junction box	Each
60409	Metal frame and grate *(description)*	Each
60410	Spring box	Each
60411	Removing and resetting metal frame and grate	Each

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.

Perform excavation and backfill work under 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 1.4-millimeter diameter galvanized wire having approximately 13 by 13-millimeter mesh openings over the outlet ends of all exposed pipes and weep holes.

605.04 Placing Underdrain. Place a layer of granular backfill at least 50 millimeters thick in the bottom of the trench.

Furnish a collector pipe at least 125 millimeters in size with all underdrains.

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 ditchlines, prevent infiltration of surface water by placing material conforming to AASHTO M 145 classification group A-4, A-5, A-6, or A-7 in the top 300 millimeters 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 600 millimeters with the upstream geotextile placed over the downstream geotextile.

Place collector pipe with the perforations down.

Place granular backfill to a height of 300 millimeters 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 300 millimeters.

(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. Construct the geocomposite underdrain so not to impede flow through 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 0.5 meter wide, backfill the trench using clean sand. Backfilling and compacting in layers is not required. Compact the sand by wheel rolling, vibrating, tamping with a mechanical tamper, or flooding with water.

When the trench is 0.5 meter wide or more, place granular backfill or clean sand to a height of 300 millimeters 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 75 millimeters 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 0.5 meter wide, backfill the trench using clean sand. Backfilling and compacting in layers is not required. Compact the sand by wheel rolling, vibrating, tamping with a mechanical tamper, or flooding with water.

When the trench is 0.5 meter wide or more, place and compact granular backfill or clean sand according to Section 209.

605.07 Acceptance. 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. See Table 605-1 for sampling and testing requirements.

Excavation and backfill will be evaluated under Section 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 underdrain systems, standard underdrain systems, geocomposite underdrain systems, and pavement edge drain systems by the meter. When measurement is for a system, do not measure geotextiles, collector pipes, backfill, and outlet pipes that are part of the system unless a pay item is shown in the contract.

Measure sheet drain systems by the square meter of front face in final position excluding overlaps.

Measure collector pipe and outlet pipe by the meter.

Measure granular backfill and sand by the cubic meter in place.

Payment

605.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
60501	Underdrain system	Meter
60502	Standard underdrain system	Meter
60503	Geocomposite underdrain system	Meter
60504	Geocomposite pavement edge drain system	Meter
60505	Geocomposite sheet drain system	Square meter
60506	___ millimeter collector pipe	Meter
60507	___ millimeter outlet pipe	Meter
60508	Granular backfill	Cubic meter
60509	Sand	Cubic meter

Table 605-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Granular backfill	Gradation	AASHTO T 27 and AASHTO T 11	1 for each 500 m	Production output or stockpile

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 spillway assemblies and pipe anchor assemblies by the each.

Measure downdrain and outlet pipes under Section 602.

Payment

606.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
60601	Spillway assembly	Each
60602	Pipe anchor assembly, ___ millimeter	Each

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 removing, cleaning, and stockpiling culvert by the meter of pipe in the stockpile.

Measure removing, cleaning, and relaying culvert by the meter along the invert of the culvert.

Measure cleaning culvert in place along the invert of the culvert. If the culvert is removed and relayed at the Contractor's option there is no additional measurement.

Measure reconditioning drainage structures by the each.

Payment

607.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
60701	Removing, cleaning, and stockpiling culvert	Meter
60702	Removing, cleaning, and relaying culvert	Meter
60703	Cleaning culverts in place	Meter
60704	Reconditioning drainage structures	Each

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 I	Grouted rubble
Type II	Mortared rubble
Type III	Concrete and rubble
Type IV	Concrete
Type V	Asphalt
Type VI	Placed riprap

Material

608.02 Conform to the following Sections and Subsections:

Asphalt mixtures	402
Bed course	704.09
Concrete	601
Granular backfill	703.03(b)
Mortar	712.05
Reinforcing steel	709.01
Riprap rock	705.02
Rubble	620

Construction Requirements

608.03 General. Perform excavation and backfill work under 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. 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 25 to 50 millimeters 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 100 millimeters of the surface. Pour and broom mortar into the joints until the mortar is 13 millimeters below the surface. Clean the excess mortar from the surface.

608.05 Mortared Rubble Paved Waterway. 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 25 millimeters minimum to 50 millimeters 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 13 millimeters of the surface but not protruding above the surface. Clean the excess mortar from the surface.

608.06 Concrete and Rubble Paved Waterway. 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 25 millimeters minimum to 50 millimeters maximum. Fill the joints between stones with mortar to 25 millimeters below the top of the stone.

608.07 Concrete Paved Waterway. Perform the work according to Section 601.

608.08 Asphalt Paved Waterway. Perform the work according to Section 402. Before overlaying existing asphalt paved waterway, clean and seal the cracks according to Section 414.

608.09 Placed Riprap Waterway. Use class I riprap. Perform the work according to Subsections 251.03 and 251.04.

608.10 Acceptance. Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsection 106.04. See Table 608-1 for sampling and testing requirements.

Bed course and granular backfill will be evaluated under Subsections 106.02 and 106.04. See Table 608-1 for sampling and testing requirements.

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 402.

Concrete will be evaluated under Section 601.

Rubble will be evaluated under Section 620.

Measurement

608.11 Measure paved waterways by the square meter, by the meter, or by the metric ton. Measure square meter width horizontally to include the total width. Measure the length parallel to the flow line.

Payment

608.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
60801	Paved waterway type ___	Square meter
60802	Paved waterway type ___	Meter
60803	Asphalt paved waterway	Metric ton

Table 608-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Bed course	Gradation Liquid limit	AASHTO T 27 and AASHTO T 11 AASHTO T 89	1 for each 500 m^3	Production output or stockpile
Granular backfill	Gradation	AASHTO T 27 and AASHTO T 11	1 for each 500 m	Production output or stockpile
Mortar	Making test specimens Compressive strength (2)	AASHTO T 23 AASHTO T 22	1 sample per installation (1)	Job site

(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	402
Bed course	704.09
Concrete	601
Joint filler	712.01
Mortar	712.05
Precast concrete curbing	725.06
Reinforcing steel	709.01
Stone curbing	705.06

Construction Requirements

609.03 General. Perform excavation and backfill work under 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 10 to 25 millimeters wide and fill the joints with mortar.

Complete the first 8 meters of curb to demonstrate the ability to build a curb meeting these requirements. Do not continue construction until the 8-meter 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 19 millimeters 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 Portland Cement 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 90 meters or less.

(1) Contraction joints. Construct curb in sections of uniform 3 meter lengths. Construct contraction joints 3 millimeters 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 18 meters using a 19-millimeter thick preformed expansion joint filler. Where the curb is constructed adjacent to or on concrete 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 5 millimeters 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 402. 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 1-meter sections of 20M reinforcing steel or 19-millimeter steel rods. Reset wheelstops in the same manner.

609.09 Acceptance. Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsection 106.04. See Table 609-1 for sampling and testing requirements.

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. See Table 609-1 for sampling and testing requirements,

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 402.

Concrete will be evaluated under Section 601.

Measurement

609.10 Measure curb and combination curb and gutter, both new and reset, by the meter along the front face of the curb. 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 carried across.

Measure wheelstops, both new and reset, by the each.

Measure bed course material by the metric ton or by the cubic meter in place.

Payment

609.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
60901	Portland cement concrete curb, ___ millimeter depth	Meter
60902	Portland cement concrete curb and gutter, ___ millimeter depth	Meter
60903	Stone curb type ___, ___ millimeter depth	Meter
60904	Precast concrete curb	Meter
60905	Asphalt concrete curb, ___ millimeter depth	Meter
60906	Reset curb	Meter
60907	Bed course material	Cubic meter
60908	Bed course material	Metric ton
60909	Wheelstop	Each
60910	Remove and reset wheelstop	Each

Table 609-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Bed course	Gradation Liquid limit	AASHTO T 27 and AASHTO T 11 AASHTO T 89	1 for each 500 m^3	Production output or stockpile
Mortar	Making test specimens Compressive strength (2)	AASHTO T 23 AASHTO T 22	1 sample per installation (1)	Job site

(1) Sample consists of 2 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 0.5 millimeter with the total slot opening equal to 4200 square millimeters per meter of pipe.

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 75 to 150-millimeter 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 150 millimeters 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 3 to 6 meters of the outlet end. Seal the space between the drilled hole and the unslotted pipe for at least 3 meters 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 horizontal drain pipe, including the length of the outlet pipe, by the meter.

Measure the collector system by the meter or lump sum.

Payment

610.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
61001	Horizontal drain pipe	Meter
61002	Collector system	Meter
61003	Collector system	Lump sum

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.

Perform excavation and backfill work under Section 209. Bed the pipe according to Subsection 209.09(b)(2).

611.04 Laying Waterline. Where it is necessary to cross a waterline over a sewer line, construct the waterline a minimum vertical distance of 450 millimeters 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 home, 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 0.2 square meters 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 300 millimeters 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 300 millimeters 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 water systems by the lump sum.

Measure waterlines and encasement pipes by the meter with no deduction for the length through tees, bends, valves, or other fixtures.

Measure valves, valve boxes, and fire hydrants by the each.

Payment

611.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Water system lump sum will be paid as follows:

(a)75 percent of the lump sum will be paid as work progresses based on the certified cost breakdown.

(b) Payment of the remaining 25 percent will be made upon successful completion of the work.

Payment will be made under:

Pay Item		Pay Unit
61101	Water system	Lump sum
61102	___ millimeter waterline *(description)*	Meter
61103	___ millimeter encasement pipe *(description)*	Meter
61104	Valve *(description)*	Each
61105	Valve box	Each
61106	Fire hydrant	Each

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
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.

Perform excavation and backfill work under Section 209. Bed the pipe according to Subsection 209.09(b)(2).

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 assure 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 sewer systems by the lump sum.

Measure sewer lines by the meter with no deduction for length through valves, ells, tees, valve boxes, reducers, manholes, or other fixtures. Where two different sizes enter or go from a manhole, measure each size to the center of the manhole.

Payment

612.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Sewer system lump sum will be paid as follows:

(a)75 percent of the lump sum will be paid as work progresses based on the certified cost breakdown.

(b) Payment of the remaining 25 percent will be made upon successful completion of the work.

Payment will be made under:

Pay Item		Pay Unit
61201	Sewer system	Lump sum
61202	___ millimeter sewer line _*(description)*_	Meter

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 will duplicate 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
Plaster mix (grout)	725.22

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 3-millimeter seam. Do not repeat the form liner pattern between expansion joints or within 6-meter 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 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 25 millimeters 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 0.6 and 1 meter. Use a minimum 20-megapascal water pressure at a rate of 12 to 16 liters 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 4 and 30 °C 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 1-meter high, by 0.5-meter wide, by 3 meter-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.

613.11 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 simulated stone masonry surface treatment by the square meter.

Measure simulated stone masonry test wall including concrete and surface finish by the each.

Do not measure form liners for payment.

Payment

613.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown on the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	**Pay Unit**
61301 Simulated stone masonry surface treatment	Square meter
61302 Simulated stone masonry test wall	Each

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
Portland cement	701.01
Water	725.01

Construction Requirements

614.03 Composition of Mix. Furnish an aggregate which is uniformly graded from coarse to fine, has a maximum size of 25 millimeters, and has no more than 10 percent passing the 75-micrometer sieve.

Proportion aggregate, cement, and water by mass or volume.

Furnish lean concrete backfill which contains 110 to 113 kilograms of cement per cubic meter.

Submit the following:

(a) Type and source(s) of aggregates
(b) Type and source of cement
(c) Scale mass or quantity of each aggregate proposed per cubic meter of lean concrete backfill
(d) Quantity of water proposed per cubic meter of lean concrete backfill
(e) Quantity of cement proposed per cubic meter of lean concrete backfill
(f) Slump

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. Place lean concrete backfill in horizontal layers not exceeding 300 millimeters in thickness.

When backfilling around culverts and other structures, place lean concrete backfill in a manner which will 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 2 °C, 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 lean concrete backfill by the cubic meter in the hauling vehicle.

Payment

614.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
61401 Lean concrete backfill	Cubic meter

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	402
Bed course	704.09
Clay or shale brick	725.07
Concrete	601
Concrete brick	725.08
Curing material	711.01
Joint fillers	712.01
Reinforcing steel	709.01

Construction Requirements

615.03 General. Perform excavation and backfill work under Section 209. Place bed course material in layers not exceeding 100 millimeters in compacted thickness. Compact each layer with at least three passes of a lightweight mechanical tamper, roller, or vibratory system.

615.04 Portland Cement Concrete Sidewalks, Drive Pads, and Medians. Perform the work according to Section 601. Use forms which 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 18 meters. Use 19-millimeter thick preformed expansion joint filler for the full depth of the joints.

(2) Contraction joints. Construct at intervals not exceeding 3 meters. 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 3 millimeters wide.

(3) Construction joints. Form construction joints around all appurtenances such as manholes, utility poles, buildings, and bridges. Use 13-millimeter thick preformed expansion joint filler for the full depth of the joints.

(b) Finishes. Provide a sidewalk finish unless otherwise required. Edge outside edges of slab and all joints with a 6-millimeter 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 402.

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 55 millimeters in 10 meters.

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. 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. See Table 615-1 for sampling and testing requirements.

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 402.

Concrete will be evaluated under Section 601.

Measurement

615.08 Measure sidewalks, drive pads, and paved medians by the square meter.

Payment

615.09 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	**Pay Unit**
61501 ________ sidewalk	Square meter
61502 ________ drive pad	Square meter
61503 ________ median	Square meter

Table 615-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Granular backfill	Gradation Liquid limit	AASHTO T 27 and AASHTO T 11 AASHTO T 89	1 for each 500 m^3	Production output or stockpile

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
Mortar	712.05
Rubble	620
Welded steel wire fabric	709.01(h)

Construction Requirements

616.03 General. Perform excavation and backfill work under 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 1.5-meter 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 150 millimeters.

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 6-millimeter 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 13 millimeters of the surface and not protruding above the top. Make the brick and masonry block joints 13 millimeters wide or less and rubble joints 25 millimeters 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. 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. See Table 616-1 for sampling and testing requirements.

Bed course material will be evaluated under Subsections 106.02 and 106.04. See Table 616-1 for sampling and testing requirements.

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 slope paving by the square meter.

Measure topsoil under Section 624.

Measure turf establishment under Section 625.

Payment

616.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
61601	Concrete slope paving	Square meter
61602	Brick slope paving	Square meter
61603	Masonry block slope paving	Square meter
61604	Rubble slope paving	Square meter
61605	Cellular concrete block slope paving	Square meter

Table 616-1
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Bed course	Gradation Liquid limit	AASHTO T 27 and AASHTO T 11 AASHTO T 89	1 for each 500 m^3	Production output or stockpile
Mortar	Making test specimens Compressive strength [(2)]	AASHTO T 23 AASHTO T 22	1 sample per installation [(1)]	Job site

(1) Sample consists of 2 test specimens.
(2) The compressive strength will be the average of two test specimens.

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, 550 grams per square meter
II	Zinc-coated, 1100 grams per square meter
III	Painted rails
IV	Corrosion resistant steel

(c) Steel guardrail classes are designated as follows:

A	Metal thickness - 2.67 millimeters
B	Metal thickness - 3.43 millimeters

(d) Terminal section types are designated as follows:

BCT	Breakaway cable terminal
CRT	Cable releasing terminal
MELT	Modified eccentric loader terminal
G4-BAT	Back slope anchor 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 anchors	725.11
Reflector tabs	710.10
Retroreflective sheeting type I or type II	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. When pavement is within 1 meter of the guardrail, set posts before placing the pavement.

Do not shorten guardrail posts unless the cut end is set in concrete. Do not shorten posts in terminal sections.

If an impenetrable object is encountered while placing posts, enlarge the hole to provide not less than 150 millimeters clearance on all sides, and to a minimum depth of 0.75 meters. Set the post in concrete to within 150 millimeters of the top of the hole. Backfill and compact the remaining 150 millimeters with acceptable material.

Drive posts into pilot holes that are punched or drilled. The dimensions of the pilot hole shall not exceed the dimensions of the post by more than 15 millimeters. Set posts plumb, backfill, and compact.

When longer posts are specified, do not use them in the terminal sections.

Stamp the post length on the top of all wood posts. Restamp numbers disturbed during installation. Stamp post length on all metal posts. Galvanize after stamping.

Alternate hole arrangements do not apply to posts in anchorage assemblies.

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 45 meters 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 6 millimeters but not more than 25 millimeters 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) 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 edges of the rail.

Field cut timber rails to produce a close fit at joints. Treat field cuts with 2 coats of chromated copper arsenate.

(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.

Use either the steel tube anchor or the concrete anchor in the construction of the anchorage assembly for the type BCT terminal section.

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 guardrail, except steel-backed timber guardrail and steel-backed log rail, by the meter along the face of the rail excluding terminal sections. Measure steel-backed timber guardrail and steel-backed log rail by the meter along the face of the rail including terminal sections. Measure transition sections from G9 rail to G4 rail as G9 rail.

Measure terminal sections by the each, except measure the following terminal sections as a part of the rail:

(a) Steel-backed timber guardrail terminal sections
(b) Steel-backed log rail terminal sections
(c) BCT anchorage assemblies constructed as a part of the CRT system

Measure removing and resetting guardrail and raising guardrail by the meter along the face of the rail including reset terminal sections.

Measure replacement posts (except replacement posts for posts damaged by construction operations) used in the removing, resetting, or raising guardrail by the each.

Measure connection to structure by the each.

Measure reinforced concrete transitions by the each.

Measure earth berms under Section 204.

Payment

617.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	**Pay Unit**
61701	Guardrail system ____, type ___, class ___	Meter
61702	Terminal section type ___	Each
61703	Removing and resetting guardrail	Meter
61704	Raising guardrail	Meter
61705	Replacement posts	Each
61706	Connection to structure	Each
61707	Reinforced concrete transition	Each

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
Precast concrete guardwall	725.11
Preformed joint filler	712.01(b)
Reinforcing steel	709.01

Construction Requirements

618.03 General. Perform excavation and backfill work under Section 209.

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 5 millimeters wide and 50 millimeters deep at 6-meter 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 19 millimeters preformed joint filler in all construction joints. Cut the joint filler to fit the cross-sectional area at structures and barrier construction joints. Construct 6-millimeter wide longitudinal joints on the sides of the barrier as indicated. 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 13 millimeters. 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 6 millimeters when a 3-meter straightedge is laid along the centerline of the barrier. Align the joints and connect adjacent sections in an acceptable manner. Shim with a 300 by 600 millimeter polystyrene foam pad under the end. Provide at least 300 millimeters of bearing surface under the shim.

Use cast-in-place barrier where transitions, split barriers, or gaps shorter than 3 meters 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 portland 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 50 millimeters 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 25 millimeters thick. Assure 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 3-meter, 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 30-meter intervals and at low points in the guardwall, dig outlet ditches and fill them with 150 millimeters of aggregate conforming to AASHTO M 43 no. 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 concrete barrier and precast concrete guardwall by the meter along the top of the barrier excluding terminal sections.

Measure terminal sections by the each.

Measure reset barrier by the meter in the relocated position including terminal sections.

Measure earth berms under Section 204.

Payment

618.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
61801	Concrete barrier	Meter
61802	Precast concrete guardwall	Meter
61803	Terminal section *(description)*	Each
61804	Reset barrier	Meter

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 Sections and Subsections:

Barbed wire	710.01
Chain link fence	710.03
Concrete	601
Fence gates	710.05
Fence posts and bollards	710.04
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 3-meter width for chain link fence and a 1-meter 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 3-meter 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 350 millimeters deep and drill end, corner, gate, and pull posts at least 500 millimeters deep in the solid rock. Make the hole width or diameter at least 25 millimeters 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 25 millimeters 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 150-millimeter 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 350 millimeters deep and end, corner, gate, and pull posts at least 500 millimeters deep in the solid rock. Make the hole width or diameter at least 25 millimeters 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 300 millimeters, 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 300 millimeters 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 200 meters 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 200 meters 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 10 by 100-millimeter 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 post face 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 15 meters 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. Warp 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 300 millimeters 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 600 millimeters in the ground or to an approved anchor at a point that will best serve to resist the pull of the wire fence. If necessary to guy the fence in solid rock, grout the guy wire in a hole 50 millimeters in diameter and 250 millimeters 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 300 millimeters in diameter and 300 millimeters 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 a 2.5-meter long, 13-millimeter 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 150 millimeters below the ground surface. Connect the grounding rod to each fence element with a 5-millimeter 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 500 meters.

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 concrete foundations according to Section 601. Concrete units may be cast-in-place or precast.

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. Suitable cleanouts shall be provided. 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 fence and remove and reset fence by the meter along the top of the fence.

Measure gates, cattle guards, brace panels, and bollard posts by the each.

Payment

619.11 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
61901	Fence *(description)*	Meter
61902	Gate *(description)*	Each
61903	Cattle guard, ___ meter	Each
61904	Brace panel	Each
61905	Bollard post	Each
61906	Remove and reset fence	Meter

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 cement mortar.

(b) Class A masonry. Stones are shaped, dressed to within 6 millimeters of true line, and laid in cement mortar.

(c) Class B masonry. Stones are shaped, dressed to within 19 millimeters of true line, and laid in cement mortar.

(d) Cement rubble masonry. Stones vary in size and shape, are roughly dressed, and laid in random courses in cement 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
Mortar	712.05
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.

Perform excavation and backfill work under 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 in freezing weather. Clean all stones thoroughly and moisten immediately before placing. Clean and moisten the bed.

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 6 millimeters or more than 38 millimeters 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 - mm	Joints - mm
Rubble	13 - 64	13 - 64
Class B	13 - 50	13 - 50
Class A	13 - 50	13 - 38
Dimensioned	10 - 25	19 - 25

620.05 Pointing. Point or finish all 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.

620.06 Constructing Walls. Construct an L-shaped sample section of wall not less than 1.5 meters high and 2.5 meters 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 150 millimeters longitudinally and 50 millimeters 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 0.5 to 1.5 meters in length, and of random heights, with a minimum height of 150 millimeters. 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 3 meters 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. 10M reinforcing steel bent into an elongated letter S to anchor the stone. Embed each anchor in a mortar bed to within 50 millimeters from the face of the stones. Project the other end ±250 millimeters into the concrete backing. Space the anchors 0.5 meter 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 600 millimeters. 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 600 millimeters. 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 75 millimeters of the exposed face of the stone work.

Where the shape of the concrete face is unsuitable for the use of metal slots, use 3.8-millimeter galvanized iron wire ties at a rate of 7 ties for each square meter 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 cement rubble masonry. Concrete corewalls for guardwall may be cast-in-place or precast units according to Section 601, except the concrete shall have a minimum 28-day compressive strength of 25 megapascals.

Construct an 8-meter 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 38 millimeters beyond the neat line. Make mortar beds and joints according to Table 620-1. Rake the joints and beds to a depth of 50 millimeters on the front and top sides and to 38 millimeters 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 100 millimeters 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. Material for mortar will be evaluated under Subsections 106.02 and 106.03. Mortar will be evaluated under Subsections 106.02 and 106.04. See Table 620-2 for sampling and testing requirements.

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 stone masonry by the cubic meter in the structure. Do not measure sample wall sections not incorporated in the work.

Measure stone masonry guardwall by the meter along the front face of the wall including terminal sections.

Measure remove and reset stone masonry by the cubic meter in the structure after resetting.

Measure repoint stone masonry by the meter of joint.

Payment

620.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for all work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
62001	_*(Class)*_ masonry, ___ finish	Cubic meter
62002	Stone masonry guardwall	Meter
62003	Remove and reset stone masonry	Cubic meter
62004	Repoint stone masonry	Meter

Table 620-2
Sampling and Testing

Material or Product	Property or Characteristic	Test Methods or Specifications	Frequency	Sampling Point
Mortar	Making test specimens Compressive strength [2]	AASHTO T 23 AASHTO T 22	1 sample 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 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 Sections and Subsections:

Concrete	601
Paint	708
Reflectors	718.12
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. Perform excavation and backfill work under 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 monuments and markers by the each.

Payment

621.06 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
62101	Monument	Each
62102	Marker	Each

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 rental equipment by the hour of production time as ordered by the CO and furnished. 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, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
62201 *(Type and size of equipment)*	Hour

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 general labor by the hour as ordered by the CO and furnished. 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, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	**Pay Unit**
62301 General labor	Hour

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:

Topsoil (furnished)	713.01(a)
Topsoil (conserved)	713.01(b)

Construction Requirements

624.03 Preparing Areas. Shape all slopes and disturbed areas to be covered with topsoil. Disk or scarify slopes 1:3 or flatter to a depth of 100 millimeters.

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 which, after settlement, will provide 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 that will not break down, stones larger than 50 millimeters, stumps, roots, and other litter according to Subsection 203.05.

Compact the topsoil after placement using a cleated roller, crawler tractor, or other similar equipment that will form longitudinal depressions at least 50 millimeters deep perpendicular to the natural flow of water.

624.05 Acceptance. Material for topsoil (furnished) will be evaluated under Subsections 106.02 and 106.03.

Material for topsoil (conserved) will be evaluated under Subsection 106.02.

Placing topsoil (furnished and conserved) material will be evaluated under Subsections 106.02 and 106.04.

Measurement

624.06 Measure furnishing and placing topsoil, and placing conserved topsoil by the cubic meter in the hauling vehicle, by the hectare on the ground surface, or by the square meter.

Payment

624.07 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	**Pay Unit**
62401	Furnishing and placing topsoil, ___ millimeter depth	Square meter
62402	Furnishing and placing topsoil, ___ millimeter depth	Hectare
62403	Furnishing and placing topsoil	Cubic meter
62404	Placing conserved topsoil, ___ millimeter depth	Square meter
62405	Placing conserved topsoil, ___ millimeter depth	Hectare
62406	Placing conserved topsoil	Cubic meter

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 Turf Establishment Seasons. Establish turf during the local growing season. Do not seed during windy weather or when the ground is excessively wet, frozen, or otherwise untillable.

625.04 Preparing Seedbed. Grade the seeding area to line and grade. Remove all weeds, sticks, stones 50 millimeters 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 100 millimeters and prepare a reasonably firm but friable seedbed. 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 hydro-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. 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. 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. Use hydro-type equipment capable of providing a uniform application. Apply when no rainfall is anticipated for 24 hours.

Apply wood or grass cellulose fiber mulch following the application of seed and fertilizer with hydro-type equipment according to Subsection 625.07(b).

Apply bonded fiber matrix hydramulch at a minimum rate of 3400 kilograms per hectare. Apply so no hole in the matrix is greater than 1 millimeter. 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 seeding and mulching by the hectare on the ground surface, by the square meter, or by the slurry unit. A slurry unit consists of approximately 4000 liters of water plus the specified turf establishment material. Ten slurry units contain the material to cover one hectare.

Measure fertilizer, dry method by the metric ton.

Measure water to establish and maintain germination by the cubic meter in the hauling vehicle or by metering.

Measure turf establishment by the hectare on the ground surface.

Measure supplemental applications of seed, mulch, fertilizer, or lime by the hectare on the ground surface, by the metric ton, or by the kilogram as ordered.

Payment

625.12 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
62501	Seeding, __________ method	Hectare
62502	Seeding, __________ method	Square meter
62503	Seeding, hydraulic method	Slurry unit
62504	Mulching, ___________ method	Hectare
62505	Mulching, ___________ method	Square meter
62506	Mulching, hydraulic method	Slurry unit
62507	Fertilizer, dry method	Metric ton
62508	Water	Cubic meter
62509	Turf establishment	Hectare
62510	*Description* supplemental application	Hectare
62511	*Description* supplemental application	Metric ton
62512	*Description* supplemental application	Pound

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

Construction Requirements

626.03 General. Do not plant in frozen ground, when snow covers the ground, or when the soil is in an unsatisfactory condition 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. Keep all plant material moist and protected (covered) in transit, in temporary storage, and on the project awaiting planting. 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. 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 1 meter, dig the pits circular in outline to the root spread plus 0.5 meter.

(2) For root spreads or ball diameters over 1 meter, excavate 1.5 times the root spread.

(b) Depth of excavation. Dig the pits to a depth that permits a minimum of 150 millimeters of backfill under the roots or balls or dig the pits to the following depths, whichever is deeper:

(1) Deciduous trees.

(a) Under 38 millimeters caliper. 0.5 meter deep
(b) Over 38 millimeters caliper. 1 meter deep

(2) Deciduous and evergreen shrubs.

(a) Under 0.5 meter height. 0.3 meters deep
(b) Over 0.5 meter height. 0.5 meters deep

(3) Evergreen trees.

(a) Under 1.5 meters height. 0.2 meters plus ball height
(b) Over 1.5 meters height. 0.3 meters 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 150 millimeters before setting the plant.

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 and tamp.

(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. 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 50 millimeters of the backfill mixture.

626.09 Watering. Construct 100-millimeter deep water basins around trees and 75-millimeter 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 20 millimeters 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 5 kilograms per cubic meter 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.

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 plants by the each.

Payment

626.16 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Partial payments for plants will be made as follows:

(a) 75 percent of the bid price will be paid following initial planting.

(b) The remaining 25 percent of the bid price will be paid after the final inspection.

Payment will be made under:

Pay Item	Pay Unit
62601 *(Plant name)*, *(size)*	Each

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 100 millimeters. Remove stones larger than 50 millimeters 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 100 millimeters.

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 1:2 or steeper and in channels, peg sod on 0.5 meter 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.

Measurement

627.09 Measure sod by the square meter. Do not measure nonsodded 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, measured as provided above, will be paid at the contract price per unit of measurement for the pay item listed below that is shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
62701 ____________ sod	Square meter

Section 628.) SPRIGGING

Description

628.01 This work consists of furnishing and planting living grass plants. Sprigging is designated as broadcast, row, or spot according to Subsection 628.06.

Material

628.02 Conform to the following Subsections:

Agricultural limestone	713.02
Fertilizer	713.03
Mulch	713.05
Sprigs	713.09
Water	725.01

Construction Requirements

628.03 General. Do not sprig during windy weather or when the ground is dry, excessively wet, frozen, or otherwise untillable.

628.04 Harvesting Sprigs. Provide at least 5 days notice before harvesting sprigs. Before harvesting, mow grass and weeds to a height of 65±15 millimeters and remove all clippings.

Loosen sprigs by cross-disking, shallow plowing, or other acceptable methods. Gather the sprigs in small piles or windrows, water, and keep moist until planting. Dispose of sprigs that freeze or dry out.

628.05 Preparing the Soil. Prepare the soil according to Subsection 627.05.

628.06 Planting Sprigs. Plant the sprigs within 24 hours after harvesting.

(a) Broadcast sprigging. Broadcast sprigs by hand or suitable equipment in a uniform layer over the prepared surface with spacing between sprigs not to exceed 150 millimeters. Force the sprigs into the soil to a depth of 75±25 millimeters with a straight spade, a disk harrow, or other equipment.

(b) Row sprigging. Open furrows along the approximate contour of slopes. Place sprigs in a continuous row in the open furrow with successive sprigs touching. Cover the sprigs immediately.

(c) Spot sprigging. Spot sprig according to (b) above, except that instead of planting in a continuous row, group 4 or more sprigs 0.5 meter apart in the rows.

After planting, clear the surface of stones larger than 25 millimeters, large clods, roots, and other litter brought to the surface during sprigging. Lightly compact sprigged area within 24 hours. Do not compact when soil is so wet that it is picked up by the equipment. Do not compact clayey soils.

When mulch is required by the contract, cover the sprigged area with mulch within 24 hours according to Section 625.

628.07 Maintaining Sprigged Areas. Keep the sprigged areas moist. Water carefully to avoid erosion.

Erect warning signs and barriers to protect newly sprigged areas. Regrade and resprig all areas damaged.

628.08 Acceptance. Material (including lime and fertilizer) for spigging will be evaluated under Subsections 106.02 and 106.03.

Planting living grass plants will be evaluated under Subsections 106.02.

Preparing of soil will be evaluated under Section 627.

Mulch will be evaluated under Section 625.

Measurement

628.09 Measure sprigging by the hectare on the ground surface or by the square meter.

Measure topsoil under Section 624.

Measure water under Section 625.

Payment

628.10 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item	Pay Unit
62801 ____________ sprigging	Hectare
62802 ____________ sprigging	Square meter

Section 629.—EROSION CONTROL MATS, ROVING, AND CELLULAR CONFINEMENT SYSTEMS

Description

629.01 This work consists of constructing erosion control for ditch and slope protection, and stabilization. This includes installing mats, roving, and cellular confinement systems.

Erosion control mats are designated as follows:

Type 1	Straw mats, burlap fabric, jute mesh, and woven paper or sisal mesh netting
Type 2	Straw and coconut mats, excelsior blanket, or mulch blanket
Type 3	Coconut mat
Type 4	Synthetic erosion control mats and meshes
Type 5	Turf reinforcement mats

Material

629.02 Conform to the following Sections and Subsections:

Erosion control mats	713.07(a)
Emulsified asphalt	702.03
Cellular confinement systems	713.07(c)
Roving	713.07(b)
Topsoil	624
Turf establishment	625

Construction Requirements

629.03 Erosion Control Mats (Types 1, 2, 3, 4, and 5). Install erosion control mats according to the manufacturer's recommendations.

Install erosion control mats to soil surfaces which are at final grade, stable, firm, and free of rocks or other obstructions. Spread erosion control mats evenly and smoothly, without stretching, to ensure direct contact with the soil at all points. Unroll erosion control mats parallel to the drainage flow direction. Lap edges as recommended by the manufacturer. Place the upslope end in a 150-millimeter vertical slot. Backfill the slot and compact.

For swale or ditch installations, place up the side slopes to extend above anticipated flow line and construct intermediated 150-millimeter vertical check slots at 8-meter intervals. Construct check slots perpendicular to flow direction. Staple erosion control mats as recommended by manufacturer. Drive all staples flush with the soil surface.

Repair damaged areas immediately. Restore the soil in damaged areas to finished grade, refertilize, and reseed.

(a) Synthetic erosion control mats and meshes (type 4). Install after Section 625 (Turf Establishment) is in place.

(b) Turf reinforcement mats (type 5). Install before Section 625 (Turf Establishment) is in place. After seeding, lightly brush or rake 15±5 millimeter of topsoil into the mat voids to fill the mat thickness.

629.04 Roving. Furnish a pneumatic ejector capable of applying roving at a rate of 0.9 kilograms per minute. Furnish an air compressor capable of supplying 1.1 cubic meters per minute at 620±70 kilopascals, complete with air hoses necessary for supplying air to areas not accessible to the compressor. Furnish an asphalt distributor with necessary hoses and a hand spray bar for slopes and other areas not accessible to the distributor.

(a) Fiber glass roving. Spread fiber glass roving uniformly at the rate of 0.16±0.03 kilograms per square meter to form a random mat of continuous glass fibers.

(b) Polypropylene roving. Spread polypropylene roving uniformly at the rate of 0.08±0.03 kilograms per square meter to form a random mat of continuous polypropylene fibers.

Anchor the roving to the ground with a slow setting emulsified asphalt applied uniformly at a rate of 1.5±0.2 liters per square meter over the roving. Bury upslope end of the roving 300 millimeters deep.

629.05 Cellular Confinement System. 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 every other cell.

Anchor the system with stakes across the top at every other cell. Repeat the anchoring pattern in every tenth row and in the bottom row.

Backfill the system with topsoil. Hand-compact the topsoil within each cell. Apply permanent turf establishment according to Section 625.

629.05 Acceptance. Material (including mats, roving, and cellular confinement systems) for erosion control, ditch and slope protection, and stabilization will be evaluated under Subsections 106.02 and 106.03.

Installation of erosion control mats, roving, 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

629.07 Measure erosion control mats, roving, and cellular confinement systems by the square meter excluding overlaps.

Measure topsoil under Section 624.

Measure turf establishment under Section 625.

Payment

629.08 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		**Pay Unit**
62901	Erosion control mat type ____	Square meter
62902	Roving	Square meter
62903	Cellular confinement system	Square meter

Sections 630, 631, and 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, or 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
Insulating material	556.06(e)
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 shown on the plans may be changed to fit field conditions. Determine the lengths of posts at time of staking.

Drive posts with a suitable driving head or set posts in drilled or punched holes. Replace all posts damaged by driving. Erect sign supports plumb, backfill, and compact.

Construct concrete footings according to Section 601. Perform excavation and backfill work under Section 209.

633.05 Panels. Use type I, II, III, or IV retroreflective sheeting. 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 2 millimeters. To reduce specular glare (mirror reflection), turn the sign panel 3 degrees away from the road in the direction of travel.

Place insulating material to prevent contact between aluminum and steel material. 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 sign installations by the each or by the square meter of front face sign panel as follows:

(a) When an installation is measured by the each, measure each installation as one sign regardless of the number of sign panels or posts in the installation.

(b) When an installation is measured by the square meter, measure the nominal dimensions of all the sign panels in the installation.

(c) A sign installation includes the support.

Measure signs by the each or by the square meter of front face sign panel. Measure each sign in a multiple configuration.

Measure posts by the meter.

Measure object markers and delineators by the each.

Measure removing and resetting permanent traffic control devices by the each 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, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

Pay Item		Pay Unit
63301	Sign installation	Each
63302	Sign installation	Square meter
63303	Signs, ________ panels, type ___ sheeting	Each
63304	Signs, ________ panels, type ___ sheeting	Square meter
63305	Posts, ________	Meter
63306	Object markers *(description)*	Each
63307	Delineators *(description)*	Each
63308	Removing and resetting *(description)*	Each

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.

Remove loose particles, dirt, tar, grease, and other deleterious material from the surface to be marked. Where markings are placed on portland cement concrete 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
- **(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 100 millimeters wide. Make broken lines 3 meters long with 9-meter gaps. Make dotted lines 0.5 meter long with 1-meter gaps. Separate double lines with a 100-millimeter 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.

634.04 Conventional Traffic Paint (Type A). Apply paint when the pavement and air temperatures are above 4 °C. Spray paint at 0.38 millimeters minimum wet film thickness before glass beads or at a rate of 2.6 square meters per liter. Immediately apply type 1 glass beads on the paint at a minimum rate of 0.7 kilograms per liter of paint.

On new asphalt pavements or new asphalt surface treatments, apply two coats. Apply the first coat at 8.8 square meters per liter and the second coat at 3.7 square meters per liter.

634.05 Waterborne Traffic Paint (Type B and C). Apply paint when the pavement and air temperatures are above 10 °C. Spray paint at 0.38 millimeters minimum wet film thickness before glass beads or at a of rate 2.6 square meters per liter.

Type B. Immediately apply type 1 glass beads on the paint at a minimum rate of 0.7 kilograms per liter of paint.

Type C. Immediately apply type 3 glass beads on the paint at a minimum rate of 1.4 kilograms per liter of paint.

On new asphalt pavements or new asphalt surface treatments, apply two coats. Apply each coat at 5.2 square meters per liter.

634.06 Epoxy Markings (Types D and E). Heat components A and B separately at 43±17 °C and mix. Discard all material heated over 60 °C. Apply epoxy when the pavement and air temperatures are above 10 °C. Apply as a spray at 43±17 °C (gun tip temperature) at a 0.38 millimeters minimum dry film thickness or 2.6 square meters per liter.

Type D. Immediately apply type 1 glass beads on the epoxy at a minimum rate of 1.8 kilograms per liter of epoxy.

Type E. Use two bead dispensers. Immediately apply type 4 glass beads on the epoxy at a minimum rate of 1.4 kilograms per liter of epoxy immediately followed by an application of type 1 glass beads at a minimum rate of 1.4 kilograms per liter.

634.07 Polyester Markings (Types F and G). Apply polyester when the pavement and air temperatures are above 10 °C. Spray at 53±4 °C (gun tip temperature) at a 0.38 millimeters minimum dry film thickness or 2.6 square meters per liter. Discard all material heated over 66 °C. Do not use fast dry polyester markings on hot asphalt concrete pavements less than 1 year old.

Type F. Immediately apply type 1 glass beads on the polyester at a minimum rate of 1.8 kilograms per liter of polyester.

Type G. Use two bead dispensers. Immediately apply type 4 glass beads on the polyester at a minimum rate of 1.4 kilograms per liter of polyester immediately followed by an application of type 1 glass beads at a minimum rate of 1.4 kilograms per liter.

634.08 Thermoplastic Markings (Type H and I). On areas to be marked on portland cement concrete 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 10 °C. Spray or extrude the thermoplastic at 220±3 °C. For centerlines and lane lines, spray or extrude 2.3 millimeters minimum dry film thickness or at a rate of 0.44 square meters per liter. For edge lines, spray or extrude 1.5 millimeters minimum dry film thickness or at a rate of 0.66 square meters per liter.

Type H. Immediately apply type 1 glass beads on the thermoplastic at a minimum rate of 0.59 kilograms per square meter.

Type I. Use two bead dispensers. Immediately apply type 5 glass beads on the thermoplastic at a minimum rate of 0.59 kilograms per square meter immediately followed by an application of type 1 glass beads at a minimum rate of 0.59 kilograms per square meter.

The minimum bond strength of the thermoplastic shall be 1.2 megapascals on portland cement concrete 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 60 °C. Roll the marking into the surface with a steel wheel roller. The finished pavement marking may extend approximately 0.25 millimeters 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 10 °C. Apply raised pavement markers with epoxy resin or asphalt adhesive.

Heat epoxy components A and B separately with indirect heat, mix, and apply at 21±6 °C. Discard all material heated over 49 °C or stiffened by polymerization.

Heat and apply asphalt adhesives at 211±7 °C. Discard all material heated over 232 °C.

Space and align the markers to within 13 millimeters of the required location. Do not place raised pavement markers over pavement joints.

The minimum bond strength shall be 12 kilopascals or a total tensile strength of 110 newtons.

634.11 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 pavement markings by the meter, by the liter, by the square meter, or by the kilometer. When two coats of paint are required, measure each coat for payment.

(a) When pavement markings are measured by the meter or kilometer, measure the length of line applied along the centerline of each 100 millimeter-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 100 millimeters, the measured length of line is adjusted in the ratio of the required width to 100 millimeters.

(b) When pavement markings are measured by the square meter, measure the number of square meters 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 meter.

Measure raised pavement markers by the each.

Payment

634.14 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Payment will be made under:

	Pay Item	**Pay Unit**
63401	Pavement markings type ___	Meter
63402	Pavement markings type ___	Square meter
63403	Pavement markings type ___	Liter
63404	Pavement markings type ___	Kilometer
63405	Raised pavement markers	Each

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
Crash cushion barrels	710.12
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.

(2) Repair or remove and replace "unacceptable" devices immediately.

(h) Remove all temporary traffic control devices upon contract completion or when approved.

635.04 Advance Warning Arrow Panels. Perform the work described under MUTCD Part VI.

635.05 Barricades. Perform the work described under MUTCD Part VI. Use type III or IV retroreflective sheeting. Use wood, metal, or plastic barricades. When type II barricades are used, use barricades that collapse when tipped over.

635.06 Cones and Tubular Markers. Perform the work described under MUTCD Part VI. Use 700 millimeter cones or tubular markers. Use type III, IV, or VI retroreflective sheeting.

635.07 Construction Signs. Use type III or IV retroreflective sheeting. Remove or completely cover all unnecessary signs with metal, plywood, or other acceptable material.

Use wood, metal, fiberglass, or other approved posts. Use breakaway posts within the traversable area adjacent to traffic. Install posts according to Section 633.

635.08 Drums. Perform work described in MUTCD Part VI. Use plastic drums that are approximately 900 millimeters high and a minimum of 450 millimeters in diameter. Use type III, IV, or VI retroreflective sheeting.

635.09 Flaggers. Furnish flaggers certified by ATSSA or a state agency. Perform the work described under MUTCD Part VI. Use type III or IV retroreflective sheeting on flagger paddles. Do not use flags.

635.10 Pilot Cars. Perform the work described under MUTCD Part VI. Employ 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 Concrete Barriers. Perform the work described under MUTCD Part VI. Furnish temporary concrete barriers that are new or used provided they are not badly damaged. Lifting holes no larger than 100 millimeters or lifting loops are permitted. Individual sections may vary in length. Connect sections so they do not separate when struck by a vehicle.

Mount 75-millimeter minimum dimension white or yellow retroreflectors, as applicable, to the top or side of the barrier on 7.5-meter centers. Mount the retroreflectors at a uniform height at least 0.6 meters above the pavement surface.

635.12 Temporary Guardrail. Used guardrail material may be used with approval. Construct temporary guardrail according to Section 617.

Mount 75-millimeter minimum dimension white or yellow retroreflectors, as applicable, to the top or side of the guardrail on 7.5-meter centers. Mount the retroreflectors at a uniform height at least 0.6 meters above the pavement surface.

635.13 Temporary Pavement Markings and Delineation. Before opening a pavement surface to traffic, provide acceptable pavement markings or delineation and signing according to Section 156 and the MUTCD.

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 0.38-millimeter minimum wet film thickness (0.38 liters per square meter). Immediately apply type 1 glass beads on the paint at a minimum rate of 0.7 kilograms per liter 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) 3-meter broken line. Four pavement markers spaced 1 meter apart followed by a 9-meter gap.

(2) 1-meter broken line. Three pavement markers spaced 0.5 meter apart followed by an 11-meter gap.

(3) 0.5-meter broken line. Two pavement markers spaced 0.5 meter apart followed by a 5.5-meter gap.

(4) Solid line. Pavement markers on 1.5-meter centers.

Remove all temporary raised pavement markers before placing additional pavement layers.

Install and maintain temporary pavement markings that are neat, crack free, true, straight, and unbroken.

Remove all temporary pavement markings from the surface course before placing permanent pavement markings.

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.

635.14 Vertical Panels. Perform the work described under MUTCD Part VI. Use wood, metal, or plastic vertical panels. Use type III or IV retroreflective sheeting.

635.15 Warning Lights. Perform the work described under MUTCD Part VI. 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 300 millimeters from ground or roadway surface as measured to top of the battery casing.

635.16 Shadow Vehicle. Furnish a shadow vehicle (6800-kilogram 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. Furnish the 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 60 meters 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 30 meters before the sign location in a blocking position.

(d) Install 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 30 meters 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. Furnish an asphalt mix according to Section 401, 402, or 417 to repair potholes and rough spots in the traveled way before reopening travel lanes to traffic.

635.18 Variable Message Sign. Furnish a self-contained, trailer mounted sign system consisting of a sign message panel, controller, power source, and structural support system. Make the trailer and sign support system safety orange. Furnish a sign system that:

(a) Has a 3 line sign message panel containing at least 8 modular and interchangeable bulb or dot matrix assemblies per line, each capable of displaying a character.

(1) Bulb matrix. Furnish a sign panel assembly containing eight lamp bank matrices with a minimum of 7 X 5 lamps per line, which displays up to eight characters minimum, 450 millimeters minimum in height. Furnish rugged, high performance, 50 millimeters diameter, sealed beam unit lamps rated at 24 volts, 20 watts with a minimum light output of 8600 lux.

(2) Dot matrix. Furnish a dot matrix assembly containing electromagnetically activated fluorescent yellow dots. Illuminate the sign panel by internal backlight. Activate the backlight system by photo cell system to measure both vertical and horizontal ambient lighting. Provide a manual over-ride switch to deactivate the photo cell system.

(b) Is legible from a distance of 275 meters.

(c) Cycles messages so 3 message cycles are displayed to the driver while approaching the sign at 90 kilometers per hour from 275 meters.

(d) Operates on a continuous basis for at least 5 days.

(e) Electrically and manually raises the message panel in the vertical axis a minimum of 2.1 meters above the pavement surface.

(f) Rotates the message panel 30 degrees vertically and 360 degrees horizontally and stops in any position.

(g) Allows the entry of all sign and message functions from a controller in a control cabinet on the trailer mounted unit.

(h) Has a start/stop switch on the controller to activate the power supply and sign panel.

(i) Requires an entry code for entry into the controller to access the memory and display messages.

(j) Has a keyboard to generate and store a minimum of 20 preprogrammed or newly composed messages.

635.19 Temporary Crash Cushions.

(a) Crash cushion barrels. Provide and install all parts of the completed barrels including placement of sand according to the manufacturer's recommendations. After the barrels are set and the sand placed, secure the lids in place to prevent loss or theft. If the barrels are placed on surfaces subject to vibrations or on steep slopes, secure the barrels according to the manufacturer's recommendations.

(b) GREAT system. Provide a 3-bay (or 6-bay) Construction Zone Guardrail Energy Absorbing Terminal (GREAT) crash cushion manufactured by Energy Absorption Systems, Inc., or an approved equal. Maintain 8 additional cartridges for use in reestablishing damaged systems. Mount type II retroreflective sheeting to the front face.

635.20 Temporary Signal System. Design, furnish, and install a temporary signal system according to Section 636 and MUTCD Part IV. Furnish either new or used material for temporary traffic signal systems. Used material is subject to the CO's approval.

Furnish signal heads with three lenses, minimum 200 millimeters diameter, indicating red, yellow, and green phases. Furnish 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. Provide and install temporary fence according to Section 619.

635.22 Portable Rumble Strip. Provide and install a strip 3 meters long, 450 millimeters wide, and 30 millimeters high to alert drivers of an approaching flagger station or work area.

635.23 Opposing Traffic Lane Divider. Provide and install 300 by 450-millimeter signs mounted on flexible supports on a temporary centerline to remind drivers of a two-way traffic pattern on sections that are normally one-way.

635.24 Steel Plates. Furnish 25-millimeter 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, barrels, 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 temporary traffic control by the lump sum.

Measure the following items for payment when ordered by the CO and installed:

(a) Measure advance warning arrow panels by the hour or by the each. When measurement is by the each, measure the panels only one time even if relocated or replaced. When measurement is by the hour, round portions of an hour up to the half hour.

(b) Measure barricades by the meter of width or by the each. Measure only one time even if relocated or replaced.

(c) Measure cones by the each. Measure only one time even if relocated or replaced.

(d) Measure construction signs by the square meter of front face sign panel. Do not measure posts and temporary supports. Measure only one time even if relocated or replaced.

(e) Measure drums by the each. Measure only one time even if relocated or replaced.

(f) Measure flaggers by the hour, for each hour a person is actually performing the work. Round portions of an hour up to the half hour. Time measured in excess of 40 hours per week will be measured at the same rate as the first 40 hours.

(g) Measure pilot cars (including operators) by the hour for each hour the car is actually performing the work. Round portions of an hour up to the half hour. Time measured in excess of 40 hours per week will be measured at the same rate as the first 40 hours.

(h) Measure temporary concrete barriers by the meter along the face of the barrier. Measure only one time even if relocated or replaced.

(i) Measure moving temporary concrete barriers by the meter along the face of the barrier as reinstalled at designated locations that are more than 3 meters from the point of initial installation.

(j) Measure temporary guardrail by the meter along the face of the rail from center-to-center of end posts.

(k) Measure temporary pavement markings by the meter, by the kilometer, by the square meter, or by the each. Measure only one application of pavement markings per lift.

When temporary pavement markings are measured by the meter or kilometer, measure the number of meters or kilometers of lines applied along the centerline of each 100-millimeter 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 100 millimeters, adjust the measured length of line in the ratio of the required width to 100 millimeters.

When temporary pavement markings are measured by the square meter, measure the number of square meters 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 tenth of a square meter.

(l) Measure temporary raised pavement markers by the each. Measure only 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.

(m) Measure pavement marking removal by the meter of line removed. Gaps will not be measured.

(n) Measure vertical panels by the each. Measure only one time even if relocated or replaced.

(o) Measure warning lights by the each. Measure only one time even if relocated or replaced.

(p) Measure shadow vehicles by the each.

(q) Measure pavement patches by the metric ton.

(r) Measure variable message signs by the each.

(s) Measure temporary crash cushions by the each for each entire crash configuration. Measure only one time even if relocated or replaced.

(t) Measure moving temporary crash cushion by the each for each entire crash configuration.

(u) Measure replacement barrels or cartridges for crash cushions by the each for barrels or cartridges damaged by public traffic.

(v) Measure temporary traffic signal system by the lump sum or each.

(w) Measure relocating temporary traffic signal system by the each.

(x) Measure temporary fence by the meter.

(y) Measure portable rumble strips by the each. Measure only one time even if relocated or replaced.

(z) Measure opposing traffic lane dividers by the each. Measure only one time even if relocated or replaced.

(aa) Measure steel plates by the square meter. Measure only one time even if relocated or replaced.

Payment

635.27 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown 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 for each item will be paid upon installation.

(b) 25 percent of the unit bid price for each item will be paid following completion of 50 percent of the contract amount.

(c) Payment of the remaining portion of the unit bid price for each item will be paid when the temporary traffic control devices are removed from the project.

Progressive 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.

Payment will be made under:

Pay Item		Pay Unit
63501	Temporary traffic control	Lump sum
63502	Advance warning arrow panel type ___	Hour
63503	Advance warning arrow panel type ___	Each
63504	Barricade type ___	Meter
63505	Barricade type ___	Each
63506	Cone _*(description)*_	Each
63507	Construction sign	Square meter
63508	Drum _*(description)*_	Each
63509	Flagger	Hour
63510	Pilot car	Hour
63511	Temporary concrete barrier	Meter
63512	Moving temporary concrete barrier	Meter
63513	Temporary guardrail	Meter
63514	Temporary pavement markings	Meter
63515	Temporary pavement markings	Kilometer
63516	Temporary pavement markings, symbols, and letters	Square meter
63517	Temporary pavement markings, symbols, and letters	Each
63518	Temporary raised pavement marker	Each
63519	Pavement marking removal	Meter
63520	Vertical panel	Each
63521	Warning light type ___	Each
63522	Shadow vehicle	Each
63523	Maintenance of traffic, pavement patch	Metric ton
63524	Variable message sign	Each
63525	Temporary crash cushion _*(description)*_ system	Each
63526	Moving temporary crash cushion	Each
63527	Replacement _*(description)*_ for crash cushions	Each
63528	Temporary traffic signal system	Lump sum
63529	Temporary traffic signal system	Each
63530	Relocating temporary traffic signal system	Each
63531	Temporary fence _*(description)*_	Meter
63532	Portable rumble strip	Each
63533	Opposing traffic lane divider	Each
63534	Steel plates	Square meter

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
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.

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. Perform excavation and backfill work under 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 11 and 54 lux. 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, 8-millimeter wide, and 45-millimeter 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 0.6-meter long backer rods.

Where the loop wire crosses a crack or joint, use a plastic sleeve which extends 100 millimeters 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 3 turns per meter from the loop to the pull box. Color code the wires of each loop for identification of separate loops. Coil 1 meter 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 microohms 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 which 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 signal installation, lighting installation, electrical installation, railroad crossing system, and relocations by the lump sum.

Measure conduits and electrical conductors (wire) by the meter.

Measure luminaires, poles, and pull boxes by the each.

Measure relocations by the each. Do not measure additional line or connections necessary, to place the fixture at the new location.

Payment

636.13 The accepted quantities, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

Lump sum items will be paid as follows:

(a)75 percent of the lump sum will be paid as the work progresses based on a certified cost breakdown.

(b) Payment of the remaining 25 percent will be made upon successful completion of the demonstration period.

Payment will be made under:

Pay Item		Pay Unit
63601	Signal installation	Lump sum
63602	Lighting installation	Lump sum
63603	Electrical installation	Lump sum
63604	Railroad crossing system	Lump sum
63605	Relocate *(description)*	Lump sum
63606	Conduit, ___ millimeter, *(description)*	Meter
63607	Electrical conductors *(description)*	Meter
63608	Luminaires *(description)*	Each
63609	Poles *(description)*	Each
63610	Pull box	Each
63611	Relocate *(description)*	Each

SECTION 637.) FACILITIES AND SERVICES

Description

637.01 This work consists of furnishing, installing, maintaining, and removing facilities (including services) such as field offices, field laboratories, 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) Field laboratory. Furnish and maintain a field laboratory according to Tables 637-1 and 637-2.

When concrete testing is required, furnish a curing tank according to AASHTO M 201 with a minimum capacity for fifty 150 by 300-millimeter cylinders. Locate the curing tank for concrete cylinders in a 14-square meter or larger room. The room may be an adjacent separate facility or may be a second room of the field laboratory.

Equip the tank with a heater and circulator, an outlet for draining the tank, and a separate pressurized water source for filling the tank.

(c) 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	Field Laboratory	Residential Housing
Floor space - m^2	37	28	46
Locking outside door - deadbolt with keys	1	1	1
Steps with slipproof tread and handrails	(1)	(1)	(1)
Windows with locks	2	2	3
Total window area - m^2	2.8	1.4	5.6
Ceiling height, 2.1 m	✓	✓	✓
Rooms, including toilet room	4	2	5(2)
Room Size, except toilet room - m^2	9	28	9
Closet - 1.2 m^3			2
Shelves, 300 mm depth - m^2	1.1	2.2	1.1
Electrical lighting	✓	✓	✓
Heat and air conditioning, maintain temperature of 22±4 °C	✓	✓	✓
Adequate electrical outlets	✓	✓	✓
Surge protectors	✓	✓	✓
Adequate Electricity (120 and/or 240 volt, 60 cycle as applicable)	✓	✓	✓
Adequate potable water supply	✓	✓	✓
Drinking water cooler with water supply	✓	✓	
Sparkproof exhaust fan - 0.6 m^3/s		✓	
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	✓	✓	✓
1.8 m 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	Field Laboratory	Residential Housing
Table 750 mm wide x 2.4 m long x 750 mm high	1		
File cabinet, 2-drawer, fire resistant, metal, with lock	1		
File cabinet, 4-drawer, metal	1	1	
Desk - 1.1 m^2	2	1	
Desk lamp	2	1	
Office chair	5	1	
Storage cabinet 1.8 m wide x 900 mm wide x 450 mm high	1		
Fire extinguisher	1	1	2
Refrigerator, 0.28 m^3			1
Range and oven, standard 900 mm			1
Kitchen table with 2 chairs			1 set
Sofa, 1.8 m			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, 900 mm			2

637.04 Acceptance. Facilities and services will be evaluated under Subsections 106.02 and 106.04.

Measurement

637.05 Measure field office, field laboratory, and residential housing by the each.

Payment

637.06 The accepted quantity, measured as provided above, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the bid schedule. Payment will be full compensation for the work prescribed in this Section. See Subsection 109.05.

The bid amount for each facility will be paid as follows:

(a)60 percent of the each bid amount will be paid after the facility is accepted as available for occupancy.

(b) Payment of the remaining 40 percent of the bid amount will be paid after final acceptance or when CO determines the facility is no longer needed.

Payment will be made under:

Pay Item		Pay Unit
63701	Field office	Each
63702	Field laboratory	Each
63703	Residential housing	Each

DIVISION 700
Material

Section 701.) HYDRAULIC CEMENT

701.01 Portland Cement and Masonry Cement. Furnish cement according to Table 701-1 and the following.

Table 701-1
Types of Cement

Type	Specification
Portland cement	AASHTO M 85
Blended hydraulic cement	AASHTO M 240
Masonry cement	ASTM C 91

Do not use different brands or types of cement, or the same brand or type of cement from different mills without approval.

Section 702.) ASPHALT MATERIAL

702.01 Asphalt Cement. Conform to AASHTO M 20, M 226, or MP 1. 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 to (c)(4)(a) below for the penetration on the residue.

(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 (c)(4)(a) below for the penetration on the residue.

(c) Quick-setting emulsions. Conform to the following:

(1) Viscosity, Saybolt Furol at 25 °C, AASHTO T 59	20 to 100 s
(2) Residue by distillation, AASHTO T 59	57% min.
(3) Sieve test, AASHTO T 59	0.10 max.
(4) Tests on residue from distillation:	
(a) Penetration, 25 °C, 100 g, 5 s, AASHTO T 49	40 to 100
(b) Solubility in trichloroethylene, AASHTO T 44	97.5% min.
(c) Ductility, 25 °C, 50 mm/min, AASHTO T 51	40 mm min.

702.04 Application Temperatures. Apply asphalt within the temperature ranges shown in Table 702-1.

Table 702-1
Application Temperatures - Range °C

Type and Grade of Asphalt	Temperature Ranges Minimum - Maximum	
	Spraying Temperatures	Mixing Temperatures (1)
Cut-back asphalt)		
MC-30	30 - (2)	)
RC or MC-70	50 - (2)	)
RC or MC-250	75 - (2)	60 - 80(3)
RC or MC-800	95 - (2)	75 - 100(3)
RC or MC-3000	110 - (2)	80 - 115(3)
Emulsified asphalt)		
RS-1	20 - 60	)
RS-2	50 - 85	)
MS-1	20 - 70	20 - 70
MS-2, MS-2h	)	20 - 70
HFMS-1, 2, 2h, 2s	20 - 70	10 - 70
SS-1, 1h, CSS-1, 1h	20 - 70(4)	20 - 70
CRS-1	50 - 85	)
CRS-2	60 - 85	)
CMS-2, CMS-2h	40 - 70	50 - 60
Asphalt cement)		
All grades	180 max.	180 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 except uniformly mix the mortar to a spreading consistency using volumetric proportions of 1 part portland cement to 3 parts fine aggregate.

(e) Asphalt plank. Conform to ASTM D 517 and the following:

(1) Thickness. 32 millimeters.

(2) Width. 225±75 millimeters. Use only one width of plank for a single structure except for necessary closers.

(3) Length. 1 to 2.5 meters. 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 ASTM D 4552 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 Subsection 725.03.

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
(11) Specific gravity at 15 °C

(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. Mix crushed stone or gravel, and asphalt in an approved plant. Conform to aggregate gradation and quality and asphalt grade and quality specifications normally used in the construction of highways by Federal or state agencies.

Do not use an aggregate asphalt mix that strips. For patching mixes, use an asphalt grade and mix that remains pliable and workable at -10 °C.

Section 703.) AGGREGATE

703.01 Fine Aggregate for Portland Cement 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 75-μm sieve, AASHTO T 11	3.0% max.
(b) Sand equivalent value, AASHTO T 176 referee method	75 min.

For lightweight fine aggregate, conform to AASHTO M 195.

703.02 Coarse Aggregate for Portland Cement 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, FLH T 512	1.0% max.

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 no. 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 Standard Sieves (AASHTO T 11 and T 27)
75 mm	100
19.0 mm	50 - 90
4.75 mm	20 - 50
75 μm	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, FLH T 507	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 4.75 millimeter 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)
63 mm	100	[1]			
50 mm	97 - 100	100[1]	100[1]		
37.5 mm		97 - 100	97 - 100[1]	100[1]	
25 mm	65 - 79 (6)			97 - 100	100[1]
19 mm			67 - 81 (6)		97 - 100
12.5 mm	45 - 59 (7)				
9.5 mm				56 - 70 (7)	67 - 79 (6)
4.75 mm	28 - 42 (6)	40 - 60 (8)	33 - 47 (6)	39 - 53 (6)	47 - 59 (7)
425 µm	9 - 17 (4)		10 - 19 (4)	12 - 21 (4)	12 - 21 (4)
75 µm	4.0 - 8.0 (3)	0.0 - 12.0 (4)	4.0 - 8.0 (3)	4.0 - 8.0 (3)	4.0 - 8.0 (3)

(1) Statistical procedures do not apply.
( ) Allowable deviations (±) 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 and T 11)
25 mm	100[(1)]
19 mm	97 - 100[(1)]
4.75 mm	41 - 71 (7)
425 µm	12 - 28 (5)
75 µm	9 - 16 (4)
Plasticity index	8 (4)

(1) Statistical procedures do not apply.
( ) Allowable deviations (±) 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 25 millimeters 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 4.75-millimeter 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, FLH T 507	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 4.75-millimeter 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 referee 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 and AASHTO T 11)					
	Grading Designation					
	A	**B**	**C**	**D**	**E**	**F**
37.5 mm	100[1]					
25 mm	97-100[1]	100[1]	100[1]			
19 mm	)	97-100[1]	97-100[1]	100[1]	100[1]	
12.5 mm	)	76-88(5)	*(5)	97-100[1]	97-100[1]	
9.5 mm	53-70(6)	)	*(6)	)	*(5)	100[1]
4.75 mm	40-52(6)	49-59(7)	*(7)	57-69(6)	*(6)	33-47(6)
2.36 mm	25-39(4)	36-45(5)	*(5)	41-49(6)	*(6)	7-13(4)
600 µm	12-22(4)	20-28(4)	*(4)	22-30(4)	*(4)	)
300 µm	8-16(3)	13-21(3)	*(3)	13-21(3)	*(3)	)
75 µm	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.
( ) Allowable deviations (±) 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, FLH T 506 75% min.
(b) 1 or more fractured faces, FLH T 506 90% min.
(c) Flakiness index, FLH T 508 30 max.

703.09 Emulsified Asphalt Pavement Aggregate.

(a) Coarse aggregate. 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, FLH T 507	75% min.
(4) Durability index (coarse), AASHTO T 210	35 min.

Do not use aggregates known to polish or carbonate aggregates containing less than 25 percent by mass of insoluble residue according to ASTM D 3042.

(b) Fine aggregate. 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 referee method	35 min.

(c) Composite aggregate blend. Size, grade, and combine the aggregate fractions in mix proportions conforming to the following:

(1) Dense graded mix gradation	Table 703-5
(2) Open graded mix gradation	Table 703-6
(3) Clay lumps and friable particles, AASHTO T 112	1.0% max.
(4) Reasonably free from organic or other deleterious material	

Table 703-5
Target Value Ranges for
Dense Graded Emulsified Asphalt Pavement Aggregate Gradation

Sieve Size	Percent by mass passing designated sieve (AASHTO T 27 and AASHTO T 11)				
	Grading Designation				
	A	B	C	D	E
50 mm	100[1]				
37.5 mm	95-100[1]	100[1]			
25 mm	)	95-100[1]	100[1]		
19 mm	60-80(7)	)	95-100[1]	100[1]	
12.5 mm	)	60-80(7)	)	95-100[1]	100[1]
9.5 mm	)	)	60-80(7)	)	95-100[1]
4.75 mm	20-55(7)	25-60(7)	35-65(7)	45-70(7)	60-80(7)
2.36 mm	10-40(6)	15-45(6)	20-50(6)	25-55(6)	35-65(6)
300 µm	2-16(4)	3-18(4)	3-20(4)	5-20(4)	6-25(4)
75 µm	0-5(3)	1-7(3)	2-8(3)	2-9(3)	2-10(3)

(1) Statistical procedures do not apply.
( ) Allowable deviations (±) from the target values.

Table 703-6
Target Value Ranges for
Open Graded Emulsified Asphalt Pavement Aggregate Gradation

Sieve Size	Percent by mass passing designated sieve (AASHTO T 27 and AASHTO T 11)			
	Grading Designation			
	A	B	C	D
37.5 mm	100(1)			
25 mm	95-100(1)	100(1)		
19 mm	)	95-100(1)	100(1)	
12.5 mm	25-65(7)	)	95-100(1)	100(1)
9.5 mm	)	20-55(7)	35-40(7)	85-100(7)
4.25 mm	0-10(5)	0-10(5)	-	)
2.36 mm	0-5(3)	0-5(3)	3-7(3)	)
1.18 mm	)	)	-	0-5(3)
75 µm	0-2(1)	0-2(1)	0-1(1)	0-2(1)

(1) Statistical procedures do not apply.
( ) Allowable deviations (±) from the target values.

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) Density, AASHTO T 19M	1100 kg/m^3 min.
(e) Coating and stripping of bitumen-aggregate mixtures, AASHTO T 182	95% min.

(f) Adherent coating on the aggregate, FLH T 512 — 0.5% max.
(g) Fractured faces, FLH T 507 — 75% min.
(h) Flakiness index, FLH T 508 — 30 max.
(i) Durability index (coarse), AASHTO T 210 — 35 min.
(j) Durability index (fine), AASHTO T 210 — 35 min.
(k) Clay lumps and friable particles, AASHTO T 112 — 1.0% max.
(l) Reasonably free from organic or other deleterious material

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 and AASHTO T 11)					
	Grading Designation					
	A	B	C	D	E	F
37.5 mm	100[1]					
25 mm	90-100(3)	100[1]				
19 mm	0-35(5)	90-100(3)	100[1]			
12.5 mm	0-8(3)	0-35(5)	90-100(3)	100[1]		
9.5 mm	)	0-12(3)	0-35(5)	85-100(3)	100[1]	100[1]
4.25 mm	)	)	0-12(3)	0-35(5)	85-100(3)	85-100[1]
2.36 mm	)	)	)	0-8(3)	0-23(4)	)
75 µm	0-1(1)	0-1(1)	0-1(1)	0-1(1)	0-1(1)	0-10[1]

(1) Statistical procedures do not apply.
( ) Allowable deviations (±) from the target values.

703.11 Slurry Seal Aggregate. Furnish natural or manufactured sand, slag, crushed fines, or other mineral aggregate conforming to AASHTO M 29 and the following:

(a) Gradation	Table 703-8
(b) Los Angeles abrasion, AASHTO T 96	35% max.
(c) Sand equivalent value, AASHTO T 176 referee method	45 min.
(d) Smooth textured sand with < 1.25% water absorption content by weight of total combined aggregate	50% max.

Table 703-8
Slurry Seal Aggregate Gradation (1) and Application Rates (2)

Sieve Size	Percent by mass passing designated sieve (AASHTO T 27 and AASHTO T 11)		
	Type of Slurry Seal		
	I	II	III
	Gradation Requirements		
9.5 mm	)	100	100
4.75 mm	100	90-100	70-90
2.36 mm	90-100	65-90	45-70
1.18 mm	65-90	45-70	28-50
600 µm	40-65	30-50	19-34
300 µm	25-42	18-30	12-25
150 µm	15-30	10-21	7-18
75 µm	10-20	5-15	5-15
Application Rate(2), kg/m²	3.3 - 5.5	5.5 - 8.2	8.2 or more

(1) Statistical procedures do not apply.
(2) Based on the dry mass of the aggregate.

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 referee 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 and T 11)
9.5 mm	100
4.75 mm	70 - 100
75 µm	0.0 - 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 9.5-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 no. 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 (5 cycles)	12% max.
(c) Durability index (coarse and fine)	35 min.
(d) Fractured faces, FLH T 506 and T 507	Table 703-10
(e) Fine aggregate angularity, AASHTO TP 33 method A	Table 703-11
(f) Flat and elongated particles, ASTM D 4791	Table 703-12
(g) Sand equivalent value, AASHTO T 176 referee method	Table 703-13

(h) Gradation. Size, grade, and combine the aggregate fractions in mix proportions that result in a composite blend between the control points for the appropriate nominal maximum size of aggregate of Table 703-14, 703-15, or 703-16. The nominal maximum size is one sieve size greater than the first sieve to retain more than 10 percent of the combined aggregate. Do not produce mixes for a nominal maximum size aggregate that fall in restricted zone shown in Table 703-14, 703-15, or 703-16 as appropriate. Test according to AASHTO T 11 and AASHTO T 27.

Table 703-10
Fractured Faces Requirement

Traffic, million ESALs	Depth from Surface	
	< 100 mm	**≥ 100 mm**
≤ 0.3	55/-	-/-
> 0.3 - 1	65/-	-/-
> 1 - 3	75/-	50/-
> 3 - 10	85/80	60/-
> 10 - 30	95/90	80/75
> 30 - 100	100/100	95/90
> 100	100/100	100/100

Note: "85/80" denotes that 85 percent of coarse aggregate has one fractured face and 80 percent has two fractured faces.

Table 703-11
Fine Aggregate Angularity

Traffic, million ESALs	Depth from Surface	
	< 100 mm	≥ 100 mm
≤ 0.3	-	-
> 0.3 - 1	40 min.	-
> 1 - 3	40 min.	40 min.
> 3 - 30	45 min.	40 min.
> 30	45 min.	45 min.

Table 703-12
Flat and Elongated Particles Requirement

Traffic, million ESALs	Percent (maximum)
≤ 1	-
> 1	10

Table 703-13
Sand Equivalent Requirement

Traffic, million ESALs	Sand Equivalent (minimum)
≤ 3	40
> 3 - 30	45
> 30	50

Table 703-14
Superpave Gradation for 12.5-mm Nominal Maximum Size Aggregate

Sieve mm	Control Points		0.45 Chart Max Den	Restricted Zone Min. Boundary	Restricted Zone Max. Boundary	Target Values	Allowable Deviation
19.00		100.0	100.0				
12.50	100.0	90.0	82.8				
9.50			73.2				
4.75			53.6			*	(6)
2.36	58.0	28.0	39.1	39.1	39.1	*	(6)
1.18			28.6	25.6	31.6		
0.60			21.1	19.1	23.1	*	(4)
0.30			15.5	15.1	15.1	*	(3)
0.15			11.3				
0.075	10.0	2.0	8.3			*	(2)

* Contractor specified target value to the nearest 0.1 percent.
( ) Allowable deviations (±) from the target values.

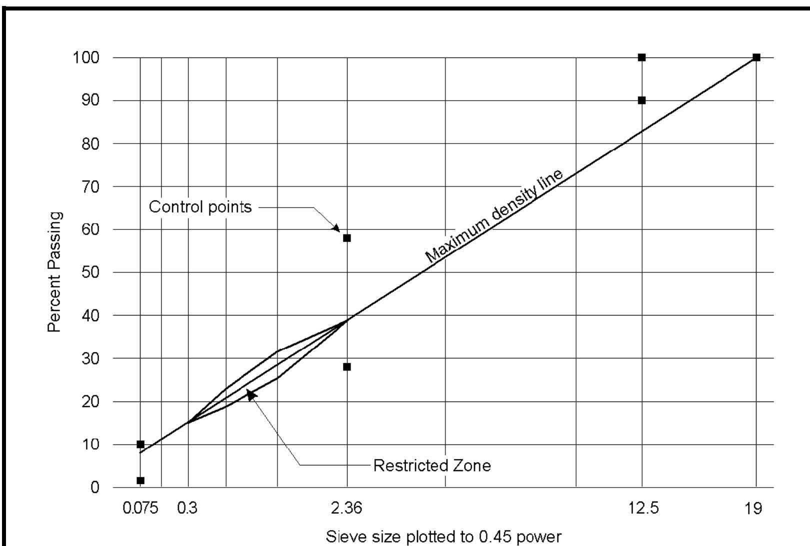

Figure 703-1
Gradation Chart for 12.5-mm Nominal Maximum Size Aggregate

Table 703-15
Superpave Gradation for 19-mm Nominal Maximum Size Aggregate

Sieve mm	Control Points		0.45 Chart Max Den	Restricted Zone Min. Boundary	Restricted Zone Max. Boundary	Target Values	Allowable Deviation
25		100.0	100.0				
19.00	100.0	90.0	88.4				
12.50			73.2				
9.50			64.7				
4.75			47.4			*	(6)
2.36	49.0	23.0	34.6	34.6	34.6	*	(6)
1.18			25.3	22.3	28.3		
0.60			18.7	16.7	20.7	*	(4)
0.30			13.7	13.7	13.7	*	(3)
0.15			10.0				
0.075	8.0	2.0	7.3			*	(2)

* Contractor specified target value to the nearest 0.1 percent.
( ) Allowable deviations (±) from the target values.

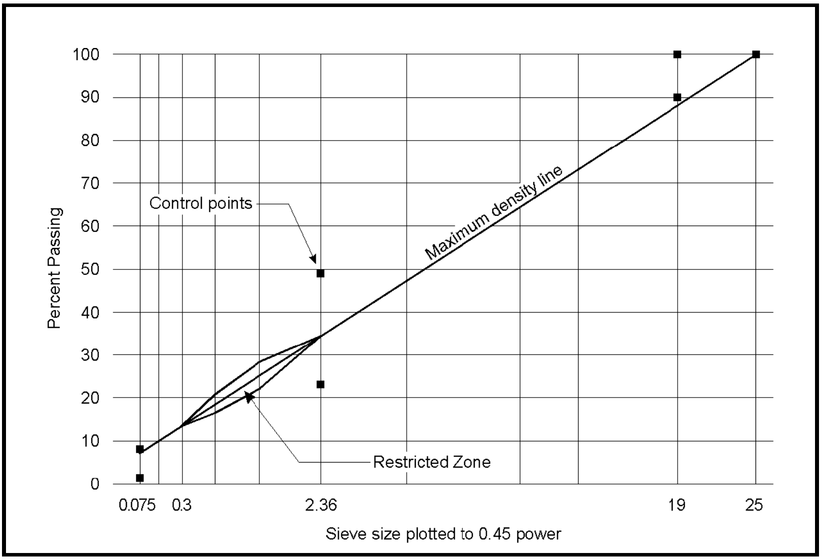

Figure 703-2
Gradation Chart for 19-mm Nominal Maximum Size Aggregate

Table 703-16
Superpave Gradation for 25-mm Nominal Maximum Size Aggregate

Sieve mm	Control Points		0.45 Chart Max Den	Restricted Zone Min. Boundary	Restricted Zone Max. Boundary	Target Values	Allowable Deviation
37.5		100.0	100.0				
25	100.0	90.0	83.3				
19.00			73.6				
12.50			61.0				
9.50			53.9				
4.75			39.5	39.5	39.5	*	(6)
2.36	45.0	19.0	28.8	26.8	30.8	*	(6)
1.18			21.1	18.1	24.1		
0.60			15.6	13.6	17.6	*	(4)
0.30			11.4	11.4	11.4	*	(3)
0.15			8.3				
0.075	7.0	1.0	6.1			*	(2)

* Contractor specified target value to the nearest 0.1 percent.
( ) Allowable deviations (±) from the target values.

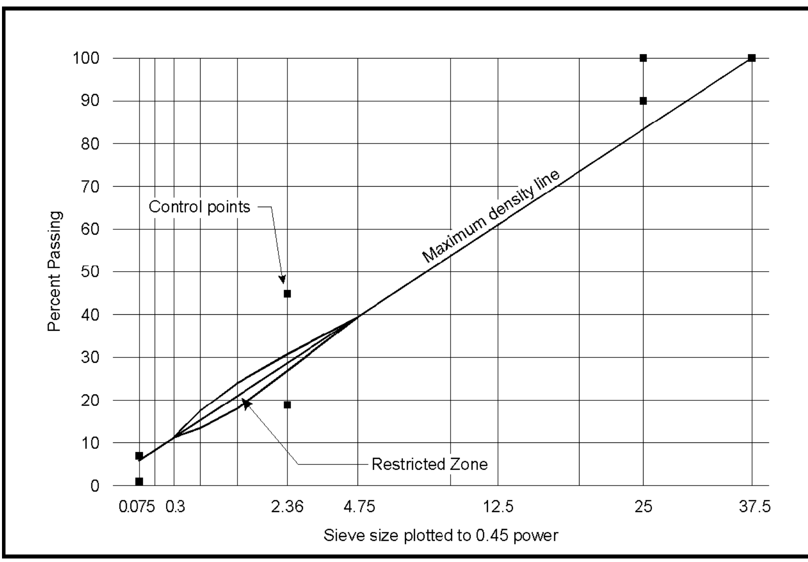

Figure 703-3
Gradation Chart for 25-mm Nominal Maximum Size Aggregate

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) Material passing 50-mm sieve	100%
(b) Soil classification, AASHTO M 145	A-1-a
(c) In wet environments, material passing 75-µm sieve, AASHTO T 27 and T 11	6% max.

704.02 Bedding Material. Conform to the following:

(a) Class A bedding material. Furnish concrete conforming to Section 601.

(b) Class B bedding material. Furnish sand or selected sandy soil free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material and conforming to the following:

(1) Material passing 9.5-mm sieve, AASHTO T 27	100%
(2) Material passing 75-µm sieve, AASHTO T 27 and T 11	10% max.

(c) Class C bedding material. Furnish sand or fine granular material free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material. Remove all rock particles and hard earth clods larger than 38 millimeters.

704.03 Backfill Material. Furnish granular material or fine soil free of excess moisture, muck, frozen lumps, roots, sod, or other deleterious material. Remove all rock particles and hard earth clods larger than 75 millimeters in the longest dimension.

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 dimension	75 mm
(b) Material passing 75-µm 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 dimension	100 mm
(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 dimension	600 mm
(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)
75 mm	100
25.0 mm	70-100
4.75 mm	30-70
150 μm	0-15

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, uniform 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 and T 11)
75 mm	100
75 μm	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, uniform 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 and T 11)
12.5 mm	100
75 μm	0 - 10

704.10 Select Granular Backfill. Furnish sound, durable, granular material free from organic matter or other deleterious material (such as shale or other soft particles with poor durability). Conform to the following:

(a) Quality requirements.

(1) Gradation	Table 704-4
(2) Shear angle of internal friction, 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 7.

(3)	Sodium sulfate soundness loss (5 cycles), AASHTO T 104	15% max.
(4)	Los Angeles abrasion, AASHTO T 96	50% max.
(5)	Liquid limit, AASHTO T 89	30 max.

(b) Electrochemical requirements.

(1)	Resistivity, AASHTO T 288	3000 Ω·cm min.
(2)	pH, AASHTO T 289	5.0 to 10.0
(3)	Sulfate content, AASHTO T 290	1000 ppm max.
(4)	Chloride content, AASHTO T 291	200 ppm max.

Note: Tests for sulfate and chloride content are not required when pH is between 6.0 and 8.0 and the resistivity is greater than 5000 ohm centimeters.

Table 704-4
Select Granular Backfill Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 and T 11)
100 mm	100
75 mm	75 - 100
75 μm	0 - 15

704.11 Special Grout Backfill. Furnish lean grout slurry composed of 3 parts portland cement and 8 parts fine aggregate by volume. Fly ash may be substituted for 2 of the 3 parts portland cement. Conform to the following:

(a)	Water/cement ratio	1.5
(b)	Portland cement	Subsection 701.01
(c)	Fly ash	AASHTO M 295 class C
(d)	Fine aggregate	Subsection 703.01
(e)	Water	Subsection 725.01

704.12 Crib Wall Backfill. Furnish material according to Subsection 704.10, except conform to the following:

(a) Gradation — Table 704-5
(b) Unit mass, AASHTO T 19M — 1900 kg/m^3 min.

Table 704-5
Crib Wall Backfill Gradation

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T 27 and T 11)
75 mm	100
4.75 mm	25 - 70
300 µm	5 - 20
75 μm	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	1600 kg/m^3 min.
(c) Gradation:	
(1) Baskets 0.3 meters or greater in the vertical dimension.	
(a) Maximum dimension	200 mm
(b) Minimum dimension	100 mm
(2) Baskets less than 0.3 meters in the vertical dimension.	
(a) Maximum dimension	150 mm
(b) Minimum dimension	75 mm

705.02 Riprap Rock. Furnish hard, durable, angular rock that is resistant to weathering and water action and free of organic and spoil material. Do not use boulders, shale, or rock with shale seams. 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	52 min.
(d) Gradation for the class specified	Table 705-1

Table 705-1
Gradation Requirements for Riprap

Class	Percent of Rock by Mass	Mass kg	Approximate Cubic Dimension (2)(3) mm
1	20	10 to 15	150 to 200
	30	5 to 10	125 to 150
	40	0.5 to 5	50 to 125
	10 (1)	0 to 0.5	0 to 50
2	20	25 to 50	200 to 250
	30	10 to 25	150 to 200
	40	1 to 10	75 to 150
	10 (1)	0 to 1	0 to 75
3	20	100 to 150	350 to 400
	30	50 to 100	250 to 350
	40	5 to 50	125 to 250
	10 (1)	0 to 5	0 to 125
4	20	250 to 350	450 to 500
	30	100 to 250	350 to 450
	40	10 to 100	150 to 350
	10 (1)	0 to 10	0 to 150
5	20	700 to 1000	650 to 700
	30	350 to 700	500 to 650
	40	25 to 350	200 to 500
	10 (1)	0 to 25	0 to 200
6	20	850 to 1600	700 to 850
	30	500 to 850	550 to 700
	40	50 to 500	250 to 550
	10 (1)	0 to 50	0 to 250

(1) Furnish spalls and rock fragments graded to provide a stable dense mass.
(2) The volume of a rock with these cubic dimensions will have 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	125 mm
(2) Minimum width	300 mm or 1½ times the thickness, whichever is greater
(3) Minimum length	1½ times the width
(4) Rocks with volume $\geq$ 0.3 m^3	50% min.

When headers are required, furnish headers with lengths no less than the width of bed of the widest adjacent stretcher plus 300 millimeters.

(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) Cement rubble masonry	40 mm
(2) Class B masonry	20 mm
(3) Class A masonry	5 mm
(4) Dimensioned masonry	Reasonably true

(c) Bed surfaces. Dress face rock bed surfaces normal to the face to a depth of 75 millimeters. Beyond that point, the departure from normal may not exceed 25 millimeters in 300 millimeters for dimensioned masonry or 50 millimeters in 300 millimeters 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 50 millimeters. Beyond that point, the departure from normal may not exceed 25 millimeters in 300 millimeters.

Do not round corners at the meeting of the bed and joint lines in excess of the following radii:

(1) Cement rubble masonry	40 mm
(2) Class B masonry	25 mm
(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 75 millimeters. Beyond that point, the departure from the radial or normal may not exceed 20 millimeters in 300 millimeters.

Dress the back surface adjacent to the arch barrel concrete parallel to the front face and normal to the intrados to a depth of 150 millimeters. When concrete is placed after the masonry is constructed, vary adjacent ring stones at least 150 millimeters 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 10 millimeters apart. Limit surface variations to 3 millimeters or less from the pitch line.

(2) Medium pointed (M.P.). Make point depressions approximately 15 millimeters apart. Limit surface variations to 5 millimeters or less from the pitch line.

(3) Coarse pointed (C.P.). Make point depressions approximately 30 millimeters apart. Limit surface variations to 10 millimeters 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 20 millimeters 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 "40 R.F." means no projections 40 millimeters 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 kg	Equivalent Cubic Dimension mm
50	Greater than 900	Larger than 700
50	40 to 900	250 to 700

(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 kg	Equivalent Cubic Dimension mm
75	Greater than 75	Larger than 300
25	40 to 75	250 to 300

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 breath and thickness at least one-third its length. Conform to the following:

- Apparent specific gravity, AASHTO T 85 — 2.50 min.
- Absorption, AASHTO T 85 — 4.2% max.
- 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 ranges 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 6 millimeters. Pitch the front and back arris lines straight and true. Limit projections or depressions on the back surface to not exceed a batter of 25 millimeters horizontal to 75 millimeters 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 25 millimeters 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 13 millimeters 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 100 millimeters 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 1.2 meters. 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 13 millimeters. On other exposed faces, the maximum allowable projection or depression is limited to 25 millimeters.

For unexposed surfaces, the maximum allowable projection or depression from a true plane on a 0.5 meter length shall be 75 millimeters.

The maximum allowable space showing on exposed faces between adjacent segments of slope stone curb is 19 millimeters. The minimum length of any segment of slope stone curb is 0.5 meter.

Section 706.) CONCRETE AND PLASTIC PIPE

706.01 Non-Reinforced Concrete Pipe. Conform to AASHTO M 86M for the diameters and strength classes specified.

706.02 Reinforced Concrete Pipe. Conform to AASHTO M 170M 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 175M type 1 or 2 and AASHTO M 86M for the diameters and strength classes specified.

706.04 Reinforced Arch-Shaped Concrete Pipe. Conform to AASHTO M 206M for the diameters and strength classes specified.

706.05 Reinforced Elliptically-Shaped Concrete Pipe. Conform to AASHTO M 207M for the diameters, placement design (horizontal or vertical), and strength classes specified.

706.06 Reinforced D-Load Concrete Pipe. Conform to AASHTO M 242M for the diameters specified.

706.07 Precast Reinforced Concrete Box Sections. Conform to AASHTO M 259M or M 273M, 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 300 to 1050-millimeter diameter pipe conforming to ASTM F 714 and minimum cell class, ASTM D 3350, 335434C.

(b) Corrugated polyethylene pipe. Furnish 300 to 900-millimeter diameter pipe conforming to AASHTO M 294 and minimum cell class, ASTM D 3350, 315412C or 324420C. For sanitary sewer applications, furnish AASHTO M 294 type S pipe with watertight joints.

(c) Profile wall (ribbed) polyethylene pipe. Furnish 450 to 1200-millimeter diameter pipe conforming to ASTM F 894 and minimum cell class, ASTM D 3350, 334433C or 335434C.

(d) Corrugated polyethylene drainage tubing. Furnish 75 to 250-millimeter diameter tubing conforming to AASHTO M 252.

(e) Smooth wall polyvinyl chloride pipe. Furnish 100 to 375-millimeter diameter pipe conforming to AASHTO M 278 and minimum cell class, ASTM D 1784, 12454C or 12364C. For sanitary sewer applications, conform to ASTM D 3034.

(f) Profile wall (ribbed) polyvinyl chloride pipe. Furnish 100 to 1200-millimeter 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 36M 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 1.32 millimeters. Use any class of perforation specified in AASHTO M 36M.

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 196M for the dimensions and thicknesses specified.

Fabricate underdrain pipe from aluminum sheets with a minimum thickness of 1.22 millimeters. 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 Subsections 707.02, 707.03, 707.08, 707.09, and 707.13 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 167M 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 219M 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 245M and M 246M. Furnish pipe with a grade 250/250 polymer coating.

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 36M and either AASHTO M 218, 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 570M grade 36. 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 36M type IR and IIR and AASHTO M 218, AASHTO M 274, or AASHTO 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 196M 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
(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	520 g/L max.
(2) Other coatings	350 g/L 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

(9) Shows no thickening, curdling, gelling, or hard caking after 6 months of storage in a full, tightly-covered container at a temperature of 20 °C

708.02 Paint for Timber Structures.

(a) Primer. Conform to FSS TT-P-25, TT-P-96D, or TT-P-001984.

(b) Paint. Conform to FSS TT-P-102 class A, TT-P-96D, TT-P-102F, or TT-P-19D.

708.03 Paint for Concrete and Masonry Block Structures. Conform to FSS TT-P-19. Color tint with universal or all purpose concentrates.

708.04 Paint for Steel Structures. Conform to the following:

(a) Inorganic zinc primer.	AASHTO M 300 type II
(b) Vinyl wash primer.	MIL-P-15328 or SSPC no. 27
(c) Aliphatic urethane coating.	USPS-C-644 type I
(d) Acrylic latex coating.	SSPC no. 24
(e) Epoxy coating.	MIL-P-24441 or SSPC no. 22

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
(7) Consignee and destination of shipment

(b) Reinforcing bars. Furnish deformed, grade 400 bars conforming to AASHTO M 31M, M 42M, or M 53M.

(c) Epoxy coated reinforcing bars. Conform to AASHTO M 284M.

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 400 bars conforming to AASHTO M-31M or M 42M, except do not use AASHTO M 42M steel for tie bars bent and restraightened during construction.

(e) Hook bolts. Furnish plain, grade 400 bars conforming to AASHTO M-31M or M 42M with M14 rolled threads or M16 cut threads. Furnish a threaded sleeve nut capable of sustaining a minimum axial load of 67 kilonewtons.

(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 50±5 millimeters of the dowel, has a closed end, and has a suitable stop to hold the closed end 25 millimeters 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 6-millimeter tolerance vertically and horizontally during concrete placement and permit unrestricted movement of the pavement slab.

Use wire conforming to AASHTO M 32M 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 225M.

(h) Welded steel wire fabric. Conform to AASHTO M 55M.

(i) Cold-drawn steel wire. Conform to AASHTO M 32M.

(j) Welded deformed steel wire fabric. Conform to AASHTO M 221M.

(k) Fabricated deformed steel bar or rod mats. Conform to AASHTO M 54M.

(l) Low alloy steel deformed bars. Conform to ASTM A 706M.

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 204M type BA or WA
- Stress-relieved seven-wire strand, AASHTO M 203M grade 270
- High-strength steel bars, AASHTO M 275M type II

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 will have 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.

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 2 meters long of each strand size from each coil.

(b) Post-tensioning method. Furnish samples of the following lengths.

(1) For wires requiring a head, 5 meters.

(2) For wires not requiring a head, sufficient length to make up one parallel-lay cable 1.5 meters long consisting of the same number of wires as the cable to be furnished.

(3) For strands furnished with fittings, 1.5 meters between near ends of fittings.

(4) For bars to be furnished with threaded ends and nuts, 1.5 meters 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 4.5-millimeter coiled spring steel tension wire conforming to ASTM A 641M hard temper with a class 3 galvanized coating or an aluminized coating having a minimum coating mass of 120 grams per square meter of aluminum. Use the same coating on the tension wire as used on the rest of the chain link fence.

710.04 Fence Posts.

(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 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.

(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	AASHTO M 222M
(2) Rail elements	ASTM A 606 type 4
(3) Fasteners	AASHTO M 164M type 3

710.07 Box Beam Rail. Furnish steel box beam rail elements conforming to the AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware,* 1995 edition.

710.08 Steel-Backed Timber Rail. Furnish timber conforming to AASHTO M 168. Fabricate the 150 by 250-millimeter timber rail and the 100 by 225-millimeter blockouts from dry, well seasoned, and dressed rough sawn Douglas fir, southern pine, or other species having a stress grade of at least 10 megapascals.

Treat the timber rail and blockout elements with CCA, ACZA, or ACA preservative treatment conforming to AWPA C14 except the minimum retention shall be 9.6 kilograms per cubic meter.

Fabricate the steel backing elements from 9.5-millimeter structural steel conforming to AASHTO M 222M. For fastener hardware, conform to AASHTO M 222M.

710.09 Guardrail Posts.

(a) Wood posts. Do not use a wood guardrail post that has a through check, shake, or end split in the same plane as, or a plane parallel to the bolt hole and extending from the top of the post to within 75 millimeters of the bolt hole.

(b) Box beam posts. Conform to the AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware*, 1995 edition.

(c) Steel-backed timber posts. Furnish 250 by 300-millimeter guardrail posts conforming to Subsection 710.08. Post lengths will be specified in the contract.

710.10 Guardrail Hardware. Conform to the AASHTO-AGC-ARTBA *A Guide to Standardized Highway Barrier Hardware*, 1995 edition.

For angles, channels, wide flanges, and plates not contained in the above standard, conform to ASTM A 36M. 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 ASTM A 123. Do not punch, drill, cut, or weld the metal after galvanizing.

Manufacture reflector tabs from 4-millimeter aluminum or galvanized steel sheets. Use an adhesive that resists peeling with a force of 0.89 kilograms per centimeter of width. Use mildew resistant adhesive which 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	1200 mm min.
(b) Mesh openings	80 to 85 mm
(c) Color	International orange
(d) Mass	0.25 kg/m min.

710.12 Crash Cushion Barrels. Furnish 900-millimeter diameter barrels made of high-density polyethylene structural foam or equal material. Furnish lids of the same material as the barrels, but of a thinner gauge. Furnish appropriate height cores made of polystyrene or equal material.

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

711.02 Air-Entraining Admixtures. Conform to AASHTO M 154. For structural concrete, furnish air-entraining admixtures classified as vinsol resin or neutralized vinsol resin.

711.03 Chemical Admixtures. Furnish water-reducing, set-retarding, and set-accelerating additives, or combinations thereof, conforming t`o AASHTO M 194. Do not combine chemical admixtures together into a mixture unless they are compatible. Furnish supporting documentation of compatibility from the manufacturers. Do not use chloride accelerators.

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	0.15 to 0.25 µm avg.
(e) Emulsion stabilizers	anionic and non-ionic surfactant
(f) Solids	46.5 to 49.0%
(g) Mass	1.00 to 1.02 kg/L
(h) pH	9 to 13
(i) Shelf life	2 years min.

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/or 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 concrete and asphalt pavement	AASHTO M 301
(3) Crack filler, hot applied, for asphalt concrete and portland cement concrete pavements	ASTM D 5078

(4) For proprietary asphalt-rubber products, furnish the following:

(a) Source and grade of asphalt cement
(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
(2) Gradation of granulated rubber

(d) Type of asphalt modifier, if any
(e) Quantity of asphalt modifier and mass as a percent of asphalt cement
(f) Other additives
(g) Heating and application temperatures
(h) Manufacturer's recommended application procedures

(b) Preformed expansion joint fillers. Furnish in a single piece for the depth and width required for the joint.

(1) Performed expansion joint filler for concrete (bituminous type)	AASHTO M 33
(2) Performed sponge rubber expansion joint fillers for concrete paving and structural construction	AASHTO M 153

(3) Performed cork expansion joint fillers for concrete paving and structural construction[(1)]	AASHTO M 153
(4) Performed 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. Furnish a polychloroprene elastomeric seal conforming to AASHTO M 220. Use a lubricant adhesive conforming to the following:

(a) Solids content by mass, ASTM D 2369	22% min.
(b) Peel strength, ASTM D 903	10 MPa max.
(c) Age from manufacturing	9 months max.

(2) Manhole, inlet, and drainage applications. Furnish a multi-sectional neoprene rubber and ethylene propylene di monomer (EPDM) rubber seal with a minimum thickness of 1.5 millimeters. Before shipping, coat the rubber with a nonhardening butyl rubber sealant to produce a watertight seal when installed. Properties and values are listed in Table 712-1.

Table 712-1
Preformed Joint Seals

Physical Properties	ASTM Test Method	EPDM	Neo-prene	Butyl Mastic
Tensile, MPa	D 412	10	12	-
Elongation, %	D 412	440	230	280
Tear resistance, N/mm	D 624 (die B)	40	20	-
Rebound, %, 5 min	C 972 (mod.)	-	-	11
Rebound, %, 2 h	C 972 (mod.)	-	-	12

(d) Foam filler. Furnish an expanded polystyrene filler having a compressive strength of not less than 70 kilopascals.

(e) Cold-poured sealer. Furnish a one-part, low-modulus silicone rubber base joint sealing compound conforming to FSS TT-S-1543 class A with an ultimate elongation of 1200 percent.

(f) Low-modulus silicone joint sealant. Furnish a one-part silicone formulation conforming to the following.

(1) Flow, MIL S-8802	8 mm max.
(2) Extrusion rate, MIL S-8802	75 to 250 g/min
(3) Tack free time, MIL S-8802	20 to 75 minutes
(4) Specific gravity, ASTM D 792, method A	1.010 to 1.515
(5) Durometer hardness, shore A, ASTM D 2240	10 to 25
(6) Tensile stress @ 150% elongation, ASTM D 412	520 kPa max.
(7) Elongation, ASTM D 412	500% min.
(8) Peel (adhesion), MIL S-8802	≥ 9 kg with ≥75% cohesive failure
(9) Age from manufacturing	6 months max.

(g) Backer rod. Furnish a closed-cell polyethylene conforming to ASTM D 3204 type 1. Use a compatible sealant as recommended by the manufacturer of the rod. For size of backer rod, conform to Table 712-2.

712.02 Joint Mortar. Furnish portland cement and fine aggregate conforming to Subsections 701.01 and 703.01 respectively. Mix one part portland cement and two parts sand with water as necessary to obtain a usable consistency. Use the mortar within 30 minutes after mixing.

712.03 Watertight Gaskets. For ring gaskets for rigid pipe, conform to AASHTO M 198 type A or B. For ring gaskets for flexible metal pipe, conform to ASTM C 361M. 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 13 millimeters 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 9-millimeter thick gasket.

Table 712-2
Backer Rod Sizes

Joint Width After Preparation	Rod Diameter
8 mm	9 mm
9 mm	13 mm
13 mm	16 mm
16 mm	19 mm
19 mm	25 mm
25 mm	32 mm
32 mm	38 mm
38 mm	50 mm

712.04 Reserved.

712.05 Mortar for Masonry Beds and Joints.

(a) Material. When the contract contains other concrete work, the same type of cement used for other work may be used for mortar. Conform to the following:

(1) Masonry cement/portland cement	Subsection 701.01
(2) Fine aggregate	Subsection 703.01 or AASHTO M 45
(3) Lime	Subsection 725.03
(4) Fly ash	Subsection 725.04
(5) Water	Subsection 725.01

(b) Composition. Mix one part masonry cement, portland cement, or air-entraining portland cement with two parts fine aggregate by volume. Lime or fly ash may be added in an amount not to exceed 10 percent of the portland cement by mass. In lieu of air-entraining cement, portland cement may be used with an air-entraining admixture according to Section 552.

(c) Compressive strength. Use mortar with a minimum 28-day compressive strength of 14 megapascals when tested according to AASHTO T 22 and T 23, except that samples shall consist of cylinders with a length to diameter ratio of 2 to 1.

712.06 Copper Water Stops or Flashings. Furnish sheet copper conforming to AASHTO M 138M copper USN no. C11000. The resistivity test is not required.

712.07 Rubber Water Stops. Furnish molded or extruded rubber with a uniform cross-section that is free from porosity or other defects. If approved, an equivalent standard shape may be furnished.

Fabricate rubber water stops from a compound of natural rubber, synthetic rubber, or a blend of the two, together with other compatible material. Do not use any reclaimed material. Furnish a certification from the producer showing the composition of the material. Conform to the following:

(a) Hardness (shore), 3021[(1)]	60 to 70
(b) Compression set, 3311[(1)]	30% max.
(c) Tensile strength, 4111[(1)]	17 MPa min.
(d) Elongation at breaking, ASTM D 412	450% min.
(e) Tensile stress, 300% elongation, 4131[(1)]	6 MPa min.
(f) Water absorption by mass, 6631[(1)]	5% max.
(g) Tensile strength after aging, 7111[(1)]	80% of original min.

Note: (1) FTMS 601.

712.08 Plastic Water Stops. Fabricate from a homogeneous, elastomeric, plastic compound of basic polyvinyl chloride and other material. Form to a uniform cross-section that is free from porosity or other defects. If approved, an equivalent standard shape may be furnished. Conform to the following:

(a) Tensile strength, ASTM D 638M	9.6 MPa min.
(b) Elongation at breaking, ASTM D 638M	250% min.
(c) Hardness, ASTM D 2240	60 to 75 shore
(d) Specific gravity, 5011[(1)]	Note [(2)]

(e) Resistance to alkali[3], ASTM D 543	
Mass change	-0.10 to +0.25%
Hardness change	±5 shore max.
Tensile strength change	15% max.
(f) Water absorption (48 hours), ASTM D 570	0.50% max.
(g) Cold bending [4]	No cracking
(h) Volatile loss, ASTM D 1203	Note (5)

Notes: (1) FTMS 406.
(2) Manufacturer's value ±0.02.
(3) Use a 10 percent solution of NaOH for a 7-day test period.
(4) Subject a 25 by 150-millimeter strip that is 3 millimeters thick to a temperature of -29 °C for a period of 2 hours. After the 2 hours, immediately bend the sample 180 degrees around a 3-millimeter diameter rod. Apply sufficient force to maintain contact with the rod during bending. Examine the sample for evidence of cracking. Test and report results for at least three individual samples from each lot.
(5) Not more than manufacturer's value.

Furnish the manufacturer's test results for the above properties with the commercial certification. If directed, furnish samples in lengths adequate for performing the specified tests.

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 25 millimeters, or other substances detrimental to the development of vegetative growth. Demonstrate that the soil will 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(d).

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	Minimum Percent by Mass Passing Designated Sieve (AASHTO T 27)
2.00 mm	90
425 µm	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 FSS JJJ-S-181. 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

Inoculate legume seed with approved cultures according to the manufacturer's instructions.

713.05 Mulch.

(a) Straw. Furnish straw from oats, wheat, rye, or other grain crops that is free from weeds, mold, or other objectionable material. Furnish straw in an air-dry condition suitable for placing with mulch blower equipment.

(b) Hay. Furnish hay from herbaceous mowing, free from weeds, mold, or other objectionable material. Furnish hay in an air-dry condition suitable for placing with mulch blower equipment.

(c) Wood fiber. Furnish processed wood fiber from wood chips that is as follows:

(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
(8) Packaged in a condition appropriate for mixing in a homogeneous slurry suitable for application with power spray equipment

(d) Grass straw cellulose fiber. Furnish processed grass straw fiber that is as follows:

(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
(9) Packaged in a condition appropriate for mixing in a homogeneous slurry suitable for application with power spray equipment

(e) 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	

(f) 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	
Seeding and sodding	12 mm max.
Erosion control	25 mm max.
(6) Organic material	50% min.
(7) Man-made inserts (plastic, glass, metal)	2% max.

(g) Straw for hydroseeding. Furnish clean agricultural straw milled to 25 millimeters or less in length. Dry the fibers to 10 percent moisture for compaction. Bale in heat-sealed plastic bags.

(h) 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 1000 grams of water per 100 grams 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.

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 Erosion Control Mats, Roving, and Geocell.

(a) Erosion control mats. Erosion control mats are designated as follows:

(1) Type 1 - Erosion control mats.

(a) Straw mats. Furnish a mat of clean agricultural straw conforming to Subsection 713.05(a) that is attached to a photodegradable polypropylene netting by sewing with cotton thread. Conform to Table 713-2.

Table 713-2
Straw Erosion Control Mat

Material	Specification
Straw[1]	240 g/m² min.
Netting	Photodegradable netting on one side 5-20 mm square mesh[2] with a 1.5 kg/100 m² mass

(1) Moisture content shall not exceed 20 percent.
(2) Dimensions are approximate and may vary to meet manufacturer's standards.

(b) Burlap fabric. Furnish burlap fabric with a standard weave and a mass of 145±20 grams per square meter.

(c) Jute mesh. Furnish jute mesh with a uniform open plain weave fabricated from jute yarn that does not vary in thickness by more than half its normal diameter. Conform to the following:

(1) Mesh size	25 by 25 mm max.
(2) Mesh mass, ASTM D 1776	0.5 kg/m² ±5%

(d) Woven paper or sisal mesh netting. Furnish mesh netting of woven paper or woven sisal twisted yarn conforming to the following:

(1) Mesh openings	3 to 6 mm
(2) Shrinkage after wetting	20% max.

(2) Type 2 - Erosion control mats.

(a) Straw and coconut mats. Furnish a mat consisting of straw and undyed untreated biodegradable jute, coconut coir, and synthetic polypropylene fibers or other approved yarn woven into a plain weave mesh. Conform to Table 713-3.

Table 713-3
Straw and Coconut Mat

Material	Specification
Straw[1] 70%	240 g/m² min.
Coconut 30%	240 g/m² min.
Netting	Photodegradable netting on both sides 16-25-mm square mesh[2] with a 1.5 kg/100 m² mass.

(1) Moisture content shall not exceed 20 percent.
(2) Dimensions are approximate and may vary to meet manufacturer's standards.

(b) Excelsior blanket. Furnish a blanket of uniform thickness consisting of curled wood excelsior secured on the top side to a biodegradable, photodegradable extruded plastic mesh. Make the blanket smolder resistant without the use of chemical additives. Conform to the following:

(1) Excelsior fibers $\geq$ 200-mm length	80% min.
(2) Mesh size	25 mm by 50 mm
(3) Blanket mass/area	0.53 ± 0.05 kg/m^2

(c) Mulch blanket. Furnish a 3 to 13-millimeter thick blanket consisting of organic, biodegradable mulch such as straw, curled wood cellulose, coconut coir, or other material evenly distributed on one side of a photodegradable, polypropylene mesh having a minimum mass of 0.27 kilograms per square meter.

(3) Type 3 - Coconut mat. Furnish a mat consisting of undyed untreated biodegradable jute, coconut coir, and synthetic polypropylene fibers or other approved yarn woven into a plain weave mesh with approximately 16 to 25 - millimeter square openings. Conform to Table 713-4.

Table 713-4
Coconut Mat

Material	Specification
Coconut [(1)] 100%	240 g/m² min.
Netting	Photodegradable netting on one side 16 to 25 mm square mesh [(2)] with a 1.5 kg/100 m² mass

(1) Moisture content shall not exceed 20 percent.
(2) Dimensions are approximate and may vary to meet manufacturer's standards.

(4) Type 4 - Synthetic erosion control mats and meshes.

(a) Synthetic mat. Furnish a machine produced flexible mat consisting of polyolefin monofilament fibers positioned between 2 biaxially oriented nets. Mechanically bind the nets together by parallel stitching with polyolefin thread to form a 3-dimensional web-like weave, highly resistant to environmental and chemical deterioration. Conform to Table 713-5.

Table 713-5
Synthetic Erosion Control Mat

Property	Specifications	Test Method
Color	Green	Visual
Thickness	6 mm min.	ASTM D 1777
Strength [(1)]	1590 x 525 N/m min.	ASTM D 5035
Elongation [(1)]	50% max.	ASTM D 5035
Porosity [(2)]	85% min.	Calculated
Resiliency [(3)]	80%	ASTM D 1777
Ultraviolet stability [(4)]	80%	ASTM D 4355

(1) Values for both machine and cross-machine directions under dry or saturated conditions. Machine direction specimen for 50-millimeter strip test includes one machine direction polyolefin stitch line centered within its width and extending the full length of the specimen.
(2) Calculation based upon mass, thickness, and specific gravity.
(3) The percentage of original thickness retained after 3 cycles of a 690-kilopascal load for 60 seconds followed by 60 seconds without load. Thickness measured 30 minutes after load removed.
(4) Tensile strength retained after 1000 hours in an Xenon ARC weatherometer.

(b) Synthetic polypropylene mesh. Furnish a flexible woven geotextile mesh fabricated from polypropylene fibers that were spun in one direction. Conform to Table 713-6.

Table 713-6
Synthetic Polypropylene Mesh

Property	Specifications	Test Methods
Color	Beige	Visual
Mass	59 g/m^2 min.	ASTM D 5261
Tensile strength	6700 x 3700 N/m	ASTM D 5035
Elongation at break	40% max.	ASTM D 5035
Mullen burst strength	515 kPa min.	ASTM D 3786

(c) Synthetic mulch control netting. Furnish a uniformly extruded, rectangular, plastic mesh netting with 50 by 50-millimeter nominal mesh openings and weighing at least 8 grams per square meter.

(d) Organic mulch control netting. Furnish a leno weave mesh netting fabricated from 12.7-kilogram biodegradable cellulose fiber yarn having 5 twists per 25 millimeters. Make the size of the mesh grid 13 to 25 millimeters square. Finish the selvedge to prevent raveling or fraying.

(5) Type 5 - Turf reinforcement mats. Furnish a web of mechanically or melt bonded polymer netting, monofilaments, or fibers that are entangled to form a strong and dimensionally stable mat. Bonding methods include polymer welding, thermal or polymer fusion, or the placement of fibers between 2 high-strength, biaxially oriented nets mechanically bound together by parallel stitching with polyolefin thread. Make the mat resistant to biological, chemical, and ultraviolet degradation. Conform to Table 713-7.

Table 713-7
Synthetic Polypropylene Erosion Control Mat

Property	Specification	Test Method
Color	Black	Visual
Thickness	13 mm min.	ASTM D 1777
Tensile strength[(1)]	1370 x 790 N/m 50% max.	ASTM D 5035
Elongation[(1)]	90% max.	ASTM D 5035
Porosity [(2)]	80% min.	Calculated
Resiliency [(3)]	80% min.	ASTM D 1777
Ultraviolet stability [(4)]		ASTM D 4355

(1) Values for both machine and cross-machine directions under dry or saturated conditions using 50-millimeter strip method.
(2) Calculation based upon mass, thickness, and specific gravity.
(3) The percent of original thickness retained after 3 cycles of a 690 kilopascal load for 60 seconds followed by 60 seconds without load. Thickness measured 30 minutes after load removed.
(4) Tensile strength retained after 1000 hours in a Xenon ARC weatherometer.

(b) Roving.

(1) Fiber glass roving. Form fiber glass roving from continuous fibers drawn from molten glass, coated with a chrome-complex sizing compound, collected into strands and lightly bound together into roving without the use of clay, starch, or like deleterious substances. Wind the roving into a cylindrical package approximately 300 millimeters high so the roving can be continuously fed from the center of the package through an ejector driven by compressed air and expanded into a mat of glass fibers on the soil surface. Do not use roving containing petroleum solvents or other agents known to be toxic to plant or animal life. Conform to the following:

(a) Strands/rove, end count	56 to 64
(b) Fibers/strand, end count	184 to 234
(c) Fiber diameter (trade designation G), ASTM D 578	0.009 to 0.013 mm
(d) m/kg of rove, ASTM D 578	340 to 600 m/kg
(e) km/kg of strand, ASTM D 578	26.2 to 2.82
(f) Organic content, ASTM D 578	1.65% max.

(2) Polypropylene roving. Form polypropylene roving from continuous strands of fibrillated polypropylene yarn. Wind the roving into a cylindrical package so the roving can be continuously fed from the outside of the package through an ejector driven by compressed air and expanded into a mat of polypropylene strands. The material shall contain no agents that are toxic to plant or animal life. Conform to the following:

(a) Tensile strength, ASTM D 2256	15.6 N
(b) Elongation at break, ASTM D 2256	15.5%
(c) Mass of strand, ASTM D 1907	360 denier
(d) Strands per rove, measured	24
(e) UV stability, ASTM D 4355	50% retained after 200 hours

(c) Geocell (cellular confinement system). Furnish a flexible honeycomb 3-dimensional structure fabricated from polyethylene that has been properly stabilized with carbon black and/or hindered aminc light stabilizers.

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 50 by 50-millimeter 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 25-millimeter diameter garden or steam hose (rubber and fabric) to be used with wire for bracing and anchoring trees.

(c) Wire. Furnish 3.8-millimeter diameter soft annealed galvanized steel wire for bracing and anchoring trees.

(d) Wrapping material. Furnish 100-millimeter wide rolls of waterproof paper (triple lamination 30-30-30) or 150-millimeter wide rolls of burlap for wrapping trees.

(e) Twine. Furnish 2-ply twine for trees 75 millimeters and less in diameter and 3-ply twine for trees over 75 millimeters 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 Sprigs. Furnish healthy living stems (stolons or rhizomes) and attached roots of the perennial turf-forming grasses specified in the contract. Obtain sprigs from approved heavy and thickly matted sources in the locality of the work. Remove all johnson grass or other objectionable grasses, weeds, or other detrimental material.

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 75-millimeter height.

713.11 Pegs for Sod. Furnish square or round pegs of sound wood and conform to the following:

(a) Length	200 mm min.
(b) Approximate cross-sectional area	600 mm^2

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.
(c) Polyvinyl acetate using emulsion resins and containing 60±1 percent total solids by mass.

713.13 Bales.

(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	1 meter
(3) Shape	rectangular
(4) Approximate mass	30 kilograms

(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	400 by 450 by 900 mm
(2) Approximate mass	33 kilograms

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	0.01 cubic meter 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. Furnish a combination of the following material constructed as specified. If approved, variations may be furnished to accommodate premanufactured fences.

(a) Posts. Furnish 75-millimeter diameter wood or 1.86-kilogram per meter steel fence posts.

(b) Supports. Furnish 2.03-millimeter steel wire with a mesh spacing of 150 by 150 millimeters or a prefabricated polymeric mesh of equivalent strength.

(c) Geotextile. Conform to Subsection 714.01 and Table 714-5 as applicable.

(d) Height. Minimum height above the ground is 760 millimeters. Minimum embedment depth is 150 millimeters.

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 1-meter 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.

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 714-1
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 4632	N	990/630	990/630	990/630	720/450	720/450	720/450
Tear Strength	D 4533	N	400 /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	0.5	0.2	0.1	0.5 $^{-1}$	0.2	0.1
Apparent Opening Size	D 4751	mm	0.45	0.25 [2]	0.22 [2]	0.45 [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 714-2
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 /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	0.7	0.2	0.1 $^{-1}$	0.7	0.2	0.1
Apparent Open Size	D 4751	mm	0.43	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 Machine Direction Cross Direction	D 4632	N	 400 400	 550 450	 550 450
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		
Maximum Post Spacing			1.2 m	1.2 m	2 m

(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	N	50% at break
Asphalt Retention	Texas DOT item 3099	L/m^2	0.90
Melting Point	ASTM D 276	°C	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 275 kilopascals 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 1-meter square sample from products supplied as sheets or panels or a 1-meter 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 1 liter per second per meter of width when tested according to ASTM D 4716 under the following test conditions:

(1) 300-millimeter long specimen
(2) Applied load of 69 kilopascals
(3) Gradient of 0.1
(4) 100-hour seating period
(5) Closed-cell foam rubber 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 1 liter per second per meter of width when tested according to ASTM D 4716 under test conditions (1) through (5) in (a) above, except the gradient shall be 1.0.

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 inflow from both sides. The drain core with the geotextile in place shall provide a minimum flow rate of 3 liters per second per meter of width when tested according to ASTM D 4716 under test conditions (1) through (5) in (a) above.

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 nonperforated 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 ASTM D 25. 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
(e) Southern yellow pine

Install steel straps along the length of the pile at not more than 3-meter centers. In addition, place a strap at 75, 150, and 300 millimeters from the tip and 2 additional straps within 600 millimeters of the butt. Use 32-millimeter wide by 0.8-millimeter thick steel strapping material fabricated from cold-rolled, heat-treated, high-tensile steel having a minimum tensile strength of 22 kilonewtons.

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 57-millimeter by 0.9-millimeter 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 Subsection 715.01, except furnish only Douglas fir or southern yellow pine piles for use in saltwater. Treat the piles with preservative according to AASHTO M 133 for the types and quantities of preservatives specified in the contract.

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 25-millimeter 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 25-millimeter 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 25 millimeters 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 25 millimeters 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 15 °C or 21 days at a minimum temperature of 4 °C. Do not transport or drive piles until cured for at least 21 days at a minimum of 15 °C or 28 days at a minimum of 4 °C. 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 < 350 mm	6 mm
• Outside cylinder diameter ≥ 350 mm	10 mm
• Tapered or fluted	4.5 mm

(a) Shells driven without a mandrel. For tapered or step tapered cast-in-place concrete piles, furnish shells having a minimum 300-millimeter diameter at cutoff and a minimum 200-millimeter diameter tip. For constant diameter cast-in-place concrete piles, furnish shells having a minimum nominal diameter of 270 millimeters.

Fabricate shells from not less than 4.5-millimeter plate stock conforming to AASHTO M 183M. 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/or 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	AASHTO M 183M
(c) Reinforced conical points for pipe closure at the tip	AASHTO M 103M
(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 AASHTO M 183M, 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 202M or M 223M. For all other sheet piles, conform to the requirements prescribed above for the particular material specified. Make the joints practically water-tight when the piles are in place.

715.08 Pile Shoes. For timber piles, prefabricate shoes from cast steel conforming to ASTM A 27M.

715.09 Splices. For H or pipe piles, manufacture splices from structural steel conforming to AASHTO M 183M.

Section 716.) MATERIAL FOR TIMBER STRUCTURES

716.01 Untreated Structural Timber and Lumber. Conform to AASHTO M 168 and the applicable standards of the West Coast Lumber Inspection Bureau, Southern Pine Inspection Bureau, or other nationally recognized timber associations. Mark all pieces with the inspection service, grade designation, species, and inspector identity.

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. Conform to Subsection 716.01. Make all dimensional cuts and incisions in the wood before pressure treatment. Treat the wood according to AASHTO M 133. When wood is to be painted, use water borne ammoniacal copper arsenate or chromated copper arsenate preservative.

Mark all treated wood with an ALSC (American Lumber Standards Committee) quality mark certifying conformance with appropriate AWPA standards.

Section 717.) STRUCTURAL METAL

717.01 Structural Steel.

(a) Structural carbon steel. Conform to the following:

(1) Primary bridge members	AASHTO M 270M grade 250T
(2) Fracture critical bridge members	AASHTO M 270M grade 250F
(3) Other shapes, plates, and bars	AASHTO M 270M grade 250

(b) High-strength low-alloy structural (HSLA) steel. Conform to the following:

(1) Primary bridge members and welded members	AASHTO M 270M grade 345T or 345WT
(2) Fracture critical bridge members and fracture critical welded members	AASHTO M 270M grade 345F or 345WF
(3) Other shapes, plates, and bars	AASHTO M 270M grade 345 or 345W

(c) High-strength quenched and tempered (QT) steel. Conform to the following:

(1) Primary bridge members	AASHTO M 270M grade 485WT, 690T, or 690WT
(2) Fracture critical bridge members	AASHTO M 270M grade 485WF, 690F, or 690WF
(3) Other shapes, plates, and bars	AASHTO M 270M grade 485W, 690, or 690W

(d) Bolts and nuts. Conform to ASTM A 307.

(e) High-strength bolts, nuts, and washers. Conform to either AASHTO M 164M or AASHTO M 253M 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 225 millimeters in diameter from annealed carbon-steel forgings conforming to AASHTO M 102 class C.

Furnish pins and rollers 225 millimeters 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 480 megapascals and a yield point of 250 megapascals.

For pin threads, conform to ANSI B1.1 Coarse Thread Series, class 2A. Thread pin ends with a diameter of 35 millimeters or more with 6 threads in 25 millimeters.

717.04 Castings.

(a) Steel castings. Conform to AASHTO M 192M class 485.

(b) Chromium alloy steel castings. Conform to AASHTO M 163M grade CA-15.

(c) Gray iron castings. Conform to AASHTO M 105 class 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 47M 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 3 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 6±1 millimeter thickness free from cracks, seams, slivers, scale, and other defects.

717.09 Steel Grid Floors. Conform to AASHTO M 270M grade 250 or 345W. AASHTO M 270M grade 250 steel shall have a minimum copper content of 0.2 percent unless galvanized. Galvanize steel grid floors unless painting is specified.

717.10 Elastomeric Bearing Pads. Conform to AASHTO M 251.

717.11 Tetrafluoroethylene (TFE) Surfaces for Bearings.

(a) TFE resin. Furnish virgin TFE resin material conforming to ASTM D 1457 and the following:

(1) Specific gravity	2.13 to 2.19
(2) Melting point	328 °C ±1 °C

(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 TFE sheet. Furnish unfilled TFE sheet made from TFE resin. Conform to the following:

(1) Tensile strength, ASTM D 1457	19 MPa min.
(2) Elongation, ASTM D 1457	200% min.

(e) Filled TFE sheet. Furnish filled TFE sheet made from TFE resin uniformly blended with filler material. For filled TFE sheets containing glass fibers or carbon, conform to Table 717-1.

(f) Fabric containing TFE fibers. Furnish fabric made from oriental multifilament TFE fluorocarbon and other fibers. Use TFE fibers, conform to the following:

(1) Tensile strength, ASTM D 2256	165 MPa min.
(2) Elongation, ASTM D 2256	75% min.

Table 717-1
Filled Tetrafluoroethylene Sheeting

Property	ASTM Method	15% Glass Fibers	25% Carbon
Mechanical:			
Min. tensile strength	D 1457	14 MPa	9 MPa
Min. elongation	D 1457	150%	75%
Physical:			
Min. specific gravity	D 792	2.20	2.10
Melting point	D 1457	327±10 °C	327±10 °C

(g) Interlocked bronze and filled TFE components. Furnish a phosphor bronze plate conforming to ASTM B 100 with an 0.25 millimeter thick porous bronze surface layer conforming to ASTM B 103M into which is impregnated a TFE compound. Overlay the surface with compounded TFE not less than 25 micrometers thick.

(h) TFE metal composite. Furnish virgin TFE molded on each side and completely through a 33-millimeter perforated stainless steel sheet conforming to ASTM A 240 type 304.

(i) Surface treatment. For epoxy bonding, factory treat one side of the TFE 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	0.91 mm min.
(2) Surface finish	0.5 µm 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 the applicable specifications of Table 717-3.

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	AWS 5.10	ER 4043
3xxx, 5xxx, and 6xxx		ER 5356
5xxx and 6xxx		ER 5556 or ER 5183

717.16 Elastomeric Compression Joint Seals. Conform to AASHTO M 220.

Table 717-3 Aluminum Alloys for Bridge Railing Systems

RAILING COMPONENT	ASTM and Aluminum Association Alloy Designation								
	Sheet and Plate	Drawn Formless Tubes	Bars, Rods, and Wire	Extruded Bars, Rods, Shapes, and Tubes	Pipe	Standard Structural Shapes	Rivet Cold and Heading Wires and Rods	Sand Castings	Permanent Mold Castings
ASTM Specification →	*B 209*	*B 210*	*B 211*	*B 221*	*B 241*	*B 308*	*B 316*	*B 26*	*B 108*
Posts and Post Bases, Structural; Wrought Cast				6061-T6	6061-T6 6063-T6	6061-T6			A444.0-T4
Posts, Ornamental Wrought Cast				6063-T6	6063-T6			356.0-T6 356.0-T6	A356.0-T6 A356.0-T6
Rails & Sleeves, Structural; Wrought		6061-T6 6063-T6		6061-T6 6063-T6 6351-T5	6061-T6 6063-T6	6061-T6			
Bolts & Screws, Misc.(2), (3) Aluminum; Wrought Stainless Steel Galvanized Steel Aluminized Steel			2024-T4(4) 6061-T6(5)						
Nuts,(6) Wrought 6 mm and under (3) 5 mm and over			2024-T4 6061-T6 6262-T9	6061-T6	(7)				

General Note: "F" temper applies to products that acquire some temper from fabricating processes.

Table 717-3 Aluminum Alloys for Bridge Railing Systems (continued)

RAILING COMPONENT	**ASTM and Aluminum Association Alloy Designation**								
	Sheet and Plate	Drawn Formless Tubes	Bars, Rods, and Wire	Extruded Bars, Rods, Shapes, and Tubes	Pipe	Standard Structural Shapes	Rivet Cold and Heading Wires and Rods	Sand Castings	Permanent Mold Castings
ASTM Specification →	*B 209*	*B 210*	*B 211*	*B 221*	*B 241*	*B 308*	*B 316*	*B 26*	*B 108*
Washers, flat:(6) Wrought	Alclad 2024-T4 Alclad 2024-T3(8)								
Washers, Springlock:(6) Wrought			7075-T6						
Rivets: Wrought				6061-T6			6061-T6 6061-T4(1) (10)		
Shims: Wrought Cast	1100-0			6063-F	(1)			443.0-F	
Weld Filler: Wrought						5356			
End Caps: Wrought Cast	6061-T6			6061-T6				356.0-T6 356.0-F 443.0-F	

Specific Notes: (1) Chemical, composition only.
(2) Use compatible stainless or coated steel nuts and washers. Do not use aluminum for anchor bolts.
(3) Coat alloy 2024-T4 with a 5-micrometer minimum thickness anodic coating with a dichromate or boiling water seal.
(4) Use alloy 2024-T4 for stress-carrying bolts and minor bolts.
(5) Use alloy 6061-T6 as an alternate material for minor bolts.
(6) Use with aluminum bolts and screws. Do not use aluminum for anchor bolt nuts and washers.
(7) B 211 is an acceptable alternate.
(8) Use T3 temper for thicknesses less than 6 millimeters and use T4 temper for thicknesses 6 millimeters and greater.
(9) Use for cold-driven rivets.
(10) Use for rivets driven at 530 to 565 °C.

Section 718.) TRAFFIC SIGNING AND MARKING MATERIAL

718.01 Retroreflective Sheeting. Conform to ASTM D 4956, except the minimum coefficients of retroreflection for brown type I sheeting shown in ASTM D 4956 Table 1, Type I Sheeting, are amended as follows: 2.0 candela per lux per square meter at 0.2 degree observation angle and -4 degree entrance angle, 1.0 candela per lux per square meter at 0.2 degree observation angle and +30 degree entrance angle and at 0.5 degree observation angle and -4 degree entrance angle, and 0.5 candela per lux per square meter at 0.5 degree observation angle and +30 degree entrance angle.

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.

Types of retroreflective sheeting are as follows:

(a) Type I. Medium-intensity sheeting with enclosed lens glass-beads.

(b) Type II. Medium-high-intensity sheeting with enclosed lens glass-beads.

(c) Type III. High-intensity sheeting with encapsulated glass beads or prismatic material.

(d) Type IV. High-intensity sheeting with unmetallized microprismatic elements.

(e) Type V. Super-high-intensity sheeting with metallized microprismatic elements.

(f) Type VI. Elastomeric high-intensity sheeting with vinyl microprismatic material.

When an adhesive is used, use ASTM D 4956 backing class 1, 2, or 3.

718.02 Test Procedures. Conform to ASTM D 4956, except Supplementary Requirement S1, Fungus Resistance, is amended as follows: The stock cultures of Aspergillus niger, ATCC no. 6275, may be kept for not more than 4 months in a refrigerator at a temperature from 3 to 10 °C. Use subcultures incubated at 28 to 30 °C for 10 to 14 days in preparing the inoculum.

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 13-millimeter thick plywood for sign panels with a facial area 0.4 square meters or less and the horizontal dimension no greater than the vertical dimension. Use 19-millimeter 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 2-millimeter continuous coat galvanized sheet steel blanks conforming to ASTM A 525M. Mill phosphatize the zinc coating (designation G 90) to a thickness of 1.1±0.5 grams per square meter 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 209M, alloy 6061-T6 or 5052-H38.

Fabricate all temporary panels and those permanent panels that are 750 by 750 millimeters or smaller from 2-millimeter thick aluminum sheets. Fabricate larger permanent panels from 3-millimeter 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 600 by 600 millimeters or smaller from 2-millimeter thick plastic blanks. Fabricate larger panels from 3-millimeter 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 16 millimeters. Signs larger than 600 by 600 millimeters 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 638M	69 MPa min.
(2) Average tensile modulus, ASTM D 638M	8.3 GPa min.
(3) Average flexural strength, ASTM D 790M	140 MPa min.
(4) Average flexural modulus, ASTM D 790M	8.3 GPa min.
(5) Average compression strength, ASTM D 695M	220 MPa min.
(6) Average compression modulus, ASTM D 695M	9.7 GPa min.
(7) Punch shear, ASTM D 732	90 MPa min.
(8) Thickness	3.4±0.1 mm
(9) Size, dimension < 3.7 m, ASTM D 3841	±3 mm

(10) Squareness in 3.7 m length, ASTM D 3841	±3 mm
(11) Surfaces, top and bottom	Smooth
(12) Color, visually uniform gray, Munsel® range	N.7.5/ - N.8.5/
(13) Coefficient of lineal thermal expansion, ASTM D 696	0.01 μm/mm/°C max.
(14) Impact resistance, -54 to 100 °C, ASTM D 3841	0.54 kg from 18.3 m
(15) Flame resistance, ASTM D 635	25 mm max.
(16) Weather resistance, 3000±100 h, ASTM D 3841	grade II min.

718.07 Extruded Aluminum Panels. Furnish panels conforming to ASTM B 221M aluminum alloy 6063-T6. For panel thickness and fabrication, conform to Subsection 718.05. The maximum allowable deviation from flat on the face is 4 millimeters per meter.

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 6 kilograms per cubic meter.

(b) Steel posts. Furnish posts from billet or rail steel conforming to ASTM A 499. Drill or punch 10-millimeter holes in the posts along the centerline of the web before galvanizing. Begin punching or drilling 25 millimeters from top of post and proceed on 25-millimeter centers for the entire length of the post. Galvanize the posts according to ASTM A 123.

(c) Aluminum posts. Furnish approved standard shapes and thicknesses conforming to ASTM B 221M alloy 6061-T6, 6351-T5, 6063-T6, or 6005-T5.

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 100 by 100-millimeter wooden posts conforming to Subsection 718.08.

(b) Steel posts. Furnish flanged U-channel steel posts weighing not less than 3 kilograms per meter and conforming to ASTM A 36M. Galvanize the posts according to ASTM A 123.

(c) Aluminum posts. Furnish standard shaped 3-millimeter thick aluminum posts conforming to ASTM B 221M 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 ASTM A 153.

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 ASTM D 4956.

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 4500-square millimeter 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)
Candelas per lux

Observation Angle °	Entrance Angle °	White [1]	Yellow	Red
0.1	0	10.7	6.5	2.8
0.1	20	4.2	2.3	1.1

(1) Crystal, clear, or colorless are acceptable color designations.

Mount the retroreflector unit in a housing fabricated from 1.6-millimeter aluminum alloy 3003-H-14 or similar, or from cold rolled, hot dip, galvanized steel, having a thickness of 1.6 millimeters. Provide antitheft attachment hardware.

(b) Type 2 (retroreflective sheeting). Furnish a fungus resistant type III, IV, or V retroreflective sheeting material 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. Furnish a ready-mixed paint for use on asphalt and portland cement concrete pavements conforming to FSS TT-P-115F.

718.14 Waterborne Traffic Paint. Furnish an acrylic water based ready-mixed paint for use on asphalt and portland cement concrete 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) Nonvolatile vehicle, % by mass, FTMS 141	40% min.
(3) Lead, chromium, cadmium, or barium	0%
(4) Volatile organic compounds	250 g/L max.
(5) Mass of paint, ASTM D 1475	1.44 kg/L 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, 0.7 kg/L type 1 waterproofed glass beads, 0.38±0.03-mm wet film thickness at 54 °C	90 s max.

(d) Flexibility. FSS TT-P-1952B	No cracking or flaking

(e) Dry opacity. FTMS 141, contrast ratio at 0.25 mm — 0.96 min.

(f) Color.

(1) White **-** FHWA standard highway white
(2) Yellow **-** FHWA standard highway yellow

(g) Daylight reflectance. (Without glass beads)

(1) White, FTMS 141 method 6121	84% relative to magnesium oxide standard
(2) Yellow, FTMS 141 method 6121	55% relative to magnesium oxide standard

(h) Bleeding ratio. FSS TT-P-1952B — 0.96 min.

(i) Scrub resistance. ASTM D 2486 — 300 cycles min.

(j) Freeze-thaw stability. FSS TT-P-1952B

(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
(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 (16.5% min. at 100% purity)	18% min.
(b) Epoxy resin	75 to 82%

(2) Yellow:

(a) Chrome yellow ($PbCrO_4$), ASTM D 211, type III (20% min. at 100% purity)	23% min.
(b) Epoxy resin	70 to 77%

(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. 0.38 millimeter film thickness (cured).

(1) White	FHWA standard highway white
(2) Yellow	FHWA standard highway yellow

(f) Directional reflectance. (Without glass beads)

(1) White, FTMS 141 method 6121	84% relative to magnesium oxide standard
(2) Yellow, FTMS 141 method 6121	55% relative to magnesium oxide standard

(g) Drying time. 0.38 millimeter film thickness with beads

(1) Laboratory at 22 °C, ASTM D 711	30 minutes maximum to no-pick-up condition
(2) Field at 25 °C, viewed from 15 m	10 minutes maximum to no-tracking condition

(h) Abrasion resistance. Wear index with a CS-17 wheel under a 1000 g load for 1000 cycles, ASTM C 501	82 max.
(i) Hardness. Shore D hardness with 72 to 96-hour cure at 22 °C, 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, FTMS 141 method 6121	80% relative to magnesium oxide standard
(2) Yellow, FTMS 141 method 6121	55% relative to magnesium oxide standard

(b) Color.

(1) White	FHWA standard highway white
(2) Yellow	FHWA standard highway yellow

(c) Viscosity. Uncatalyzed polyester at -4 °C, ASTM D 562	70 to 90 Krebs units
(d) Bleeding. ASTM D 969	6 minimum
(e) Drying time in field. Viewed from 15 m	45 minutes max. 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**
2.36 mm			100
2.0 mm		100	95 - 100
1.7 mm	100	95 - 100	80 - 95
1.4 mm	95 - 100	80 - 95	10 - 40
1.18 mm	80 - 95	10 - 40	0 - 5
1.0 mm	10 - 40	0 - 5	0 - 2
850 µm	0 - 5	0 - 2	
710 µm	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/sieve size

(c) Refractive index, AASHTO M 247 1.50 - 1.55

718.20 Raised Pavement Markers. Furnish prismatic retroreflector type markers consisting of a methyl methacrylate, polycarbonate, or suitably compounded acrylonitrile-butadiene-styrene (ABS) shell fitted with retroreflective lenses. Make the exterior surface of the shell smooth.

Use a retroreflector with a minimum coefficient of (retroreflected) luminous intensity conforming to Table 718-3.

Table 718-3

Minimum Coefficient of (Retroreflected) Luminous Intensity (R_I)
Millicandelas per lux

Observation Angle °	Entrance Angle °	White (1)	Yellow	Red
0.2	0	279	167	70
0.2	20	112	67	28

(1) Crystal, clear, or colorless are acceptable color designations.

Make the base of the marker flat, patterned, or textured and free from gloss or substances that may reduce its bond to the adhesive. The deviation from a flat surface shall not exceed 1 millimeter.

718.21 Temporary Pavement Markings.

(a) Preformed retroreflective tape. Furnish 100-millimeter 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 1.5-millimeter minimum thickness polyurethane. Fabricate the vertical leg about 50 millimeters high by about 100 millimeters wide. Fabricate the base for the marker body about 30 millimeters wide.

Factory apply a 3-millimeter minimum thickness and 19-millimeter 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. Furnish traffic control devices (barricades, cones, tubular markers, vertical panels, drums, portable barriers, warning lights, advance warning arrow panels, traffic control signals, etc.) whose designs and configurations conform to the MUTCD. When interpreting the requirements in the applicable MUTCD sections, replace the word "should" with the word "shall."

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 be 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 hardened portland cement and asphalt concrete 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 portland cement concrete class A(AE) with a minimum 30-megapascal, 28-day compressive strength.

(2) Conform to Subsection 562.11 and fully support the units until the concrete reaches a minimum compressive strength of 7 megapascals. The units may be shipped and/or installed after the concrete reaches a minimum compressive strength of 24 megapascals.

(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 6 millimeters. 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 25 millimeters. All other dimensions within 5 millimeters.

(b) Panel squareness. Squareness, as determined by the difference between the 2 diagonals, shall not exceed 13 millimeters.

(c) Panel surface finish. Surface defects on smooth formed surfaces 1.5 meters or more in length shall not exceed 3 millimeters. Surface defects on textured-finished surfaces 1.5 meters or more in length shall not exceed 8 millimeters.

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.
- Color variation on front face of panel due to excess form oil or other reasons.

(b) Wire facing. Fabricate from MW40 x MW15 welded wire fabric conforming to AASHTO M 55M except the average shear value shall not be less than 450 kilopascals. After fabrication, galvanize according to AASHTO M 111.

(c) Backing mat. Fabricate from MW10 x MW10 (minimum) welded wire fabric conforming to AASHTO M 55M. After fabrication, galvanize according to AASHTO M 111.

(d) Clevis connector. Fabricate from cold-drawn steel wire conforming to AASHTO M 32M and weld according to AASHTO M 55M. After fabrication, galvanize according to AASHTO M 111.

(e) Connector bars. Fabricate from cold-drawn steel wire conforming to AASHTO M 32M. Galvanize according to AASHTO M 111.

(f) Fasteners. Furnish 13-millimeter diameter, heavy hexhead bolts, nuts, and washers conforming to AASHTO M 164M. Galvanize according to AASHTO M 232.

(g) Hardware cloth. Fabricate with maximum 7-millimeter 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 32M. Weld the wire into the finished mesh fabric according to AASHTO M 55M. 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-allow structural steel conforming to AASHTO M 223M grade 450, type 3. After fabrication, galvanize according to AASHTO M 111.

(j) Tie strip. Fabricate from hot-rolled steel conforming to ASTM A-570M 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 641M class 3 or aluminized steel wire conforming to ASTM A 809. Use wire with a minimum tensile strength of 415 megapascals when tested according to ASTM A 370. The galvanized or aluminized coating may be applied after mesh fabrication. Make the mesh openings with a maximum dimension less than 120 millimeters, an area less than 7000 square millimeters, and a size less than the gabion or revet mattress rock to be used with the mesh.

(1) Gabion baskets (0.3 meter or greater in the vertical dimension). Fabricate the mesh for galvanized or aluminized coated baskets from nominal-sized 3.0-millimeter or greater diameter wire and fabricate the mesh for polyvinyl chloride coated baskets from nominal-sized 2.7-millimeter 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 3.9-millimeter or greater diameter selvedge wire. For polyvinyl chloride coated baskets, tie the perimeter edges of the mesh for each panel to a 3.4-millimeter 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 2600 newtons with no value less than 2000 newtons. For polyvinyl chloride coated baskets, weld each connection to obtain a minimum average weld shear strength of 2100 newtons with no value less than 1600 newtons.

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 0.3 meter in the vertical dimension). Fabricate the mesh from nominal-sized 2.2-millimeter 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 2.7-millimeter 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 1300 newtons with no value less than 1000 newtons.

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	0.38 mm min.
(c) Specific gravity, ASTM D 792	1.20 to 1.40
(d) Tensile strength, ASTM D 638M	15.7 MPa min.
(e) Modulus of elasticity, ASTM D 638M	13.7 MPa min. at 100 strain
(f) Hardness - shore "A", ASTM D 2240	75 min.

(g) Brittleness temperature, ASTM D 746	-9 °C 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 63 °C) for 3000 hours	No visual effect *(c)* $\Delta < 6\%$ *(d)* $\Delta < 25\%$ *(e)* $\Delta < 25\%$ *(h)* $\Delta < 10\%$
(j) Mandrel bend, 360° bend at -18 °C around a mandrel 10 times the wire diameter	No breaks or cracks in coating

(b) Permanent fasteners.

(1) Lacing wire. Furnish nominal-sized 2.2-millimeter 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 2600-newton 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 197M
(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 3.3-millimeter thick round steel plate including coating with holes not more than 1.6 millimeters 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 0.5-millimeter 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 5 millimeters. 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 16-millimeter diameter, 2.5-meter 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 is at least 9 meters 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
(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 3-millimeter thick round steel conforming to ASTM A 595 or aluminum shafts conforming to ASTM B 429 alloy 6063-T6, tapered uniformly at 12 millimeters per meter. Provide hand holes with no rough edges and a reinforcing frame and cover designed to maintain the required pole strength. Weld a 60 to 75-millimeter 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 4.5-meter lengths. Furnish pole sections less than 21 meters in height in 2 sections or less; between 21 and 30 meters in 3 sections or less; and over 30 meters in 4 sections or less.

Design and furnish poles capable of sustaining the following loadings:

(1) A horizontal load of 2.2 kilonewtons applied 450 millimeters 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 220 newtons applied at the luminaire attachment point and normal to the pole bracket member plane, with a vertical load of 130 newtons 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 440 newtons 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 1.1 kilonewtons 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 50 millimeters 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 103M grade 450-240
(2) Steel plate	AASHTO M 183M
(3) Aluminum castings	ASTM B 26M alloy SG70A-T6 (356-T6)

(d) Bolts, nuts, and washers.

(1) Steel anchor bolts. Conform to AASHTO M 183M except as amended by *(a)* or *(b)* below:

(a)	*(1)* Yield strength	380 MPa min.
	(2) Tensile strength	520 to 650 MPa
	(3) Elongation in 200 mm	18% min.

	(4) Elongation in 50 mm	21% min.
	(5) Area reduction	30% min.
(b)	*(1)* Yield strength	725 MPa min.
	(2) Tensile strength	680 to 1030 MPa
	(3) Elongation in 50 mm	15% min.
	(4) Area reduction	45% min.

(2) Hex head bolts. Conform to the following:

(a) 380 MPa yield anchor bolts	AASHTO M 164M
(b) 725 MPa yield anchor bolts	ASTM A 354 grade BC

(3) Nuts. Conform to AASHTO M 291M. Furnish nuts appropriate for the strength of the anchor bolt.

(4) Washers. Furnish flat, circular washers conforming to AASHTO M 293.

Galvanize the top 300 millimeters 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 6-millimeter 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 slip-fitter. 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, which will start lamps at a minimum ambient temperature of -29 °C.

(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, which will start lamps at a minimum ambient temperature of -29 °C.

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 21 megapascals.

(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 203M
(2) Uncoated high-strength steel bar for prestressed concrete	AASHTO M 275M
(3) Steel strand uncoated seven-wire compacted stress relieved for prestressing concrete	ASTM A 779 and AASHTO M 203M

(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 1.5 millimeters.

(b) Hot-melt extruded polypropylene tube. Conform to ASTM D 4101 cell classification PP 210 B5554211 with a minimum wall thickness of 1.5 millimeters.

(c) Hot-melt extruded polyethylene tube. Conform to ASTM D 33-50 and D 1248 high-density type III with a minimum wall thickness of 1.5 millimeters.

(d) Steel tubing. Conform to ASTM A 500 with a minimum wall thickness of 5 millimeters.

(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 0.75 millimeters.

(b) Corrugated, polyvinyl chloride tubes. Conform to ASTM D - 1784 class 13464-B.

(c) Fusion-bonded epoxy. Conform to AASHTO M 284M with a minimum film thickness of 0.4 millimeters.

(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 mixed according to Subsection 725.22. Use type I, II or III portland cement conforming to Subsection 701.01.

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.

Furnish grout capable of reaching a cube strength (AASHTO T 106) of 25 megapascals in 7 days. Make grout cubes for testing from random batches of grout as directed. Normally, strength testing 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 AASHTO M 183M or M 222M.

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.

Sections 723 and 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 and Magnesium Chloride.

(a) Calcium chloride for dust control. Conform to AASHTO M 144 type S for the grade and class specified.

(b) Magnesium chloride. Furnish a brine solution conforming to the following:

(1) Magnesium chloride by mass	28 to 35%
(2) Water by mass	65 to 72%
(3) Specific gravity, ASTM D 1298	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
(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. 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 Blocks. Furnish rectangular or segmented concrete masonry blocks. When required, form the block ends to provide an interlock at vertical joints. Conform to the following:

(a) Solid load-bearing blocks	ASTM C 139
(b) Hollow load-bearing blocks	ASTM C 90
(c) Nonload-bearing blocks	ASTM C 129

725.10 Cellular Concrete Blocks. Conform to ASTM C 90 grade N-I or N-II, normal mass, except use concrete conforming to Section 601.

725.11 Precast Concrete Units. Cast the units in substantial permanent steel forms. Provide additional reinforcement as necessary to provide for handling the units. Use concrete conforming to the following:

(a) 28-day strength, AASHTO T 22	25 MPa min.
(b) Air content by volume, when required	
(1) 9.5 mm max. size aggregate	5% min.
(2) > 9.5 mm max. size aggregate	4% min.

Cure the units according to AASHTO M 170M.

Cast a sufficient number of concrete cylinders from each unit to permit compression tests at 7, 14 and 28 days. Make at least 3 cylinders for each test. If the strength requirement is met at 7 or 14 days, the units will be certified for use 14 days from date of casting.

Do not use precast concrete units when:

- Representative cylinders do not meet the strength requirement by 28 days.
- Cracks, honeycombed, or patched areas are larger than 0.02 square meters.

Furnish precast reinforced concrete manhole risers and tops conforming to AASHTO M 199M.

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 asphalt varnish or 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 103M
(c) Structural steel	AASHTO M 183M
(d) Galvanizing	AASHTO M 111
(e) Malleable iron castings	ASTM A 47M
(f) Aluminum alloy ladder rung material	ASTM B 221M alloy 6061-T6
(g) Aluminum castings	ASTM B 26M alloy 356.0-T6
(h) Asphalt varnish	FSS TT-V-51

725.13 Corrugated Metal Units. For steel corrugated units, conform to AASHTO M 36M. For aluminum corrugated units, conform to AASHTO M 196M. For coatings, conform to the following:

(a) Asphalt-coated corrugated units	AASHTO M 190 type A
(b) Polymer precoated corrugated units	AASHTO M 245M 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 88M type L for the designated sizes.

725.19 Plastic Lining. Furnish a film having a thickness of 175±25 micrometers and conforming to one of the following:

(a) Polyvinyl chloride plastic film	ASTM D 1593 type II
(b) Polyethylene plastic film	ASTM D 2103 type 02000

725.20 Lignin Sulfonate. 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 210	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) Hydraulic cement grout. Furnish a mixture of portland cement, fine aggregate, water, expansive admixture, and/or fly ash conforming to the following:

(1) 7-day compressive strength, AASHTO T 106	4 MPa min.

(2) Flow (time of efflux), FLH T 502 or ASTM C 939	16 to 26 s

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:

- Mill certifications for the cement
- Physical and chemical analysis for the pozzolans
- Independent laboratory test results (1-day, 3-day, and 7-day strengths, flow cone times, shrinkage and expansion observed, and time of initial set)

(b) Polymer grout and mortar. Furnish a polymer binder and fine aggregate in the proportions recommended by the polymer manufacturer with a minimum compressive strength of 25 megapascals in 4 hours.

(c) Nonshrink grout. Conform to ASTM C 1107.

(d) Plaster mix (grout). Conform to the following:

(1) Adhesive strength, 28-day, sheer-bond adhesion testing method	2 MPa min.
(2) Freeze-thaw resistance, ASTM C 666, method B, 300 cycles	No cracks or delamination
(3) Accelerated weathering, 5000 hours	No visible defects
(4) Slat spray resistance, 300 hours	No deterioration or loss of adhesion
(5) Absorption, ASTM C 67	3.5% max.
(6) Flexural strength, ASTM C 348, 28-day	6.8 MPa min.
(7) Compressive strength, AASHTO T 106, 28-day	27.5 MPa min.

(e) Portland cement grout. Furnish 1 part portland cement and 3 parts sand. Thoroughly mix with water to produce a thick, creamy consistency.

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	38 kg 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 21 °C 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 will remain 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 which attaches easily to the forming system. Install the form liner so it does not compress more than 6 millimeters at a concrete pour rate of 3650 kilograms per square meter.

725.28 Aluminum-Impregnated Caulking Compound. Conform to FSS TT-C-598 grade 1.

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