State of Wyoming
Department of Transportation
Cheyenne, Wyoming

Standard Specifications for Road and Bridge Construction

2010 Edition

Adopted by
the Transportation Commission of Wyoming
March 18, 2010

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Acknowledgments

The Wyoming Department of Transportation (WYDOT) expresses its appreciation to its employees, the Federal Highway Administration (FHWA), and the Wyoming Contractors Association (WCA) for their cooperation and assistance in producing the *Standard Specifications for Road and Bridge Construction*. The department gratefully acknowledges the principal authors from the Construction Office and the valuable review and input from WYDOT's Bridge, Geology, Highway Development, Contracts & Estimates, Environmental Services, Maintenance, Traffic, Materials, and District Construction and Maintenance programs; the State of Wyoming's Attorney General's Office and Department of Administration and Information—Risk Management; FHWA; and WCA; and editing, layout, and graphics services provided by WYDOT's Management Services Program and Lori Hart of LAS Consulting.

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101.1 Active Voice and Imperative Mood

1 The Wyoming Department of Transportation has rewritten this edition of *Standard Specifications for Road and Bridge Construction* with an emphasis on the active voice. In a sentence written in the active voice, someone acts on something. For example: "The engineer will take a sample." A similar sentence in the passive voice—"A sample will be taken"—would be unclear about who was responsible for taking the sample.

2 This edition of *Standard Specifications* also makes use of the imperative mood. The imperative mood is used when the party issuing an instruction and the party receiving it are already understood. In *Standard Specifications*, the department is stating its requirements or directions for work to the contractor; such statements have the same force as if they contained the word "shall." In an imperative sentence such as, "Pour the concrete," the department is indicating that it requires the contractor to pour the concrete. Before the award of a contract, imperative statements are directed to the bidder. After a contract has been awarded, imperatives are directed to the contractor.

3 The department will identify parties other than the bidder or contractor to whom it gives a responsibility in *Standard Specifications*. In phrasings where the responsible party has already been clearly identified or in factual statements when it is not important to do so, the department may use the passive voice.

101.2 Organization of Specifications

101.2.1 General

1 With the exception of Division 100, General Provisions, Division 800, Materials, and Section 701, Electrical Devices, the sections of *Standard Specifications* are written in a five-part format. Each section contains the following primary subsections:

XXX.1	Description
XXX.2	Materials
XXX.3	Equipment
XXX.4	Construction
XXX.5	Measurement and Payment

2 The subsections contain varying numbers of titled sub-subsections composed of higher and lower levels, as in an outline. For example, the equipment portion of Section 401, Plant Mix Pavements and Recycled Plant Mix Pavements, includes the following:

401.3	Equipment	
401.3.1	Milling	
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401.3.3	Mixing Plant	
401.3.3.1	General	*lower levels of Subsection 401.3.3, Mixing Plant*
	1. Cold feed control system . . .	
	2. Control unit . . .	
401.3.3.2	Batch Plants	
401.3.3.3	Drum Plants	
401.3.4	Hauling Equipment	

101.2.2 Hierarchy of Organization

1 The requirements of a subsection apply to subordinate subsections. In addition, and as shown at Subsection 401.3.3, Mixing Plant, in the example, many subsections begin with a lower-level subsection called "General." The requirements of "General" subsections apply to the associated same-level subsections that follow. For example, the requirements of Subsection 401.3.3.1, Mixing Plant, General, (which includes requirements about cold feed control and control units), apply to Subsections 401.3.3.2, Batch Plants, and 401.3.3.3, Drum Plants. They do not apply to the higher-level Subsection 401.3.4, Hauling Equipment.

101.2.3 Titles (or Headings) and References

1 The titles or headings of sections and subsections are for convenience and do not bear on the meaning of the text.

2 Technical specifications and other documents referenced in the contract refers to the edition in effect at the time of award of the contract, unless otherwise specified.

101.3 Measurement Units: Inch-Pound (U.S. Customary) Versus International System (SI or Metric)

1 *Standard Specifications* shows sizes and measurements in both inch-pound (U.S. Customary) and International (SI or Metric) System units. Inch-pound units appear first, followed by a metric counterpart inside square brackets "[ ]."

2 When reading *Standard Specifications*, use the system of measurements used by the department for the bid items on its "Proposal" (Form E-91). Do not mathematically convert the units from one system of measure to another; the department does not intend its measurement values to be equivalent and does not consider values interchangeable.

101.4 Abbreviations, Signs, and Symbols

1 Acronyms and abbreviations in *Standard Specifications*, represent the full text shown in Table 101.4-1, Acronyms and Abbreviations Used.

Table 101.4-1
Acronyms and Abbreviations Used

Acronym or Short Form	Full Name or Meaning
AADT	annual average daily traffic
ac	alternating current
a.m.	ante meridiem (before noon)
AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
AGC	Associated General Contractors of America
AIA	American Institute of Architects
AISI	American Iron and Steel Institute

Table 101.4-1
Acronyms and Abbreviations Used, *continued*

Acronym or Short Form	Full Name or Meaning
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute
AOSA	Association of Official Seed Analysts
AREMA	American Railway Engineering and Maintenance-of-Way Association
ARTBA	American Road and Transportation Builders Association
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATSSA	American Traffic Safety Services Association
AWG	American Wire Gauge
AWPA	American Wood-Preservers' Association
AWS	American Welding Society
AWWA	American Water Works Association
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
CMP	corrugated metal pipe
CMS	changeable message sign
CPM	critical path method
CRSI	Concrete Reinforcing Steel Institute
CR	corrosion resistance
CSP	corrugated steel pipe
DBE	disadvantaged business enterprise

Table 101.4-1
Acronyms and Abbreviations Used, *continued*

Acronym or Short Form	Full Name or Meaning
DMS	dynamic message sign
DSR	dynamic shear rheometer
EBL	eastbound lane
EBS	electronic bidding system
EEI	Edison Electric Institute
EIA	Electronic Industries Alliance
EPA	Environmental Protection Agency
ESAL	equivalent single axle load
f Nc	specified compressive strength of concrete
FCC	Federal Communications Commission
FE	flared end
FHWA	Federal Highway Administration
FTMS	Federal Test Method Standard
HERCP	horizontal elliptical reinforced concrete pipe
HID	high intensity discharge
ICEA	Insulated Cable Engineers Association
ID	inside diameter
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
IMSA	International Municipal Signal Association
ISSA	International Slurry Surfacing Association
ITE	Institute of Transportation Engineers
ITS	intelligent transportation system

Table 101.4-1
Acronyms and Abbreviations Used, *continued*

Acronym or Short Form	Full Name or Meaning
JMF	job mix formula
LAR	Los Angeles abrasion resistance or LA abrasion
LED	light emitting diode
LL	liquid limit
MIL	military specification
MS	military standard
MUTCD	Manual on Uniform Traffic Control Devices
NBL	northbound lane
NCHRP	National Cooperative Highway Research Project
NEC	National Electrical Code as approved by ANSI and NFPA
NEMA	National Electric Manufacturers Association
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
No.	number
Nos.	numbers
NOAA	National Oceanic and Atmospheric Administration
NP	nonplastic
NPDES	National Pollution Discharge Elimination System
OD	outside diameter
OHW	ordinary high water
OSHA	Occupational Safety and Health Administration
p.m.	post meridiem (after noon)
PAMS	poly-alpha-methyl styrene

Table 101.4-1
Acronyms and Abbreviations Used, *continued*

Acronym or Short Form	Full Name or Meaning
PAV	pressure aging vessel
PCI	Precast/Prestressed Concrete Institute
PE	polyethylene
PGAB	performance graded asphalt binder
PLS	pure live seed
PTC	positive temperature coefficient
PVC	polyvinyl chloride
RAP	reclaimed asphalt pavement
RC	reinforced concrete
RCP	reinforced concrete pipe
RPCCP	reclaimed portland cement concrete pavement
RSC	rigid galvanized steel conduit
RTFO	rolling thin film oven
SAE	Society of Automotive Engineers
SBL	southbound lane
SE	service entrance
SI	International System of Units (metric system)
SME	steel mitered end
SSPC	Society for Protective Coatings
TAPPI	Technical Association of the Pulp and Paper Industry
TBC	time-based coordination
TCD	traffic control device
U.S.	United States
UBC	Uniform Building Code

Table 101.4-1
Acronyms and Abbreviations Used, *continued*

Acronym or Short Form	Full Name or Meaning
UF	wire insulation—underground feeder
UL	Underwriters Laboratories, Inc.
UV	ultraviolet
USE	wire insulation—underground service entrance
V:H	vertical units to horizontal units, ratio
VAC	voltage—alternating current
VECP	Value Engineering Contractor Proposal
VMA	voids in mineral aggregate
VOC	volatile organic compounds
WBL	westbound lane
WCA	Wyoming Contractors Association
WCLIB	West Coast Lumber Inspection Bureau
WDA	Wyoming Department of Agriculture
WDEQ	Wyoming Department of Environmental Quality
WPSC	Wyoming Public Service Commission
WPWC	Wyoming Public Works Council
W.S.	Wyoming statute
WSHPO	Wyoming State Historic Preservation Office
WWPA	Western Wood Products Association
WYBET	Wyoming box beam end terminal
WYDOT	Wyoming Department of Transportation
XHHW	wire insulation—moisture and heat resistant; wet and dry locations; cross-linked polyethylene

2 Table 109.1.2-1, Unit Symbols for Bid and Pay Items, provides a list of symbols for units used in quantifying bid and pay items. For specifying sizes, dimensions, and similar physical properties, the department will use the symbols for units of measure as shown in Table 101.4-2, Measurement Symbols.

Table 101.4-2
Measurement Symbols

Inch-Pound Units (U.S. Customary System)		**Kind of Quantity or Measurement**	**SI (International System) Units—Metric**	
Symbol	**Unit Name**		**Unit Name**	**Symbol**
mil	mil (0.001 inch)	**Length**	micrometer	µm
in	inch		millimeter	mm
ft	foot			
yd	yard		meter	m
mi	mile		kilometer	km
in^2	square inch	**Area**		
ft^2	square foot			
yd^2	square yard		square meter	m^2
mi^2	square mile		square kilometer	km^2
acre	acre			
fl oz	fluid ounce	**Volume**	milliliter	mL
pt	pint			
qt	quart			
gal	gallon		liter	L
in^3	cubic inch		cubic meter	m^3
ft^3	cubic foot			
yd^3	cubic yard			

Table 101.4-2
Measurement Symbols, *continued*

Inch-Pound Units (U.S. Customary System)		Kind of Quantity or Measurement	SI (International System) Units—Metric	
Symbol	**Unit Name**		**Unit Name**	**Symbol**
oz	ounce	**Weight [Mass]**	gram	g
lb	pound		kilogram	kg
ton	ton, short (2000 lb)		metric ton	t
°F	degree Fahrenheit	**Temperature**	degree Celsius	°C
s	second	**Time**	second	s
min	minute		minute	min
h	hour		hour	h
d	day		day	d
mph	miles per hour	**Speed**	kilometers per hour	km/h
psi	pounds per square inch	**Pressure**	pascal	Pa
			kilopascal	kPa
			megapascal	MPa

Table 101.4-2
Measurement Symbols, *continued*

Inch-Pound Units (U.S. Customary System)		Kind of Quantity or Measurement	SI (International System) Units—Metric	
Symbol	**Unit Name**		**Unit Name**	**Symbol**
W	watt	**Power, Energy, and Electrical**	watt	W
kW	kilowatt		kilowatt	kW
A	ampere		ampere	A
V	volt		volt	V
VA	voltampere		voltampere	VA
S	ohm		ohm	S
Hz	hertz		hertz	Hz
J	joule		joule	J
lm	lumen		lumen	lm
fc	footcandle		lux	lx
			candela	cd
hp	horsepower			
lbf	pound-force	**Force**	newton	N
kip	1000-pounds force		kilonewton	kN
		Viscosity, Dynamic	pascal second	Pa•s
KU	Krebs unit		centipoise	cP
			poise	P

Table 101.4-2
Measurement Symbols, *continued*

Inch-Pound Units (U.S. Customary System)		Kind of Quantity or Measurement	SI (International System) Units—Metric	
Symbol	**Unit Name**		**Unit Name**	**Symbol**
cSt St	centistokes stokes	**Viscosity, Kinematic**	meter squared per second	m^2/s
gpm	gallons per minute	**Flow**	liters per second	L/s

3 *Standard Specifications* uses mathematical and other signs and symbols with meanings in accordance with Table 101.4-3, Mathematical and Other Signs and Symbols Used.

Table 101.4-3
Mathematical and Other Signs and Symbols Used

Symbol	Meaning
+	plus
-	minus
±	plus or minus
=	equal to
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to
×	multiplied by; dimensional indicator
$\bar{x}$	arithmetic mean (or "average")
/	per
%	percent
μ	10^{-6} ("micro")
°	degree (as a unit of angular measurement)
Ω	ohm
:	ratio; proportionality
$	U.S. dollar

101.5 Definitions

Accept (Acceptance). Unless otherwise explicitly stated, these words refer to the resident engineer's acceptance of work or materials for the purpose of initiating a **Monthly Progress Payment** (or payments) to the contractor. Authority to grant final acceptance of the completed project, and to transfer responsibility for the work to the **Department**, belongs to the district engineer, in accordance with Subsection 113.4, Final Acceptance.

Addendum. See **Contract**.

Adverse Weather Day. A day that:

1. Weather precludes five or more hours of work on the **Controlling Activity** (or activities);
2. The contractor has a workforce on the project attempting to work on the **Controlling Activity** (or activities); and
3. Would otherwise be a **Working Day.**

Advertisement. The public announcement inviting bids for work or furnishing materials. Also called an **Invitation for Bids**, the advertisement describes briefly the work or materials and gives information on the availability of bid packages and the time and place of the opening of bids.

Agreement. See **Contract**.

Annual Average Daily Traffic. The average (mean) daily traffic averaged over a full year, as computed by the **Department**.

Award. The acceptance of a bid by the **Commission**.

Award Date. The date, as shown on the first line of the **"Contract" (Form E-82A)**, on which the **Commission** accepts the contractor's **Bid** to undertake the project.

Base Course. See **Pavement Structure.**

Bid. The executed and submitted offer of a **Bidder** to perform the **Work** specified in a department **“Proposal” (Form E-91)** at the prices quoted.

Bid Bond. The security executed by the **Bidder** and **Surety** or sureties and given to the **Department** in the amount of 10 percent of the bid to guaranty execution of the **Contract**.

Bidder. A person or business submitting a **Bid** in response to a department **“Proposal,” (Form E-91)**.

Bid Envelope. The preaddressed, individually labeled envelopes prepared by the **Department**. Available only to prequalified bidders approved to bid on a specific advertised project and solely for the purpose of submitting a **Bid**.

Bridge. A structure and supports spanning and providing passage over a gap or obstacle and having a length greater than 20 ft [6.1 m], as measured along the centerline between the abutments’ front faces or the extreme ends of openings for multiple culverts and including the widths of intervening piers or division walls.

Calendar Day. A day on the calendar, beginning and ending at midnight.

Clear Zone. A traversable and hazard-free portion of the **Roadside** of the width specified.

Commercial Source. An established, lawful business operating at the time of bid opening as a source to the general public of materials or products relevant to the project.

Commission. Transportation Commission of Wyoming, as constituted for the governance of the Department of Transportation under the laws of the State of Wyoming.

Construction Limits. Locations designated by and in which the **Department** will allow construction activity or disturbance and includes the following, as approved by the **Engineer**:

1. From the beginning to the ending station(s) of the project between the slope stakes;

2. Area within the defined boundaries of a **Construction Permit**(s);

3. Material sources;

4. Designated haul roads;

5. Plant sites;

6. Staging areas;

7. Stockpiling sites; and

8. Other locations approved by the engineer.

Construction Permit. A permit giving the **Department** the restricted right to use property for construction purposes outside the highway **Right-of-Way**.

Contract. The collection of documents that together form the agreement between the **Contractor** and the **Commission** or **Department** and sets forth the obligations of each party. The contract includes:

1. The **Proposal Package**. A group of documents made available to a **Bidder**. These become part of the contract upon award of the project and execution of the **"Contract" (Form E-82A)** and include the following:

   1.1. **"Proposal" (Form E-91)** as returned and submitted by the contractor and containing the contractor's **Bid**. The "Proposal" includes or states:

      1.1.1. The location and description of the project;

      1.1.2. The bid items and estimated quantities (listed together on the *Schedule of Items*) for which **Unit Bid Price**s are invited;

      1.1.3. The completion date;

      1.1.4. The amount of the **Bid Bond**;

1.1.5. The date, time, and place of the opening of bids;

1.1.6. Certification of *Registration with the Wyoming Secretary of State*;

1.1.7. Certification of *Suspension or Debarment*;

1.1.8. Certification of *Free Competitive Bidding* (for federal projects) or *Noncollusive Bidding* (for state projects);

1.1.9. Certification of *Previous EEO Performance* (for federal projects);

1.1.10. Certification of *Lobbying Activities for Federal Aid Contracts* (for federal projects);

1.1.11. Certification of *Disadvantaged Business Enterprise Participation* (for federal projects); and

1.1.12. Certification of *Nondiscrimination*.

1.2. **"Performance Bond" (Form E-82).** The Department's approved form of security, provided by the contractor and the contractor's **Surety** or sureties and guaranteeing performance of the **Work** specified and the payment of all related debts.

1.3. **Agreements.** Binding documents between the Department and third parties that pertain to the use of water, materials, or other resources and apply to the project.

1.4. **Supplementary Documents.** Any document in the Bid package generically titled "Supplementary Document for *A Specific Purpose*."

1.5. **Contract Provisions.** Provisions required on federal-aid contracts.

1.6. **Specifications.** The collection of provisions and requirements for performing the work in a contract, including:

1.6.1. **Special Provisions.** Revisions to the standard and supplementary specifications that apply to a single project.

1.6.2. **Supplementary Specifications.** Revisions to the *Standard Specifications*.

1.6.3. **Standard Specifications.** The current edition of this book ("*Standard Specifications*"). Standard specifications are approved for general, repeated use.

1.7. **Plans.** The approved drawings (or exact reproductions) showing the locations, character, dimensions, and details of the project. As appropriate, plans include:

1.7.1. **Plan and Profile Sheets.** Sheets showing the alignment of the centerline, the profile of the existing and proposed terrain on that centerline, and other project information.

1.7.2. **Typical Sections.** A section showing the slope criteria for the roadway cut-and-fill slopes, the crown or cross-slope of the finished roadway, the lane(s) and shoulder widths, the thicknesses and tapers for the surfacing courses, the position of the profile grade line, and the **Clear Zone**.

1.7.3. **Summary Sheets.** Sheets indicating the general notes, materials and rates information, and quantities and locations for pay items included in the contract.

1.7.4. **Project Specific Supplemental Details and Sheets.** Details that supplement the plan and profile sheets and provide material, earthwork, or other project specific information.

1.8. **General Cross-Sections and Earthwork.** Sections that indicate the existing and proposed terrain at intervals along the centerline and are used to determine the excavation and embankment requirements. The areas developed from the cross-section and the length of the intervals between sections are used to calculate earthwork volumes.

1.9. **Soils Profile.** A plot of the proposed gradeline and existing groundline with test holes, samples, and laboratory data, including related recommendations from the **Geology** and **Materials Programs** (or consultants) and the field engineer.

1.10. **Standard Plans.** Drawings of objects, features, details, or similar elements used commonly by the Department. Applicable standard plans are included in the bid package for a project.

1.11. **Electronic CADD Files.** Files in native Microstation and Geopak format used by the **Department**. Files may be version specific. The Department will not perform conversions to other formats and will not provide Microstation and Geopak support.

As appropriate, electronic CADD files may include:

1.11.1. Project coordinate geometry (COGO) database (.gpk).

1.11.2. Design Mainline Cross Sections (_xsd.dgn).

2. **Addenda.** Contract revisions issued after advertisement and before the opening of bids.

3. **"Contract" (Form E-82A).** The signed (or "executed") document that legally binds the contractor and Commission or Department.

4. **Notice to Proceed.** Written authorization from the Department

to the contractor to start work on the project.

5. **Working Drawings.** Drawings, diagrams, illustrations, schedules, calculations, or other supplemental forms of information for physical items permanently incorporated in the project that the Department requires the contractor to submit for approval.

6. **"Contract Amendment" (Form E-61).** A written change to the contract.

Contract Amendment (Form E-61). See **Contract**.

Contract Amount. The original amount **Bid** by the **Contractor**, shown as the "Bid Total" on the *Schedule of Items* in the **"Proposal" (Form E-91)**.

Contract Completion Date. The calendar date specified on the **"Contract" (Form E-82A)** for completing the **Work**.

Contract Time. Begins 14 **Calendar Days** after the **Award Date** and consists of the number of calendar days up to and including the **Contract Completion Date**.

Contractor, a. Any person or business holding prequalification status and bidding or eligible to **Bid** on a department **"Proposal" (Form E-91)**.

Contractor, the. The person or business with whom the **Commission** or **Department** enters into agreement through a binding **Contract** for performance of the specified **Work**.

Controlling Activity. See **Critical Path**.

Critical Activity. See **Critical Path**.

Critical Path. The longest continuous sequence of work for which the combined duration of the work's individual scheduled activities produces the minimum overall project duration. Activities on the critical path control the project's completion and appear in two forms:

1. **Critical Activity.** Any activity on the critical path.

2. **Controlling Activity.** A **Critical Activity** that would normally be in progress at a given moment.

Culvert. A structure other than a **Bridge** that creates a transverse opening under a roadway or embankment for drainage or similar purposes.

Department. The Wyoming Department of Transportation, as constituted under the laws of the State of Wyoming.

Director (Superintendent). The director of the **Department**.

Electronic Bidding System (EBS). The **Department**'s computerized system for the receipt and tabulation of bids.

Engineer. The chief engineer of the **Department** acting directly or through any of several authorized representatives, such as a district or resident engineer, the project supervisor, or various **Inspector**s. Responsibility for engineering and administrative supervision of the project resides with the engineer.

Extra Work. Work within the intended scope of the **Contract** but beyond or varying from that originally provided for and that the **Department** later finds essential for satisfactory completion of the project.

Extension (in **Bid** or **Pay Items).** The arithmetic product of a bid or pay item's quantity multiplied by the **Unit Bid Price**.

Force Account. A method of payment for work performed by the **Contractor** at the engineer's direction; calculated in accordance with Subsection 109.4, Extra and Force Account Work.

Gauge. *U.S. Standard Gauge*, as defined in 15 U.S. Code, Section 206, when referring to sheet iron and plate steel. *Galvanized Sheet Gauge* when referring to zinc coated sheets.

American Wire Gauge (AWG) when referring to nonferrous wire. Most commonly used in specifying copper and aluminum conductors. AWG is sometimes known as Brown and Sharpe (B&S) Wire Gauge.

Geology Program. The **Department**'s Geology Program.

Highway, Street, Road. Interchangeable general terms denoting a public way used for vehicular travel. Includes the entire area within the **Right-of-Way**.

Holidays. Holidays recognized by the State of Wyoming are:

1st day of January (New Year's Day)
3rd Monday of January (Martin Luther King, Jr./Wyoming Equality Day)
3rd Monday in February (President's Day)
Last Monday in May (Memorial Day)
4th day of July (Independence Day)
1st Monday in September (Labor Day)
11th day in November (Veteran's Day)
4th Thursday in November (Thanksgiving Day)
25th day in December (Christmas Day)
Other days declared by the governor

For holidays that fall on a Saturday, both the Saturday and the preceding Friday are considered legal holidays. For a holiday that falls on a Sunday, both the Sunday and the following Monday are considered legal holidays.

Inspector. A representative of the **Engineer** authorized to make detailed inspections of the materials provided and the **Work** performed.

International System of Units (SI). The metric system of measurement.

Laboratory. The **Department**'s Materials Program Laboratory in Cheyenne or any other testing laboratory designated by the **Engineer** to test soils, work, and materials.

Lift. A single, continuous layer of soils, aggregate, or plant mix pavement to which the same compactive effort is applied during placement.

Liquidated Damages. Monetary damages paid at a specified rate by the **Contractor** to the **Department** for **Work** not completed by completion dates or within specified time frames.

Lump Sum Pay Item. A nondivisible whole unit comprising everything necessary to complete the item as specified and which the **Department** will measure and pay for as a whole.

Major Pay Item. A pay item for which the original contract cost is both:

1. Greater than 5 percent of the **Contract Amount** and

2. Greater than $20,000.

Materials. All components required for construction of the project.

Materials Program. The **Department**'s Materials Program.

Materials Testing Manual. The edition of the **Department**'s *Materials Testing Manual* in effect at the time of the public opening of bids. Issued by the Department and providing such information as the rationale, scope, and methods for assessing the conformance of **Work** and materials to contract requirements.

Median. The interior of a divided highway or street, including the inside shoulders.

Monthly Progress Payment. Scheduled partial payments made by the **Department** to the **Contractor** as the **Work** progresses. Payments are based on the engineer's estimate of the value of the work performed during the pay period.

Neat Lines. The horizontal and vertical lines established in the **Contract** to describe the locations, shapes, and borders of planned activities such as excavation or backfilling. When specified, neat lines also define limits for calculating pay item quantities.

Notice to Proceed. See **Contract**.

Overburden. The surface layer atop material suitable for road or bridge construction, excluding topsoil.

Own Organization. The workers employed and paid directly by the **Contractor** and equipment owned or rented by the Contractor, with or without operators; does not include employees or equipment of a **Subcontractor**, assignee, or agent of the Contractor.

Pavement Structure. The layers of specified materials placed on a **Subgrade** to support and distribute the traffic load to the roadbed, including any combination of:

1. **Subbase.** The layer(s) placed on the subgrade to support the base course.
2. **Base Course.** The layer(s) placed on the subbase or subgrade to support the surface course.
3. **Surface Course.** The uppermost layer(s), designed to resist skidding, traffic abrasion, and weathering.

Pay Item. A described item of **Work** for which a unit price is included in the **Contract**.

Performance Bond. See **Contract**.

Plans. See **Contract**.

Professional Engineer. A person registered and authorized to practice in one or more branches of engineering by the Wyoming State Board of Registration for Professional Engineers and Professional Land Surveyors. When the expertise of a particular branch of engineering is specified (civil engineering, for example), the **Department** requires registration in that discipline.

Professional Land Surveyor. A person registered and authorized to practice land surveying by the Wyoming State Board of Registration for Professional Engineers and Professional Land Surveyors.

Profile Grade. The trace (either elevation or gradient, according to context) of a vertical plane intersecting a roadway surface, usually along the longitudinal centerline of the roadbed.

"Proposal" (Form E-91). See **Contract**.

Proposal Package. See **Contract**.

Responsive Bid. A **Bid** that meets all requirements of the **Proposal Package**.

Right-of-Way. A general term denoting land, property, or interest acquired for or devoted to highway purposes.

Road. See **Highway, Street, Road**.

Roadbed. The graded portion of highway within the top and side slopes, prepared as a foundation for the **Pavement Structure**.

Roadside. A general term denoting the area between the outside shoulder edge and the **Right-of-Way** limits.

Roadway. The portion of a highway within the **Construction Limits**.

Royalty. Payment to a rights holder for permission to withdraw, use, or exploit a natural resource.

Shoulder. The portion of the **Roadway** next to the traveled way. Provided for stopped vehicles, emergency use, and lateral support of the base and surface courses.

Sidewalk. That portion of the **Roadway** primarily constructed for use by pedestrians.

Special Provisions. See **Contract**.

Specialty Item. A uniquely designated **Pay Item** requiring specialized knowledge, craftsmanship, or equipment not usually available within the organizations of prequalified contractors. Usually not a **Major Pay Item**; specialty items are excluded from computations to determine allowable subcontracting percentages.

Specified (or **As Specified).** Used to refer to a requirement of the **Contract**. “As specified” can be read to mean “as specified in the contract,” which in turn means any document defined as belonging to the Contract.

Specifications. See **Contract.**

Split Sample. Two or three samples that represent the same material. Obtain these samples by reducing one large sample or by taking adjacent samples.

Standard Plans. See **Contract.**

Standard Specifications. See **Contract.**

State. The State of Wyoming, acting through an authorized representative.

Station. 100 linear feet [1 kilometer], measured horizontally.

Street. See **Highway, Street, Road.**

Stripping Material. See **Overburden**.

Subbase. See **Pavement Structure**.

Subcontractor. A person or business to whom the **Contractor** sublets part of the **Contract**.

Subgrade. The top of a **Roadbed**, upon which the **Pavement Structure** and shoulders are built.

Substantial Completion. The project is complete such that it can be safely and effectively used by the public without further delays, disruption, or other impediments and only clean up and **Work** of a minor nature, as agreed to by the **Engineer**, remains to be finished.

Substructure. The lower portions of a **Bridge**, generally below the bearings or skewbacks of arches, which transmit the total weight [mass] of the bridge, applied live loads (vehicular, pedestrian, or both) and other forces to the supporting bedrock or soil foundation.

Superintendent. The contractor's representative in charge of the **Work**.

Superstructure. The portion of a **Bridge** above the **Substructure**.

Supplementary Document. See **Contract**.

Supplementary Specification. See **Contract**.

Surety. A person or business bound with the **Contractor** to ensure the satisfactory fulfillment of the **Contract** and of the contractor's financial and legal obligations.

Surface Course. See **Pavement Structure**.

Survey Manual. The edition of the **Department**'s *Survey Manual* in effect at the time of the public opening of bids. Establishes survey methods and accuracy requirements.

Traveled Way. The portion of the **Highway** for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Unit Bid Price. The price bid for one unit of a bid item on a submitted **"Proposal" (Form E-91)**, including reasonable estimated costs for labor, materials, and equipment, plus reasonable proportionate shares of anticipated profit, overhead, and indirect costs.

Value Engineering Contractor Proposal (VECP). A creative proposal initiated by the **Contractor** to amend the **Contract** so as to use an alternate method, design, material, or similar element and thereby reduce the project's cost or improve its outcome for both the **Department**'s and contractor's benefit.

Volumetric Measurements. Measurements made by the **Department** for calculating quantities of items paid by volume. The Department may use any of the following methods:

1. Average end area;

2. **Neat Lines**;

3. Digital terrain modeling, including surface to surface measurement; or

4. Other method mutually agreed to between the **Engineer** and

the **Contractor**.

Work. The elements and activities necessary to complete a project (including labor, materials, equipment, and the interim products and stages attained in the course of reaching completion).

Working Day. A **Calendar Day** on which conditions within the contractor's control allow, or would allow, **Work** on the **Controlling Activities** for at least five hours with a workforce consistent in size and type for the work to be performed. Saturdays are working days if the **Contractor** chooses to work. Sundays and **Holidays** are working days if the **Engineer** allows the contractor to work. Days in December, January, February, and March are not working days even if the engineer allows the contractor to work and the contractor so chooses.

Working Drawings. See **Contract**.

SECTION 102
Bidding Requirements and Conditions

102.1 Prequalification of Bidders

1 Information and forms to apply for prequalification are contained in the "Standard Prequalification Questionnaire and Financial Statement for Bidders" (Form PQ-2), which is available on the department's Web site or from:

Prequalification Officer
Wyoming Department of Transportation
State Construction Office
5300 Bishop Boulevard
Cheyenne, WY 82009-3340
Phone: (307) 777-4056

2 Return completed and notarized applications to the same address.

102.2 Proposal Package

1 On request, the department will provide proposal packages and addenda for advertised projects. The proposal package includes the documents as defined in Subsection 101.5, Definitions.

2 Anyone may purchase a package without a bid envelope upon payment to the department of the amount stated in the invitation for bids.

102.3 Bid Envelope and Electronic Bid System Device

1 The department will issue a bid envelope and an electronic bid system (EBS) device that enables submission of a bid to contractors prequalified for a given project. The department will not issue a bid envelope or device to contractors who have not first submitted a "Current Work Affidavit" (Form E-103) or whose prequalification status has expired. The department may also refuse to issue a bid envelope and device to contractors for any of the following reasons:

1. The work classification for which the bidder is prequalified does not include the types of work constituting the major portion of the contract.

2. An outstanding commitment to uncompleted work that, in the judgment of the department, could prevent the timely completion of new work.

3. Failure to pay or satisfactorily settle any claim on record with the department.

4. Default under previous department contracts.

5. Nonpayment for a period longer than 30 calendar days of monies due the department.

6. Failure to perform at least 30 percent of the work with their own organization.

102.4 Interpretation of Quantities in the Proposal

1 The bid item quantities included in the proposal package are approximate and prepared solely for the comparison of bids. Without invalidating bid prices, the department may change quantities or eliminate pay items.

102.5 Examination of Documents and Work Site

102.5.1 General

1 Before submitting a bid, the department expects contractors to examine sites and routes related to the work, as well as contract documents and those documents cited in the proposal package and addenda. The department considers submission of a bid conclusive evidence that the bidder has made such examination and is aware of and satisfied as to site conditions and project requirements. The department is not bound by oral interpretations of this information by its employees.

102.5.2 Subsurface Conditions

1 The department makes no guarantees regarding the character or extent of utilities, water levels, soil, rock, or other subsurface conditions the bidder may encounter during the work. The department interpolates test data from completed borings in its reports and representations of subsurface conditions and does not guarantee the accuracy of these interpolations, nor does the department guarantee the accuracy of the test data itself except at the exact points where samples were taken.

2 The department requires bidders to make their own evaluation of subsurface conditions and to determine how these conditions may affect the methods and cost of construction. The department will not consider claims for damages or other compensation should the scope or progress of the work differ from those anticipated by the contractor. Material quality within sources naturally varies, so expect this.

102.5.3 Bid Item Numbers

1 The department identifies each bid item listed on the “Proposal” (Form E-91) by a joint numeric code and descriptive name. The first three digits in the numeric code indicate the principal section in *Standard Specifications* or the principal division in Special Provisions or Supplementary Specifications containing requirements for the item’s use, provision, or installation.

102.5.4 Nominal Dimensions

1 In the “Proposal” (Form E-91), the department specifies standard, manufactured items (such as fence, wire, timber, pipe, etc.) by the nominal units of measure or means of identification conventional within an industry.

102.6 Preparation of Bids

102.6.1 General

1 The department will accept for consideration only those bids for which—before the advertised time of bid opening—it has received a bid envelope containing the following:

1. The completed “Proposal,” (Form E-91) on both the EBS device and EBS-generated paper printout.
2. A notarized signature on the paper printout from one of the following:
    - 2.1. The owner of the company;
    - 2.2. An officer of the company, as recorded on the “Standard Prequalification Questionnaire and Financial Statement for Bidders” (Form PQ-2); or

2.3. Someone for whom, in writing, authorization has been requested by an officer of the company and approved by the department's Contracts and Estimates Engineer.

3. Electronic bid bond documentation.

102.6.2 Electronic Bid System

102.6.2.1 General

1 The department uses an electronic bid system (EBS) and requires bidders to prepare and submit bids using this same software. The EBS can be downloaded from the WYDOT Web site.

102.6.2.2 Multiple Proposals on a Device

1 The bid device will contain proposals for every project in a letting. A contractor may bid on every project for which he or she has received a bid envelope. The department will provide a labeled device envelope. The label is used to indicate the name of the bidder and the call order(s) for which bids are being submitted. The department will charge a fee of $100 to bidders who submit a bid envelope and EBS-generated paper bid but no bid device with the corresponding electronic "Proposal" (Form E-91) and bid data. The department requires contractors submitting multiple bids at a letting to submit their multiple electronic proposals on a single device.

102.6.2.3 Addenda

1 The department will send an e-mail message for updating the bid documents whenever it issues an addendum modifying the "Proposal" (Form E-91). If multiple addenda are sent for a project, the department is not responsible for ensuring that the updates are applied in order. Acknowledge all addenda within the EBS program.

102.6.2.4 Format for Paper Printouts

1 In addition to storing data on a device, the EBS software will generate the "Proposal" (Form E-91) with the contractor's bid incorporated in the printout. Print and submit the printout on standard office paper (8½ in × 11 in [215 mm × 280 mm], width by height). Use black ink dark enough to allow reproduction.

102.6.2.5 Discrepancy Between Device Data and Printout

1 Bid information on the printed “Proposal” (Form E-91) takes precedence over that on the bid device in the event of a discrepancy. A bid may be changed on the paper printout if initialed in ink by an authorized representative.

102.6.3 Handwritten Bid Submissions

1 The department will not accept a handwritten bid.

102.7 Irregular Bids

1 The department will not consider or publicly read bids with an improper or missing signature or notarization on the “Proposal” (Form E-91) or bids that lack printed numerical values.

2 The department will publicly read at the bid opening, but may reject, bids with any of the following irregularities:

1. Ambiguity as to any part of a bid.
2. A missing unit bid price or extension.
3. Alteration, deletion, loss, or substitution of any page or part of the “Proposal” (Form E-91) or the addition or attachment of conditional provisions.
4. An erasure or change in a unit bid price not initialed in ink by the bidder.
5. The presence of any unit bid price that generates reasonable doubt that award to that bidder would result in the lowest ultimate cost to the department.
6. A nonmatching check digit on any page of the “Proposal” (Form E-91).
7. An improper electronic bid bond or lack of a cashier’s check payable to the Transportation Commission of Wyoming and in the amount of 10 percent of the bid.

102.8 Delivery of Bids

1 The department will only accept for consideration bids submitted in the department-issued bid envelope affixed with the original label indicating to whom the envelope was issued and for what project.

2 However delivered, the bid opening official will stamp bids with the time and date of receipt, as indicated by the department's designated "official clock." The department will only accept for consideration those bids received before the time and at the place advertised in the invitation for bids. Bids not meeting these criteria will be returned unopened.

102.9 Withdrawal or Revision of Bids

1 At no time will the department or its employees revise a bid for a contractor.

2 Provided the request is made in writing and received before the advertised time of bid opening, bidders may withdraw or revise an already submitted bid. Bidders may not withdraw submitted bids between the advertised time of opening and the completed reading of bids for the first project in the letting. After the completed reading for each project, bidders may (in writing) withdraw unread bids for other projects. Withdrawal of a bid is irrevocable, regardless of the reason for the withdrawal.

102.10 Combination Proposals

1 The department may issue proposals and will consider bids for projects in combination or separately. On such projects, the department reserves the right to make awards in combination or separately, to its advantage. The department will not consider combination or separate bids on proposals not so specified.

102.11 Public Opening of Bids

1 The department will open and publicly read bids at the time and place stated in the advertisement.

102.12 Disqualification of Bidders

1 The commission may reject bids, disqualify bidders from future bidding until reinstated, or both, upon evidence of any the following:

1. Submission from the same person, firm, or corporation (under the same or different names) of multiple bids for the same work or evidence that one bidder has a financial interest in the firm of another bidder for the same work.

2. Collusion among bidders.

3. Declaration of the bidder's default on a department contract.

4. Determination that the bidder has made fraudulent statements on the "Standard Prequalification Questionnaire and Financial Statement for Bidders" (Form PQ-2).

5. Past or present disbarment, disqualification, or restriction from bidding by another government agency.

6. An attempt, successful or not, to influence department policy through gratuities or gifts to or the employment of department personnel.

7. Demonstrated inability to meet contract requirements.

SECTION 103
Award and Execution of Contract

103.1 Consideration of Bids

1 After the public reading, the commission will compare bids on the basis of each bid's summed extensions. Results will be immediately available to the public. The commission will give precedence to the unit bid price in the event of a discrepancy between unit bid prices and extensions.

2 The commission reserves the right to reject any or all bids, to waive bid irregularities, or to readvertise for new bids.

103.2 Award of Contract

103.2.1 General

1 Within 30 calendar days of the bid opening, the commission will do one of the following:

1. Award the contract to the qualified bidder making the lowest responsive bid that complies with all requirements;
2. Award the contract conditionally when there are conditions requiring clearance before an outright award can be made; or
3. Reject all bids.

2 Bids may be withdrawn without penalty if the department does not act within 30 calendar days of the bid opening.

103.2.2 Conditional Awards

1 If an award is conditional and the bidder is responsible for clearance, the award date is the date of the conditional award.

2 If an award is conditional and the department is responsible for clearance, the award date is the date the condition is cleared and the award is made. If the department does not obtain clearance within 30 calendar days of the conditional award, the bidder may withdraw the bid without penalty.

103.2.3 Notification

1 By letter mailed to the address on the submitted bid, the commission will notify the apparent low bidder of one of the following:

1. Award of the contract;
2. Conditional award of the contract, with a statement of conditions;
3. Rejection of the bid as unresponsive; or
4. Rejection of all bids.

103.3 Cancellation of Award

1 The commission reserves the right to cancel an award before execution of the contract without liability.

103.4 Return of Bid Bonds

1 The department will return all bid bonds after its receipt of a satisfactory performance bond and execution of the contract.

103.5 Performance Bond

103.5.1 General

1 When the contract is executed, the department will require the successful bidder to provide a performance bond in a sum equal to the full amount of the contract. Obtain the bond on the department-provided “Performance Bond” (Form E-82).

103.5.2 MEASUREMENT and PAYMENT

1 Include the cost of the performance bond in the mobilization item.

2 At the preconstruction conference, provide the engineer with a statement from the surety indicating the cost of the bond based on the rate schedule and contract amount and a rate schedule from the surety indicating how the performance bond will be adjusted based on the final contract cost.

3 Using the surety’s rate schedule, the department will adjust the cost of the pay item for the performance bond when the difference between the final contract

amount and the bid total from the submitted “Proposal” (Form E-91) represents a percentage change greater than shown in Table 103.5.2-1, Performance Bond Adjustment.

Table 103.5.2-1
Performance Bond Adjustment

Bid Total	Change in Final Contract Amount Without Adjustment in Bond Cost
< $500,000	± 20%
$500,000 to $2,500,000	± 15%
> $2,500,000	± 10%

4 The department will pay for Performance Bond as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Mobilization	LS	LS	LS

5 The engineer will make performance bond adjustments using Item 999.06000, Adjustment of Performance Bond.

103.6 Execution and Approval of Contract

1 The department will send the successful bidder three copies each of the “Contract” (Form E-82A) and the “Performance Bond” (Form E-82). Sign and return each copy of each document.

2 File a *Certificate of Insurance* with the department’s Contracts and Estimates Program verifying that insurance coverage has been obtained for Commercial General Liability Insurance, Umbrella/Excess Liability Insurance, Business Automobile Liability Insurance, and Payment of Premium and Notice of Revocation in accordance with Subsection 107.4, Contractor’s Insurance Requirements. The department will not execute the contract until it has received

the certificate and approved the insurance. Approval does not limit or affect the contractor's liability.

3 Bidders may withdraw their bid without penalty if the department fails to execute the contract within 21 calendar days of receiving the signed documents and certificates of insurance. Contracts are not effective until executed by all parties.

103.7 Bidder's Failure to Execute Contract

1 If the bidder fails to sign and return all copies of all required documents within 30 calendar days of the award date the department may cancel the award. Such failure is also cause for forfeiture of the bid bond for liquidation of damages sustained by the department. The department may then award the contract to the qualified bidder making the next lowest responsive bid or readvertise the project.

103.8 Document and Data Retention

1 Keep from the time of bid preparation through final acceptance of the project, and for at least three years afterwards, records of all information involving project costs and related business documents. Such data and documents include, but are not limited to, records pertaining to bid preparation, overhead, payroll, payments to suppliers and subcontractors, equipment lease agreements, and lease agreement payments. Maintain the records in an organized manner conducive to review and audit by the department. If a contract dispute arises and remains unresolved for more than three years after final acceptance, keep the records until the dispute is resolved. Actual cost documentation is required to substantiate all claims. The department will not accept estimates, averages, etc.

SECTION 104
Scope of Work

104.1 Intent of Contract

1 The intent of the contract is to state the roles and obligations of the department and the contractor.

104.1.1 Voluntary Partnering

1 The department seeks to encourage a cooperative partnership with the contractor and its principal subcontractors and suppliers. This partnership should draw on the strengths of each organization to identify and achieve mutual goals. Its objectives are effective and efficient contract performance.

2 Partnerships are voluntary, with each participant considered the equal of the other. Participants will agree to and share equally the costs associated with partnering meetings.

3 Before the preconstruction conference (specified in Subsection 108.3.3, Preconstruction Conference), the contractor's management personnel and the engineer should plan and hold a workshop to initiate the partnership and agree on a charter. The engineer, the contractor's on site project manager, and key project personnel from all parties, including subcontractors and suppliers, are encouraged to attend. Follow-up workshops may be held, as agreed to by the contractor and the department.

4 The establishment of a partnership charter does not change the legal relationship of the parties or relieve either from any terms of the contract.

104.2 Contract Amendments

104.2.1 General

1 The department reserves the right to amend the contract at any time. Amendments do not invalidate the contract or release the surety, and the contractor agrees to perform the work as amended. The department will implement contract amendments by issuing a "Contract Amendment" (Form E-61). Do not begin any amended work until the engineer provides authorization or the "Contract Amendment" is signed.

2 The department will consider requests from the contractor for an amendment to the contract amount or time only when the engineer is notified in accordance with Subsection 104.2.7, Contractor-Engineer Notification.

3 The department will pay for amendments at contract unit bid prices unless the contractor's cost of production or the character of the work is materially changed, in which case the department may adjust the contract as specified in Subsection 109.4, Extra and Force Account Work. The department will not pay for lost or anticipated profits resulting from an amendment to the contract.

104.2.2 Differing Site Conditions

1 Before the conditions are disturbed or the affected work performed or continued, notify the engineer in accordance with Subsection 104.2.7, Contractor-Engineer Notification, if either of the following are encountered:

1. Latent physical conditions that differ materially from those indicated in the contract or
2. Unusual physical conditions that differ materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the contract.

2 The department will not grant or consider contract amendments based on differing site conditions if it does not receive timely written notice in accordance with Subsection 104.2.7, Contractor-Engineer Notification.

104.2.3 Engineer-Ordered Suspensions

1 The engineer may suspend all or part of the work. If a contract amendment appears warranted because of a suspension that is unreasonably long (not anticipated, customary, or inherent to the construction industry), notify the engineer in accordance with Subsection 104.2.7, Contractor-Engineer Notification.

2 The department will not grant or consider contract amendments based on an engineer-ordered suspension:

1. Without timely written notice in accordance with Subsection 104.2.7, Contractor-Engineer Notification;

2. To the extent that the suspension is overlapped by or falls within a suspension or delay due to any other cause, including delays caused by the contractor;

3. For which an amendment is already addressed by another contract requirement; or

4. That include profit.

104.2.4 Significant Changes in the Character of Work

1 The engineer may alter contract quantities, the work, or both as necessary to complete the project. The department will make appropriate amendments to the contract if such alterations significantly change the character of the work.

2 Before performing significantly changed work, reach agreement with the department concerning the basis for the amendment as specified in Subsection 109.4, Extra and Force Account Work, and Subsection 108.6, Extension to the Contract Completion Date. If the department disagrees as to whether an alteration constitutes a significant change, use the notification procedures specified in Subsection 104.2.7, Contractor-Engineer Notification.

3 If alterations do not significantly change the character of the work specified in the contract, the department will pay for the altered work at the contract unit price.

4 Either of the following constitutes a “significant change”:

1. When the character of the work as altered differs materially in kind or nature from that specified in the contract or

2. When the original quantity, as specified in the “Proposal” (Form E-91), of a major pay item is changed by more than 25 percent, in which case the department will adjust unit prices in accordance with the following:

   2.1. In the case of an increase, adjustment in the unit price applies only to the portion greater than 125 percent of the original quantity.

   2.2. In the case of a decrease to less than 75 percent of the original quantity, adjustment applies only to the actual quantities used. The department will not pay a total for the item that exceeds 75 percent of the original extension.

104.2.5 Extra Work

1 When necessary or desirable to complete the project, the engineer may direct the contractor to perform unforeseen work for which there is no pay item or unit price in the contract. The department will pay for such work in accordance with Subsection 109.4, Extra and Force Account Work, based on an approved "Contract Amendment" (Form E-61).

104.2.6 Exception

1 The department will not consider any condition at an available source of local materials whether furnished by the department or the contractor, as meeting the requirements of Subsections 104.2.2, Differing Site Conditions, or 104.2.4, Significant Changes in the Character of Work.

104.2.7 Contractor-Engineer Notification

104.2.7.1 General

1 The engineer will consider requests for contract amendments only when the notification procedures in this subsection are followed. The engineer will not consider requests when these procedures are not followed; the specified time limits may only be extended through a written, jointly signed agreement between the contractor and the engineer. Throughout, the engineer will endeavor to address the underlying issue prompting the notification in a timely and satisfactory manner.

104.2.7.2 First Notice, by Contractor

1 Notify the engineer verbally as soon as a contract amendment appears necessary. Do not start or continue an activity or item of work for which a contract amendment may be necessary without authorization from the engineer.

104.2.7.3 Written Notice, by Contractor

1 Provide a written notice within five working days of the first notice. Include the following:

1. A description of the situation;
2. The time and date the situation was first identified;

3. The location of the situation, if appropriate;

4. A clear explanation of why the situation represents a change to the contract, including accurate reference to the pertinent portions of the contract;

5. A statement of the amendments deemed necessary in the contract price(s), delivery schedule(s), phasing, time, etc. Because of its preliminary nature, the department recognizes that this information may rely on estimates;

6. An estimate of the time by which the engineer must respond to minimize cost, delay, or disruption; and

7. Anything else that will help achieve a timely resolution.

104.2.7.4 Written Acknowledgment, by Engineer

1 In writing, the engineer will acknowledge receipt of the contractor's written notice.

104.2.7.5 Final Written Response, by Engineer

1 Within ten working days of receiving the contractor's written statement, the engineer will provide a written response that includes one of the following:

1. Confirmation of the need for a "Contract Amendment" (Form E-61).

2. Denial of the request for a contract amendment, in which case the engineer will make clear, through reference to the contract, why the issue does not represent a change.

3. A request for additional information, in which case the engineer will state clearly what is needed and by when; the engineer will issue a final response within ten working days of receiving the additional requested information.

104.2.7.6 Contractor's Recourse

1 If the outcome of the request for a contract amendment is unacceptable or the engineer's response untimely, the contractor may pursue a dispute in accordance with Subsection 105.15, Dispute Resolution.

104.3 Value Engineering Contractor Proposals

104.3.1 General

1 The contractor may submit a written Value Engineering Contractor Proposal (VECP) for contract modifications that are likely to benefit the department. The department encourages VECPs for any aspect of a project but reserves the right to reject any submission with or without review. The department will notify the contractor in writing of its decision to accept or reject a VECP in whole or in part. This decision is final and not subject to appeal.

2 VECPs apply only to an executed contract. Do not base bid prices on the anticipated approval of a VECP. If a VECP is rejected, complete the contract as bid and specified.

3 The department will notify the contractor promptly in writing if the response date indicated on a VECP (as specified in Subsection 104.3.4(6), Submitting a VECP) allows insufficient time for review. The department bears no liability for monetary damages or delays based on a failure to respond by the date indicated on the VECP.

4 Approved or rejected, a VECP applies only to the contract referenced. The department retains the right to use, duplicate, or disclose, in whole or in part, any information needed to implement a VECP. The department also retains the right to use in whole or in part any accepted VECP on other contracts without obligation to the contractor.

5 The department bears no liability for costs or delays resulting from the rejection of a VECP, including but not limited to development costs, loss of anticipated profits, increased material, or labor costs.

104.3.2 Preliminary VECP Meeting

1 Meet with the engineer before formally submitting a VECP to discuss the proposed change and its potential benefits.

104.3.3 Conditions

1 The department may reject any VECP that requires excessive time or cost for review. The department will use the following conditions to determine if a VECP qualifies for consideration:

1. The contract has been executed in accordance with Section 103, Award and Execution of Contract.

2. The department will not consider VECPs that impair essential functions or characteristics of a project, including but not limited to service life, economy of operation, maintenance, appearance, and safety.

3. Cost reductions resulting from corrections to contract errors identified by the contractor do not qualify for submission as a VECP.

4. The department will not consider a VECP that is not consistent with the department's design policies and criteria for the contract.

5. The department will not consider a VECP containing experimental features.

6. The department will not consider a VECP if the contract contains equivalent options.

7. The department will only consider a VECP if the likely benefit is sufficient to warrant review and processing.

8. The department will only consider VECPs from the contractor. The department invites and encourages VECPs from subcontractors but will only consider those submitted through the contractor.

104.3.4 Submitting a VECP

1 To submit a VECP, give the engineer two copies of the following:

1. A cover letter indicating the submission is a VECP.

2. A description of the difference between the existing contract and the proposed change and the comparative advantages and disadvantages of each. Where applicable, include effects on service life, economy of operations, maintenance, appearance, and safety.

3. Separate cost estimates for the affected parts of the contract, including the performance bond, with and without the proposed changes. Break the estimates down by pay item numbers, and indicate quantity increases or decreases and deleted pay items. Use current department

pay item names and numbers to identify proposed work not covered by the existing contract. In preparing the estimates, include overhead and profit within each affected pay item.

4. Preliminary drawings and specifications describing the proposed changes. Include an itemization of details, sheets, design standards, and specifications that would require changes or additions if the VECP were adopted.

5. Analyses in sufficient detail to identify and describe features of the contract that would require change if the VECP were adopted. Support design changes with engineered-elements by computations sealed by a professional engineer in the appropriate discipline. Provide a discussion of how these changes can be accomplished, and assess their effect on other contract elements.

6. The date by which a "Contract Amendment" (Form E-61) adopting the VECP must be executed to obtain the maximum benefit.

7. A statement detailing the VECP's effect on the contract completion date.

8. A description of previous use or testing of the same or a similar VECP and the circumstances and results. If submitted on another department project, indicate the date, project number, and the action taken by the department.

9. When asked in writing, provide within ten calendar days of the date of request any additional information needed by the department. The department will consider the contractor's failure to do so as cause for rejection.

104.3.5 Payment

1 The department will use a "Contract Amendment" (Form E-61) to incorporate changes resulting from an adopted VECP and to authorize payment. Payment will be determined and made as follows:

1. As appropriate, the department will change pay item quantities, add new pay items, eliminate pay items, or change pay item unit prices, as agreed.

2. The department will pay the contractor 55 percent of the net savings realized, calculated as the difference between the total contract amount with and without the VECP.

SECTION 105
Control of Work

105.1 Authority of the Engineer

1 The engineer will decide all questions regarding the quality and acceptability of materials, work, rate of progress, cooperation between contractors, and interpretation and fulfillment of the contract. The engineer may not pay for work done contrary to the contract or deemed unacceptable. The engineer may change quantities or eliminate pay items as warranted by the project conditions. The engineer does not have authority to amend the contract without implementing a “Contract Amendment” (Form E-61) in accordance with Subsection 104.2, Contract Amendments.

2 The engineer may suspend the work wholly or in part in accordance with Subsection 108.5.2, Engineer-Ordered Suspensions.

105.2 Working Drawings

105.2.1 General

1 Provide and submit to the engineer for approval working drawings in sufficient detail to control and complete the work. Working drawings supplement the contract; their approval does not relieve the contractor of responsibility for completion of the work as specified. The work and costs of preparing and obtaining approval for working drawings is incidental to the related pay items in the contract.

105.2.2 Shop Drawings

1 When specified, the department requires the contractor’s fabricator to submit shop drawings. Send drawings to the following address:

The Specified Program or Engineer Title
Wyoming Department of Transportation
5300 Bishop Boulevard
Cheyenne, WY 82009-3340

2 The department requires shop drawings to show dimensions, sizes of materials, and other information and data necessary to make and erect the work. Provide

drawings on paper sized approximately 11 in × 17 in [280 mm × 430 mm] or 22 in × 36 in [560 mm × 910 mm]. Review time of shop drawings will be proportional to the complexity of work, but in no case will such time be less than 35 calendar days. Submit two complete sets of advance shop drawings for each structure or fabricated item on the project, with any deviation from the contract requirements identified clearly as such. Note any deviation from the contract in the transmittal letter, and forward a copy of the letter to the engineer and the contractor. Ensure that each drawing shows the name of the structure (if applicable), road route, station, Wyoming project number, county, structure number (if applicable), and the department drawing number (if applicable).

3 Allow 14 calendar days for the department to review and return each shop plan drawing submittal. The department will keep one set of the advance shop drawings and return the other with necessary corrections noted. Make the changes indicated; clearly identify changes other than those requested by the department and note in the transmittal letter. Return to the department six complete sets of corrected drawings, each marked "Final" along with the transmittal letter. Forward a copy of the letter to the engineer and the contractor. Upon review and approval by the department, final shop drawings become part of the contract; the department will mark the drawings as "Approved" and distribute as follows:

1. One set to the fabricator, along with permission to begin fabrication;
2. One set to the contractor;
3. Two sets to the engineer;
4. One set to the department's shop inspector; and
5. One set to stay with the departmental program responsible for providing the approval.

4 Do not make or order materials before receiving the "Approved" drawings. Do not substitute materials, change dimensions, or deviate from the "Approved" shop drawings without written consent from the department.

5 The department's approval of shop drawings constitutes its acceptance of the character and sufficiency of details; it does not constitute a check on dimensions and does not relieve the contractor or fabricator from responsibility for errors or omissions and their necessary correction.

105.3 Conformity with Contract

1 Perform work and provide materials in accordance with the lines, grades, cross-sections, dimensions, tolerances, and requirements specified. Perform incidental work in accordance with the technical section associated with the work. The engineer may, in accordance with Subsection 113.3, Unacceptable Work and Materials, choose to accept work or materials that meet the contract's intent but not its requirements.

2 Contract references to standard test methods or specifications such as those from AASHTO, ASTM, IMSA, and the *Materials Testing Manual* refer to the methods or specifications in effect on the advertised date of the public bid opening. If a later change to a cited document affects successful completion of the project, the department will incorporate the new reference with a "Contract Amendment" (Form E-61).

105.4 Coordination and Precedence of Documents in the Contract

1 The contract comprises complementary documents that together describe a whole, such that a requirement or specification in one binds and acts as though appearing in all. In case of discrepancy, federal laws, rules, and regulations supersede conflicting contract requirements for projects involving federal funds, and documents have the following order of precedence:

1. Successive "Contract Amendments" (Form E-61) in order of issuance, most recent first.
2. Addenda
3. "Contract" (Form E-82A).
4. Department-obtained agreements.
5. "Proposal" (Form E-91).
6. Special provisions.
7. Supplementary documents.
8. Plans.
9. Supplementary specifications.

10. Standard plans.

11. These *Standard Specifications*.

12. Electronic CADD files.

2 Calculated dimensions take precedence over scaled dimensions.

3 Notify the engineer upon discovery and do not take advantage of errors or omissions in the contract. The engineer will correct as necessary.

4 Paper documents take precedence over electronic files.

105.5 Superintendence

1 In writing, and in accordance with Subsection 108.3.3, Preconstruction Conference, the department requires the contractor to designate a project superintendent, who is an employee of the contractor with the following:

1. The ability to read, interpret, and implement the relevant contract documentation;

2. Experience in work of the project's nature;

3. Authority to represent and act for the contractor, including authority to execute directions by the engineer; and

4. Authority to obtain and provide sufficient materials, equipment, tools, labor, and incidentals to complete the project as specified.

2 When work is underway, including work by a subcontractor, ensure the presence at the worksite of the project superintendent unless otherwise agreed to by the engineer.

105.6 Cooperation by Contractor

1 Cooperate with the engineer and inspectors.

105.7 Cooperation Between Contractors

1 The department may contract with separate contractors for additional work on or near the worksite. When separate contracts are let, the department requires each contractor to cooperate with and to work without hindering each other.

2 Each contractor assumes liability, financial or otherwise, for its own errors, acts, or omissions and holds the department harmless from damages or disputes arising from inconvenience, delay, or loss due to the presence and operations of other contractors on or near the worksite, including material sources.

3 These provisions apply also to work by the department's employees and equipment.

105.8 Equipment Storage

1 The contractor may store equipment on approved portions of the right-of-way outside the specified clear zone. After use, restore storage sites to their original condition, at no additional cost to the department. If needed, provide additional space at no additional cost to the department.

105.9 Construction Stakes, Lines, and Grades

105.9.1 General

1 Do not begin work until the lines and grades that will control the work are staked. Preserve project control, stakes, and marks placed by the engineer. The department will charge the contractor, or deduct from monies due, the cost of their replacement at a rate of $100 per hour. The department makes available necessary information defining the control through its placement of stakes, the contract, or the engineer.

105.9.2 Department Surveying

1 When the contract does not include Contractor Surveying as a pay item, the engineer will set construction stakes establishing lines, slopes, profile grades, centerline, and bench marks. The department assumes responsibility for the accuracy of its work; use the engineer's stakes and marks to establish extended control. To avoid delays, notify the engineer at least ten calendar days before starting work that requires staking.

105.9.3 Contractor Surveying

105.9.3.1 General

1 When Contractor Surveying is a pay item, the contractor is responsible for grade staking the project. The department considers Contractor Surveying a

specialty item for the purposes of subcontracting in accordance with Subsection 108.1, Subletting of Contract. Perform survey work under the supervision of a professional land surveyor or professional engineer registered in the state of Wyoming.

2 The department will establish horizontal and vertical control for the project. The department will set centerline and benchmarks for culverts, protective and accessory structures, and appurtenances as required. The engineer will furnish necessary information relating to lines, slopes, and grades. Use these stakes and information as the field control to establish the project benchmarks and to perform the work.

3 Do not set grade stakes until the subgrade elevation is within 4 in [100 mm] of the final grade based on the slope stake information.

4 Keep survey notes in a clear, orderly, neat manner and in accordance with the *Survey Manual*; the engineer may randomly inspect the notes for compliance. Survey records belong to the department; ensure their availability to the engineer for inspection or reproduction at all times. Correct deficiencies and transmit survey records to the engineer for inclusion in the project records before final project acceptance.

5 Upon discovery, notify the engineer of apparent errors in or discrepancies with previous surveys. Obtain corrections or interpretations before proceeding.

6 Correct deficient work due to incorrect staking or failure to report errors or inaccuracies in work previously performed by the department. Reset grade stakes, benchmarks, reference points, or property corners lost, damaged, or destroyed by traffic or construction.

105.9.3.2 Materials

1 Provide personnel, materials, and equipment necessary to perform the work. Calibrate equipment before starting, and submit calibration data, information from field checks of the calibration, and results including location and dates performed, to the engineer. Use stakes measuring at least 1 in × 1 in × 6 in [25 mm × 25 mm × 150 mm]. Equip each stake with chasers.

105.9.3.3 Grade Staking

1 Run a level circuit to check the project benchmarks on each roadway section before beginning roadway staking. Submit a letter to the engineer stating that

the vertical control has been established, checked, and meets the requirements of the *Survey Manual* for level accuracy.

2 Set grade stakes required to control the work. Establish the grade stake elevation for the subgrade and each base course using grade information provided by the engineer. Consult the engineer before setting grade stakes for curve runoffs and ramps.

3 On typical sections using special borrow, the department considers the top of the special borrow the subgrade for grade staking purposes.

4 Set reference points and reference lines to control alignment and the grade elevations at the subgrade and at the top of each base gravel course. Establish additional lines as required for passing or climbing lanes and slope or crown breaks between shoulders.

5 Set reference points and lines to produce the typical sections and ride quality specified.

6 Set subgrade grade stakes for tangent sections at intervals no greater than 100 ft [25 m], no greater than 50 ft [12.5 m] for curves, and at other miscellaneous break points as specified. Set grade stake lines for safety shoulders, median, and shoulder ditches at intervals of 100 ft [25 m].

7 Drive the top of each stake to within 0.02 ft [0.005 m] of the specified elevation.

8 Maintain horizontal alignment of each completed course within 0.15 ft [0.045 m] in 500 ft [152 m] of the true line.

105.9.4 MEASUREMENT and PAYMENT

1 The engineer will measure Contractor Surveying as a complete unit.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Contractor Surveying	LS	LS	LS

1. Twenty-five percent with the first monthly progress payment;

2. Twenty-five percent with the monthly progress payment following submission of the letter to the engineer stating that the vertical control has been established and checked and meets the requirements; and

3. Between 50 percent and up to 90 percent, payment will be based on request from the contractor.

4. The final 10 percent upon completion of the surveying.

105.10 Extracontractual Agreements By Contractor

1 The contractor may enter into agreements with third parties, whether public or private, for the purpose of acquiring the use of land or materials to complete the project. Such agreements are subject to review by the engineer; except for those with commercial sources, submit copies of the signed documents describing the agreement to the engineer.

105.11 Authority of the Inspector

1 The engineer, or an inspector representing the engineer, has authority to inspect all work and materials at any stage, including preparation, fabrication, or manufacture. Inspectors do not have authority to amend the contract.

105.12 Inspection of Work

1 Give the engineer, or an inspector representing the engineer, access, information, and all help needed to enable safe, complete, detailed inspections during every phase of the work. Notify the engineer at least one working day before performing work that will need inspection.

2 If the engineer was not provided the opportunity for inspection, expose the work as directed, at no additional cost to the department. The engineer may order the removal and replacement of work performed or materials used without inspection, at no additional cost to the department.

3 If the engineer was provided the opportunity for inspection and failed to inspect the work or materials, expose portions of the finished work for inspection as directed. After inspection, restore the work. The engineer will pay for the cost of exposing and restoring the work as extra work, in accordance with Subsection 109.4, Extra and Force Account Work, if the work meets the contract requirements; the engineer will not pay this cost if the work does not meet the contract requirements.

4 Representatives of governmental entities, railroads, or utilities that pay for or participate in parts of the work have the right to conduct inspections. Such inspections do not make these agencies a party to the contract and do not affect the rights of the contractor or the department.

105.13 Load Restrictions

1 Except as provided in this subsection, comply with legal load restrictions when moving equipment or hauling materials on public roads that remain in service. A permit from the department to operate an overweight, oversized, or overwidth vehicle does not relieve the contractor of liability for damage to public roads due to the moving of equipment or materials.

2 The engineer may stop or reroute material transportation or eliminate the corresponding pay item from the contract if the activity appears detrimental to the roads used.

3 Without damaging structures, roadways, or other work, the contractor may operate empty, overweight, or oversize equipment on roadways within the construction limits as required to perform the work. Such operation does not require an overweight, oversized, or overwidth permit but is subject to approval by the engineer. Approval does not relieve the contractor of responsibility for the repair of resulting damage.

4 Do not allow loads on concrete pavement, base, or structures before the strength or time requirements for the concrete has been met. In the case of pipes, do not allow loads before placing the specified cover fill. Do not exceed the current maximum legal load limit when hauling materials over partially, wholly, or previously finished base or surface courses within the construction limits.

5 Repair damage by hauling equipment at no additional cost to the department.

105.14 Maintenance of the Work During Construction

1 Protect the work and roadway from damage. Except as provided in Subsections 113.4, Final Acceptance, and 108.5, Suspension of Work, preserve and maintain the undamaged work and roadway during construction and until final acceptance of the project. Use adequate and effective equipment and forces to keep the work and roadway in satisfactory condition at all times. Maintenance of the work and roadway is incidental to the pay items in the contract.

2 When placing a course upon other courses or subgrade, maintain the previous layers as constructed. Maintenance includes, but is not limited to, draining, recompacting, regrading, or, if damaged, removing and replacing the damaged course(s). As necessary, use equipment, labor, and new materials.

3 The engineer will notify the contractor immediately if the work or roadway is not maintained. If satisfactory maintenance is not performed, the engineer may direct other organizations to perform the maintenance. The department will deduct the cost from monies due the contractor or will bill the contractor, as appropriate.

105.15 Dispute Resolution

105.15.1 General

1 The department will not consider a submitted dispute if the contractor has not followed the notification process in accordance with Subsection 104.2.7, Contractor-Engineer Notification.

2 Notify the engineer in writing within five working days if the result of a request to amend the contract remains unacceptable at the end of the procedure specified in Subsection 104.2.7, Contractor-Engineer Notification. Send by USPS certified mail “Return Receipt Requested.” State clearly the activity or item of work disputed and the reason for continued disagreement with the engineer. Upon receipt of this notice, the engineer may direct the contractor to start or resume the disputed work while the dispute is resolved. With the exception of a dispute concerning final quantities, which will be handled in accordance with Subsection 109.8, Final Quantities, the contractor waives the right to seek a contract amendment if the engineer receives the written notice more than 30 calendar days after the contractor’s receipt of the district engineer’s letter of final acceptance of the work, as specified in Subsection 113.4, Final Acceptance.

3 The contractor waives the right to seek a contract amendment by failing to meet a specified time limit. The contractor and the department may, however, extend a time limit by a specific written mutual agreement.

4 The process specified in this subsection is intended to produce a reasonable resolution of disputes. Conduct the process in good faith; completing the process is a condition precedent to filing suit in Wyoming state courts.

5 Payments warranted as a result of a dispute pursued in accordance with this subsection will be based on the actual costs incurred as shown in provided documentation without a percentage markup for profit. The department may also require an audit of the contractor's project records, home office records, financial records, and other records.

105.15.2 Supporting Documentation

1 Within 30 calendar days of notifying the engineer, send to the engineer for review and audit accurate and complete documentation supporting the requested contract amendment. Send by USPS certified mail "Return Receipt Requested." Provide copies of pertinent data arranged in a logical sequence; include at least the following:

1. Copies of all previous correspondence related to the activity or item of work disputed;

2. Data and information used to assemble the bid, if bid preparation is relevant to the disputed issue;

3. Schedules and updates prepared in accordance with Subsection 108.3.2, Schedule, if time or delays are relevant to the disputed issue;

4. Documents similar in nature to those used to substantiate payments for extra or force account work, as specified in Subsection 109.4.4(5), Force Account, Documentation;

5. Supporting actual cost records; and

6. Accounting records and statements, if overhead is relevant to the disputed issue.

2 Accompany the submission with the following signed statement:

> *The undersigned is duly authorized to certify the enclosed documentation on behalf of* (the contractor).
>
> (The contractor) *certifies that the documentation is submitted in good faith, that the information provided is accurate and complete to the best of* (the contractor's) *knowledge and belief, and that the monetary amount requested accurately reflects the contract amendment for which* (the contractor) *believes the department is responsible.*
>
> (THE CONTRACTOR)
>
> *By:* ________________________
> (Name and title)
> *Date:* ________________________

105.15.3 Decision by Resident Engineer

1 Within 30 calendar days of the date the supporting documentation is received, the engineer will review the request and return, by USPS certified mail "Return Receipt Requested" to the contractor a written decision, along with copies of documentation used by the engineer, but not provided by the contractor, in deciding the issue.

2 Submission of additional information at any subsequent level of review by anyone will not be allowed once the claim record is assembled and the engineer has made a decision.

105.15.4 Appeal to District Engineer

1 Within 30 calendar days of the date the resident engineer's decision is received, if that decision is unacceptable, send a written notice of appeal to the district engineer by USPS certified mail "Return Receipt Requested." Within 30 calendar days of receiving this notice, the district engineer will convene a meeting of the resident engineer and the contractor to resolve the dispute. Within 30 calendar days of this meeting, the district engineer will send a written decision to the contractor by USPS certified mail "Return Receipt Requested."

105.15.5 Appeal to Chief Engineer

1 Within 30 calendar days from the date the district engineer's decision is received, if that decision is unacceptable, send a written notice of appeal to the chief engineer by USPS certified mail, "Return Receipt Requested" with a copy to the district engineer. Within 30 calendar days of receiving this notice, the chief engineer will convene a meeting of the district engineer, the resident engineer, and the contractor to resolve the dispute. Within 30 calendar days of this meeting, the chief engineer will send a written decision to the contractor by USPS certified mail, "Return Receipt Requested."

2 The department will not consider additional appeals after this decision.

105.15.6 Adjudication

1 Within 30 calendar days from the date the chief engineer's decision is received, if that decision is unacceptable, the contractor may sue the commission in state district court. Adjudication will be by bench trial.

2 No part of this Subsection 105.15, Dispute Resolution, supersedes the laws of the State of Wyoming. The commission, in seeking to resolve a dispute, does not waive its sovereign immunity. The contractor agrees not to challenge the commission's right to assert sovereign immunity as a complete or limited bar to the extent it has been reserved and in consideration for which the commission agrees not to assert sovereign immunity as a defense to resolve a dispute provided none of the following are included in the claim:

1. Prejudgment interest on the amount of the claim;
2. Exemplary or punitive damages;
3. Attorney's fees, consultant fees, or other costs of litigation;
4. Damages exceeding the actual costs as supported by the documentation presented; or
5. Consequential damages (meaning those not encompassed in items 1, 2, and 3) exceeding 10 percent of the calculated amount in item 4.

3 These items are meant to limit the potential liability of the commission. If the contractor seeks relief beyond the limits of these items, the commission may assert sovereign immunity as an affirmative defense and complete bar to the action.

SECTION 106
Control of Material

106.1 Quality Requirements

1 Provide and use materials that meet the specified requirements. The engineer will use procedures from the *Materials Testing Manual*, when applicable, to determine whether materials meet the requirements.

2 When standard test methods or specifications are referenced in the contract, use methods and specifications in accordance with Subsection 105.3, Conformity with Contract.

3 When the contract refers to a particular product or manufacturer, followed by the phrase "or an approved equal," the department is establishing a standard of quality, durability, and design; it is not limiting competition. The department will accept products of other manufacturers if they are equal to those specified and the engineer approves in writing.

4 Submit certifications in accordance with Subsection 800.1, Manufactured Product Certifications.

106.2 Inspection and Tests at Source of Supply

1 The engineer may inspect materials at their source. Ensure the engineer's access to relevant areas of the suppliers' production facilities. Provide facilities to enable sampling of material at no additional cost to the department. Before their incorporation in the work, the engineer may retest materials tested at their source.

106.3 Sources, Sites, and Haul Roads

106.3.1 General

1 Provide material sources, stockpile sites, plant sites, and associated haul roads if not designated in the contract as department-furnished.

106.3.2 Department-Furnished

106.3.2.1 General

1 The department may acquire and make available for the contractor's use, material sources, stockpile sites, plant sites, and haul roads. For material sources, interpret the department's data from the boring logs in accordance with Subsection 102.5, Examination of Documents and Work Site.

2 The contractor has the right to determine the equipment and amount of work needed to produce a material that meets the contract requirements. The engineer may specify the location of the procurement of material from any portion of a deposit.

3 Perform the following at no additional cost to the department:

1. Moving equipment within a pit;
2. Moves made for the contractor's benefit; and
3. Moves made due to the presence of unacceptable material, except when the original location was designated by the engineer.

106.3.2.2 Available Material Sources

1 In the contract, the department may show available sources for required materials. The engineer may approve changes from available sources by issuing a "Contract Amendment" (Form E-61). When the contract allows and the contractor elects to use a department-furnished source as a contractor-furnished source, a Contract Amendment is not required. The department will determine the quality of the material from the proposed source in accordance with Subsection 106.3.3.3, Approval of Materials.

2 When the contractor chooses to use a source other than those initially designated as available, excluding commercial sources, the department will pay for quantities up to the specified amount at the contract unit price for the affected pay item(s). The department will consider as incidental the following costs associated with the change:

1. Additional costs from increases in quantities for:

   1.1. Overburden storing and placing;

1.2. Topsoil storing or placing;

1.3. Haul length;

1.4. Temporary fence;

1.5. Asphalt binder;

1.6. Hydrated lime;

1.7. Crushed base;

1.8. Plant mix pavement;

1.9. Seeding, fertilizer, or mulch; and

1.10. Royalty.

2. All costs associated with:

2.1. A change in the type of seed, fertilizer or mulch;

2.2. Development costs;

2.3. Haul roads;

2.4. Erosion control measures; and

2.5. Necessary permits, agreements, and environmental clearance.

3 The engineer will not approve use of a source not initially designated as available, or its associated haul road(s), before the contractor has submitted copies of the necessary permits and agreements from the owners or land management agency. The engineer will not approve use of a proposed source that is not or has not been commercially active before the contractor has obtained environmental clearances in accordance with Subsection 106.3.3, Contractor-Furnished, and given copies to the engineer before starting work. The contractor is responsible for delays associated with obtaining and using such sources.

106.3.2.3 Mandatory Material Sources

1 When the department designates a source as mandatory, use it.

106.3.2.4 Stockpile Sites, Plant Sites, and Haul Roads

1 In the contract, the department may show available stockpile sites, plant sites, or haul roads. The engineer may approve, in writing, requests to change from available sites and roads to contractor-furnished sites and roads in accordance with the procedures and assessment of additional costs specified in Subsection 106.3.2.2, Available Material Sources, but may not issue a "Contract Amendment" (Form E-61).

106.3.3 Contractor-Furnished

106.3.3.1 General

1 When using commercial or contractor-furnished sources, sites, and haul roads, all associated costs will be considered incidental to the contract. The contractor is responsible for:

1. Submitting a letter to the engineer asking to use the proposed source;
2. Acquiring the necessary rights to take material;
3. Ensuring that the materials taken meet the requirements of Subsection 106.3.3.3, Approval of Materials;
4. Associated delays;
5. Maintaining and repairing associated haul roads;
6. Submitting an acceptance statement signed by the landowner stating that all conditions and stipulations in the agreement have been met; and
7. Royalty, including when the contract allows and the contractor elects to use a department-furnished source as a contractor-furnished source and for commercial sources.

106.3.3.2 Environmental Requirements

1 If the proposed site, source, or associated haul road is not or has not been commercially active, obtain and give the engineer copies of the following documents and clearances:

1. A United States Geological Survey 7.5 minute quadrangle map showing the location of the features and activity.

2. Necessary permits from owners, land management and regulatory agencies (BLM, WDEQ, etc.), and approved mitigation plans, as appropriate.

3. Documents reflecting the proposed activity's socioeconomic, cultural, natural, or physical impacts and the approved mitigation plans, as appropriate. For all proposed activities, provide the following:

    3.1. A completed copy of the department's "Environmental Impact Evaluation" (Form E-15), summarizing the findings.

    3.2. A copy of the class III cultural resource inventory report, to be completed by a qualified archaeologist. Include documentation of findings meeting Wyoming State Historic Preservation Office standards, evaluations of eligibility to the National Register of Historic Places, and determination of no effect or no adverse effects by the proposed activity to any cultural resources located. The department will deny all requests if the cultural resource inventory report has a determination of anything other than no effect or no adverse effects.

    3.3. A copy of the wetlands report if wetlands are locted in or near the area.

    3.4. A copy of the Army Corps of Engineers permit, if required.

    3.5 A copy of the biological assessment if endangered, threatened, or proposed species, as defined in the Endangered Species Act of 1973, are present in or near the area. The biological assessment must result in a determination of no effect or not likely to adversely affect for all endangered, threatened, and proposed species in or near the area. If the biological assessment results in a may affect or likely to adversely affect determination, the department will not approve the change. The contractor must agree to and implement the terms and conditions of the current Programmatic Biological Opinion issued by the United States Fish and Wildlife Service.

3.6 A copy of approved mitigation plans, as stipulated in permits from the appropriate regulatory agency.

2 The engineer will review the documents and provide a written response within 30 calendar days of receipt of the information.

106.3.3.3 Approval of Materials

106.3.3.3.1 General

1 Use an AASHTO-accredited laboratory to perform tests for source approval. Do not use materials from a source before the engineer has approved the source. Approval of a material's source does not constitute approval of the project-specific material produced.

2 Agree with the engineer on a sampling plan. Obtain representative samples in accordance with the procedures in the *Materials Testing Manual*. Submit the samples to the engineer along with the request to use a contractor-furnished source. Also include the following:

1. The sampling layout of the source;
2. Test data for:
   - 2.1. Wear grading,
   - 2.2. Plastic index,
   - 2.3. Liquid limit, and
   - 2.4. Soundness ($MgSO_4$), soundness ($NaSO_4$), or both, as required.
3. Depth at which samples were taken, vertical limits of the useable material, and depth of the pit floor.

3 The department will notify the contractor of its determination within 21 calendar days of receiving the samples and data.

106.3.3.3.2 Commercial Sources

1 The test frequency requirement will be once per year. Submit the information directly to the Materials Program when not being submitted for a specific contract. The engineer may waive the tests for temporary or small quantities of materials.

106.3.4 Reclamation

1 Whether department or contractor furnished, reclaim sites and associated haul roads used for material sources, plant sites, or stockpiling after completing the work. Perform reclamation as follows:

1. Where practical, place or leave out of sight from the roadway those stockpiles designated to remain.
2. Return stockpiles of rejected or unused materials and overburden to the pit and blend with the surrounding terrain.
3. Remove oil, asphalt, and discarded parts and equipment.
4. Leave slopes no steeper than 1V:3H, unless the slopes' initial grade was steeper.
5. Spread topsoil.
6. Seed, fertilize, and mulch.

106.4 Vacant

106.5 Field Laboratory

106.5.1 General

1 Provide, maintain, and equip a field laboratory for the department's exclusive use at a location directed by the engineer for the duration of the project. As specified, equip the lab with a built in or separate restroom for the department's exclusive use, and keep the restroom clean and useable. The department will repair damage due to abuse or negligence by its personnel.

2 For projects with multiple operation sites, the engineer may request to move the lab to accommodate project operations. Level, block, and tie down the lab when placing.

3 The engineer will inspect field laboratories. The decision to approve or disapprove a lab is independent of the lab's history of use or approval on prior projects. The lab remains the property of the contractor after completion of the project.

106.5.2 MEASUREMENT and PAYMENT

1 The engineer will measure each Field Laboratory, including maintenance and two moves, as a complete unit provided for the duration of the project. The engineer will measure additional directed moves in accordance with Subsection 109.4, Extra And Force Account Work.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Field Laboratory	EA [Ea]	EA [Ea]	EA [Ea]

106.6 Storage of Materials

1 Store materials in a manner that facilitates inspection and preserves the materials' quality and suitability for use. The engineer may reinspect stored, previously inspected materials before approving their use in the work.

2 As approved by the engineer and outside the clear zone, the contractor may use portions of the right of way for material storage. If needed, provide additional storage space at no additional cost to the department. Before using property outside the right-of-way or specified construction permits, provide the engineer copies of agreements with the landowner, lessee, or land management agency.

3 After use, reclaim storage sites to their original condition in accordance with Subsection 106.3.4, Reclamation, at no additional cost to the department.

4 Storage of materials or equipment not directly involved with bridge work will not be allowed on the bridge. Do not stockpile, place, or store debris, rubble, or aggregate on bridges.

106.7 Handling Materials

1 Handle materials so as to preserve their quality and suitability for use in the work. Transport materials in vehicles built to prevent loss, contamination, or segregation after loading and measuring.

106.8 Department-Furnished Material

1 If specified, the department will provide material for incorporation into the project. The department will deliver such material to, or make available at, the locations specified. Take responsibility for material after the department has delivered or made it available. The subsequent costs of handling and placing the material are incidental to the associated contract pay item.

106.9 Rights in and Use of Materials Found in the Work

1 The engineer may authorize the use of aggregate or other material found in excavation for another pay item. The department will pay the established contract unit price for the excavation of such material and for the pay item for which it was used. If the excavated material is used for another pay item but was otherwise needed for embankments, backfills, approaches, or other purposes, provide an acceptable replacement at no additional cost to the department.

2 Do not excavate or take material outside the slope stake limits without the engineer's written approval. The right to use and process material found within the project limits excludes use and processing for noncontract work. If the contractor produces or processes more material from the project than is required for the contract, without additional compensation to the contractor, the department may:

1. Take possession of the excess material and direct its use or
2. Require removal of the material and restoration of the land to a satisfactory condition.

106.10 Requirements for Steel and Iron

1 The department requires the use of domestic iron and steel in the permanent components of a project. "Domestic" means all manufacturing processes occur within the United States. Such processes include, but are not limited to, rolling, extruding, machining, bending, grinding, drilling, and coating or similar processes to manufacture or modify the physical properties or chemical composition of iron or steel. Coatings include any protective or value-enhancing process. The department will, however, accept:

1. Foreign iron or steel components whose total combined value, including the cost of delivery to the project, does not exceed 0.1 percent of the total contract amount, or $2,500, whichever is greater.

2. The use of the following nondomestic raw materials: scrap, pig iron, and processed, pelletized, and reduced iron ore.

3. Nondomestic items that are used temporarily then abandoned in place at the contractor's convenience.

2 For iron and steel components, obtain from the manufacturer and provide to the engineer a material test report or certification that states clearly the country of manufacture. Include two copies of the itemized invoices for materials used and transportation costs for shipment to the project.

3 Ensure that foreign-made bolts, fasteners, and associated hardware are tested and certified by an independent domestic testing laboratory in accordance with Division 800, Materials. Submit the test data and certifications to the engineer before use.

4 To seek a waiver of these provisions, submit a written request to the engineer. Accompany the request with supporting information showing that the specified steel or iron products are not manufactured in the United States in sufficient, available quantities of satisfactory quality. The department will not grant time extensions or pay compensation for delays resulting from processing such a request.

106.11 Stockpiling Aggregate

1 Clear and grub aggregate stockpile sites in accordance with Section 201, Clearing and Grubbing. Ensure that sites are firm, smooth, and well-drained. Do not stockpile aggregate in a manner that causes or allows contamination or excessive degradation.

2 When not included as a pay item, the stockpiling of aggregates for construction is incidental to the associated pay items.

106.12 Contractor Testing

106.12.1 General

1 When specified, take responsibility for development of a mix design as applicable, material sampling, quality control testing, and quality acceptance testing.

106.12.2 MEASUREMENT and PAYMENT

1 The engineer will measure Contractor Testing as a complete unit.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Contractor Testing	LS	LS	LS

3 The department will divide and pay out the lump sum as follows:

1. Twenty-five percent with the first monthly progress payment;
2. Twenty-five percent with the monthly progress payment that follows the engineer's written acceptance of the contractor mix design or the beginning of placement of tested material(s); and
3. The final 50 percent upon completion of the sampling and quality control and quality acceptance testing.

4 The department will not pay directly for changes to an accepted contractor mix design made for the contractor's benefit; complete it at no additional cost to the department. At a negotiated lump sum price, the department will pay for changes to an accepted contractor mix design made at the engineer's request.

SECTION 107
Legal Relations and Responsibility to the Public

107.1 Applicable Laws

1 Become familiar with and adhere to all federal, state, and local laws, ordinances, and regulations and all orders and decrees of bodies or tribunals having any jurisdiction or authority that may affect those engaged or employed on the project or affect the conduct of the work. Indemnify, defend, and hold harmless the state and its representatives against any dispute or third party liability claim due to a violation of any of the foregoing, whether by the contractor or any party or person engaged by the contractor. The department will not grant time extensions or pay compensation for delays or disruption resulting from actions against the contractor due to such violations.

2 The provisions of W. S. 16-6-121 apply when the contract amount is for $50,000 or more.

107.2 Permits, Licenses, and Taxes

1 Obtain all permits and licenses; pay all charges, fees, and taxes; and give all notices necessary or related to the lawful prosecution of the work.

107.3 Patented Devices, Materials, and Processes

1 Observe all patent and copyright laws and obtain through legal agreement with rights holders all necessary permissions for the use of intellectual property employed or incorporated in the work. Indemnify, defend, and hold harmless the department, affected third parties, and affected political entities from claims, lawsuits, or causes of action for infringement filed against the contractor by the rights holder of protected intellectual property. Pay any costs, expenses, or damages incurred by reason of such infringement, at any time.

107.4 Contractor's Insurance Requirements

107.4.1 General

1 Provide the following insurance and file a *Certificate of Insurance* with the Contracts and Estimates Program in accordance with Subsection 103.6, Execution and Approval of Contract, verifying each type of coverage; the department's approval of insurance does not affect the contractor's liability:

1. **Workers' Compensation and Employers' Liability Insurance.** Provide proof of workers' compensation coverage for every employee who will work on the project. Obtain the coverage under the Wyoming Workers' Safety and Compensation program or such workers' compensation insurance, as appropriate. Do not allow a subcontractor to work on the project without first giving the department proof of the subcontractor's workers' compensation and employers' liability insurance.

2. **Commercial General Liability Insurance.** Provide coverage for the duration of the contract against claims arising out of bodily injury, death, damage to or destruction of the property of others, including loss of use thereof, and products and completed operations, in the amount of at least $1,000,000 per occurrence and $2,000,000 general aggregate.

   Endorse the policy to include Employees Liability "Stop Gap" coverage, in an amount of at least $500,000 per employee, for each accident, for each disease.

3. **Umbrella/Excess Liability Insurance.** Maintain for the duration of the contract, and in addition to all other policies, Umbrella/Excess Liability coverage in the amount of at least $1,000,000 per occurrence and $1,000,000 in the aggregate.

4. **Business Automobile Liability Insurance.** Maintain for the duration of the contract, automobile liability insurance for claims arising out of the use of an automobile, including owned and nonowned automobiles in the amount of at least $500,000 combined single limit.

5. **Unemployment Insurance.** Register and stay registered with the Department of Employment, Employment Tax Division for the duration of the contract. Provide the department with notice of satisfactory unemployment insurance coverage, prepared by the Department of Employment, Employment Tax Division, for every subcontractor before allowing the subcontractor to work on the project.

6. **Payment of Premiums and Notice of Revocation**. Maintain required insurance policies in effect for the duration of the project. Obtain primary, not contributory, policies. Provide insurance certificates for all

policies; include a clause stating that each policy will not be revoked, canceled, amended, or allowed to lapse until the expiration date of at least 30 calendar days or 10 calendar days if the cancellation is for nonpayment of premium with advance written notice.

107.4.2 Department May Insure for Contractor

1 If a provision of this section is breached, the department may purchase and maintain insurance in the name of the contractor. The department will deduct the cost of such insurance from monies due the contractor or will bill the contractor, as appropriate.

107.4.3 Department as Additional Insured

1 Except for the workers' compensation and unemployment compensation insurances, obtain policies that name the department as an additional insured and that contain a waiver of subrogation against the department, its agents, and employees. Provide a copy of the endorsement providing this coverage to the Contracts and Estimates Program, in accordance with Subsection 103.6, Execution and Approval of Contract.

107.4.4 Department's Right to Reject

1 The department may reject a *Certificate of Insurance* if the issuing company is regarded in the insurance industry as financially unstable. This includes, but is not limited to, insurance companies with an "Omit" rating in the A.M. Best insurance rating guides.

107.4.5 Department's Right to Contact Insurer

1 The department may obtain relevant policy information from the contractor's insurance agent. This includes but is not limited to exclusions endorsed and in-progress claims that could significantly reduce the annual aggregate limit. If the policy is a "claims made" policy instead of an "occurrence" policy, other information the department may obtain includes, but is not limited to:

1. Retroactive dates;
2. Extended reporting periods or tails; and
3. Applicable deductibles.

107.5 Employee Health and Safety

1 Provide and maintain a safe workplace. Provide and maintain, in a neat and clean condition, portable sanitation facilities for use by everyone at the worksite.

2 Do not operate equipment within 500 ft [150 m] of survey or testing personnel. Move equipment to another location. If equipment cannot be moved, provide flagging for the protection of all survey and testing personnel, as approved by the engineer. The department will pay for flagging in accordance with Subsection 703.5, Measurement and Payment.

107.6 Railway-Highway Provisions

1 The department may arrange with railway companies for work within railroad rights-of-way. Perform work on railroad property as directed by the rail company. Take responsibility for damages, delays, or injuries and for related suits, actions, or disputes due to the contractor's operations within or next to a rail company's right-of-way

2 Obtain the necessary right-of-entry permit(s), and notify the rail company before work begins inside the railroad right-of-way.

107.7 Use of Explosives

1 Give at least three calendar days notice to property owners and utility companies with facilities near the site prior to using explosives. If necessary, monitor vibrations, air blast and noise with a seismograph or other equipment to prevent damage to adjacent structures.

2 Fourteen calendar days before using explosives, submit to the engineer for review a detailed plan showing hole spacing, diameter, and pattern; loading; timing; and other pertinent data. Include plans for traffic control, and indicate the precautions that will be taken to satisfy the requirements of this subsection. Such notices and plans do not relieve the contractor of responsibility for damage from blasting.

107.8 Protection and Restoration of Property, Markers, and Landscape

107.8.1 General

1 Preserve public and private property during work on the project. Take responsibility for damage or injury resulting from:

1. Any act, omission, negligence, or misconduct in the execution of the work;
2. Defective work or materials; and
3. The work of a subcontractor.

2 At no additional cost to the department, immediately restore or replace real property damaged or injured in the course of the work to its prior or a similar condition. Coordinate repairs, replacements, or both with the affected property owner, and obtain his or her written approval when the final work is complete-in-place. Submit a copy of the property owner's approval to the engineer. If the contractor fails to perform such restoration within a reasonable time, the engineer may do so and deduct the cost from monies due the contractor or bill the contractor, as appropriate.

3 Do not remove, relocate, or damage land monuments, highway monuments, or property markers or corners without direction from the engineer.

4 Install temporary fencing or other measures approved by the engineer to control access of unauthorized vehicles onto adjacent private property or onto the highway right-of-way.

107.8.2 Protection of Livestock

1 Take the measures necessary to confine and prevent livestock from entering the highway right-of-way. Install temporary stock-tight fence, if necessary.

2 If existing fencing is removed in the course of the work, replace and restore to its original condition as soon as practical.

107.8.3 Vehicle Damage Claims

1 If a vehicle owner makes a claim of vehicle damage, send a written response to the claimant addressing the claim and the actions that will be taken. Send a copy of the response letter to the engineer and to the following address:

State of Wyoming
Department of Administration and Information
ATTN: Risk Manager
700 West 21th Street
Cheyenne, WY 82002

107.9 Accommodations for Irrigation

1 Where the project involves work over, through, or around irrigated lands or irrigation facilities, make arrangements with the owner(s) for the timing and sequence of work. Document these arrangements and give copies to the engineer before starting the relevant work. Do not interfere with the proper handling or delivery of water.

107.10 Responsibility for Damage Claims

1 Indemnify and hold harmless the department, its officers, and its employees from suits, actions, or claims arising from:

1. Injury or damage to any person, persons, or property resulting from acts, errors, or omissions by the contractor, including but not limited to:
    1.1. Neglect in safeguarding the worksite or work in progress;
    1.2. Use of unacceptable materials;
    1.3. Acts, errors, omissions, or misconduct causing injury or damage to a third party; and
    1.4. Work outside of the construction limits.
2. The Wyoming Workers' Compensation Act or any other state or federal law, ordinance, order, or decree.

2 If such a suit, action, or claim is initiated against the department, the department may withhold money due the contractor for use by the state. If no money is due, the department may hold the contractor's surety until such suit(s), action(s), or claim(s) for injuries or damages are settled. The department will pay or release such money or surety when it receives evidence of settlement. The department will not withhold money due the contractor when provided with evidence of

the contractor's adequate protection by public liability and property damage insurance. The contractor's lack of response to a third-party claimant may affect the contractor's prequalification status.

107.11 Traffic Provisions and Public Safety

107.11.1 General

1 In each area where traffic has been restricted from normal flow, work continuously until the work is complete. Return traffic to normal unrestricted flow immediately after completion of the work. Work in a manner and sequence that least obstructs traffic in all its forms, including but not limited to vehicular, pedestrian, and bicycle. Give consideration to the location of detours and the provision for handling traffic. Provide for the safety and convenience of both the general public and residents near the work. The contractor's rights of travel do not supersede those of the public. Obtain written approval from the engineer before stopping traffic, conducting construction activities across or through traffic, or closing public roads.

2 Notify the engineer in writing at least 21 calendar days before starting an activity that will restrict the movement of oversized loads. Do not proceed with the activity until approved by the engineer.

3 The contractor's responsibility for traffic and roadway maintenance begins on the project's first day of physical work. Notify the engineer of unsafe conditions that need immediate correction.

4 Provide continuous temporary approaches to businesses and residences adjacent to the roadway, intersections, detours, crossings, and similar features or facilities to safely accommodate customary vehicular or pedestrian traffic affected by the work. Provide, maintain, and remove such accommodations in accordance with Subsection 108.5, Suspension of Work. Do not prohibit access to adjacent businesses or residences without first obtaining written approval from the affected owners or tenants and from the engineer. Providing, maintaining, and removing temporary accommodations for traffic is incidental to associated pay items when not included as a pay item in the contract.

5 Maintain an adequate surface on traffic carrying lanes, including those of detours and temporary facilities, under all weather conditions. Control dust by using water or other palliatives. Do not hinder traffic or restrict the width of the paved surface, traveled way, or shoulders from December 1 to March 31 without the

approval of the engineer. Do not place or leave materials or equipment within the specified clear zone.

107.11.2 Drainage Structures for Detours

107.11.2.1 General

1 Determine the size of the structure required to accommodate the anticipated volumes of water and provide a structure designed for an HS20 loading. Furnishing, installing, maintaining, and removing the drainage structure is incidental to associated contract pay items. Loss or damage incurred as a result of an inadequately-sized temporary drainage structure(s) is the contractors responsibility.

107.11.2.2 Bridges

1 If electing to use a bridge as a drainage structure for a detour, design the structure in accordance with the edition of the *AASHTO Standard Specifications for Highway Bridges* in effect at the time of the public opening of bids. For review and approval, provide the engineer with three copies of the design computations and plans for the bridge structure, in accordance with Subsection 105.2, Working Drawings, at least 21 calendar days prior to the anticipated installation. Prepare the design computations and the plans under the supervision of a professional engineer registered in the state of Wyoming.

2 Design and construct bridges to provide a minimum clear roadway width equal to the detour top width specified and include bridge rail and approach guardrail systems.

107.11.3 Delay to the Traveling Public

1 Maintain two-way traffic. When the department specifies or allows one way, alternating traffic, do not allow delays to an individual vehicle passing through the project longer than the following:

1. **Rural and Residential Areas.** No single delay longer than 15 minutes and total delay no longer than 20 minutes.

2. **Business Areas.** No single delay longer than 10 minutes and total delay no longer than 15 minutes.

107.11.4 Temporary Traffic Control

1 Provide, install, and maintain necessary devices to control traffic, ensure safety of the public, and protect the work. Use barricades to protect highways closed to traffic. Erect warning signs before places where work may interfere with the road's use by traffic and at intermediate places where the project crosses or coincides with an existing road, bike path, or sidewalk.

2 Where it is impossible or impractical to divert traffic on existing roads or detours, perform the work under traffic. Provide for traffic movement in accordance with the approved traffic control plan. As necessary, use flagging, pilot car escorts, or both.

3 Provide, install, and maintain temporary traffic control devices in accordance with the contract and the MUTCD. Temporary traffic control is incidental to associated pay items when not included as a pay item in the contract.

107.11.5 Edge Drop-Off

1 Do not expose any form of traffic to unprotected vertical drop-offs greater than 1 in [25 mm]. For drop-offs greater than 1 in [25 mm], construct an edge slope no steeper than 1V:4H from material approved by the engineer or provide other appropriate barricade devices. Slope grading or other excavation work to match the existing slopes or with a temporary slope no steeper than 1V:3H. When constructing pavements thicker than 1 in [25 mm] under traffic, schedule the work in accordance with Subsection 401.4.19, Spreading and Finishing. Do not taper temporary pavement ends more steeply than 1V:6H.

2 Use temporary traffic control or safety devices to delineate drop-offs, unless otherwise directed. The provision, maintenance, and removal of temporary controls and tapers is incidental to associated pay items in the contract.

107.12 Responsibility for Safeguarding the Work

1 The contractor's responsibility for the work lasts until final written acceptance of the project by the district engineer, in accordance with Subsection 113.4, Final Acceptance, and includes protection against injury or damage to any part of the project from any cause. Except for damage due to unforeseeable causes beyond the control of and without the fault or negligence of the contractor, rebuild, repair, restore, and make good damages to any portion of the project from any cause before final acceptance and without additional cost to the department.

Suspension of the work does not relieve the contractor of responsibility for the project, except in accordance with Subsection 108.5, Suspension of Work.

107.13 Responsibility for Utility Procedures and Services

107.13.1 Location

1 The department makes every effort to indicate the location of utility and pipeline facilities in the contract and to notify utility companies of impending construction. Before proceeding with the work, confirm the final grade and locations of such facilities in accordance with W.S. 37-12-301 et sequens (the "Wyoming Underground Facilities Notification Act") and W.S. 37-3-301 et sequens (the "Wyoming High Voltage Power Lines and Safety Restrictions Act").

2 Notify utility and pipeline companies of the proposed construction schedule at least three working days before the start of work. Ask for the nature, location, and depth of pipes and cables and the areas where they may conflict with the work. If a company cannot or will not provide this information, obtain it by alternate means. Where conflicts may exist, locate the relevant pipes or cables in three dimensions. Do not begin excavation until all such features have been located, their owners notified, and the engineer has approved. Do not start work near fire hydrants or gas regulators without arranging continued service.

107.13.2 Utility Line Conflicts and Damage

1 If utility lines are determined to be in conflict with or are damaged during the work, stop work in the immediate area, notify the utility or pipeline company immediately, and cooperate with the owner to move or repair the utility.

107.13.3 Safety

1 Advise laborers and equipment operators whenever work will occur near high voltage power lines or underground utilities, and warn them to use caution.

2 Before beginning any work, or a major change in operation, schedule a safety conference with the engineer at a mutually agreeable time to discuss safety issues and policies. Ensure that appropriate subcontractors attend the conference.

107.13.4 MEASUREMENT and PAYMENT

1 The department will measure and pay for work required to locate utilities as force account work in accordance with Subsection 109.4.4, Force Account.

107.13.5 Department Utility Work

1 The department may construct, access, or work on a department utility any time if it is located in a right-of-way under the jurisdiction of the department, a municipality, or a county.

2 The department may grant permits enabling other parties to construct, access, or work on any utility any time within the right-of-way. The engineer may direct the contractor to make repairs due to such activities. Payment for such extra work will be in accordance with Subsection 109.4, Extra and Force Account Work. For delays caused by the utility work, the engineer may make an extension to the contract completion date in accordance with Subsection 108.6, Extension to the Contract Completion Date.

SECTION 108
Prosecution and Progress

108.1 Subletting of Contract

108.1.1 Contractor's Required Participation

1 The contractor is responsible for completion of the project as specified; no subcontract releases the contractor from contract obligations. The contractor must perform work equaling at least 30 percent of the value of the original contract amount using his or her own organization. In computing the contractor's required participation, the department will exclude the value of designated "specialty items" from the contract amount and the subcontracted amount.

108.1.2 Subcontracts and Subcontractors

1 With the State Construction Engineer's written approval, the contractor may sublet portions of the contract. In turn, subcontractors may sublet to lower tier subcontractors, but no subcontractor at any tier may sublet more than 70 percent of the value of the work for which it has subcontracted.

2 Sign and submit to the State Construction Office for approval before the start of subcontracted work, and for every subcontractor at every tier, a "Request to Subcontract" (Form E-59/59A). Attach proof of the subcontractor's workers' compensation and employers' liability insurance in accordance with Subsection 107.4, Contractor's Insurance Requirements. For federal-aid projects, attach to each form a copy of the subcontract agreement. For subcontractors not on the department's list of current prequalified contractors or certified as a disadvantaged business enterprise (DBE) with the department, also attach an "Equal Employment Opportunity Affidavit" (Form FR-2200).

3 With each subcontract request, submit proof of workers' compensation, employers' liability insurance, and unemployment insurance in accordance with Subsection 107.4, Contractor's Insurance Requirements. The department will not approve requests without this documentation.

4 Do not allow a subcontractor to work until the department has approved the subcontract. Work performed without an approved subcontract will be designated as unacceptable work in accordance with Subsection 105.1, Authority of the Engineer. The engineer will suspend work by a subcontractor without an approved subcontract.

5 Submit to the department's Civil Rights Office the DBE Notification of Intent to Subcontract, Federal-Aid Projects (Form DBE-2), for each disadvantaged business enterprise committed to in the contract. No subcontracts will be approved until all Form DBE-2 paperwork has been received.

6 The department may reject a subcontract if at the time of the request, the proposed subcontractor has failed to pay or satisfactorily settle any claim on record with the department.

7 The department may reject a contractor if it has been determined that he or she did not perform at least 30 percent of the work with his or her own forces under a previous department contract.

108.1.3 Work Performed by Equipment Rental Agreement

1 Submit written notice to the engineer before starting work with rented equipment. Include the following information:

1. Name of the rental agency;
2. Anticipated rental period;
3. Whether the rental agency will provide an operator; and
4. Description of the equipment.

2 The engineer may request a copy of the rental agreement.

3 Except for truck drivers who haul and do not further handle or place material from a commercial source to the project, wage determination decisions specified in the contract apply to operators of rented equipment. Maintain, and provide as requested, payroll documentation of operators' names and wages, plus substantiation that operators (except the exempt truck drivers) are carried on the contractor or subcontractor's payroll.

108.2 Notice to Proceed

1 Start work when the department has provided a fully executed contract in accordance with Subsection 103.6, Execution and Approval of Contract, and a signed letter giving Notice to Proceed.

108.3 Prosecution and Progress

108.3.1 General

1 Notify the engineer at least 24 hours before changing shift schedules or project operations. If prosecution of the work is stopped for any reason:

1. Maintain the project in accordance with Subsection 108.5, Suspension of Work, and

2. Notify the engineer at least 24 hours before restarting work.

2 Do not work on Sundays or holidays without written authorization from the engineer. Request such authorization at least 48 hours in advance.

108.3.2 Schedule

108.3.2.1 General

1 Provide a schedule using the bar chart method in accordance with Subsection 108.3.2.2, Bar Chart Method, except when the contract specifies a schedule using the critical path method (CPM). With the engineer's approval, a CPM schedule may be provided in place of the bar chart schedule.

2 Plan and schedule the project and report progress to the engineer. At least 10 calendar days before the preconstruction conference, submit an initial project schedule in accordance with the requirements for an initial bar chart in Subsection 108.3.2.2, Bar Chart Method (or, if applicable, Subsection 108.3.2.3, Critical Path Method). Ensure that the schedule meets specified partial and contract completion dates.

3 The engineer will review the initial schedule at the preconstruction meeting. No more than five calendar days after the preconstruction meeting, the engineer will accept the initial schedule or ask for more information. The kinds of information requested may include estimated manpower, equipment, quantities, and production rates used to determine the duration of an activity or item of work. Provide the information and resubmit the revised initial schedule no more than five calendar days after the engineer's request.

4 The engineer will accept or reject the initial schedule based solely on completeness. Acceptance does not modify the contract or constitute endorsement

or validation by the engineer of the contractor's logic, activity durations, or assumptions in creating the schedule. The department may withhold monthly progress payments until the engineer accepts the initial schedule.

5 Submit a schedule update to the engineer on the first working day of each month, or as requested by the engineer. The department may withhold monthly progress payments if schedules are not updated as specified or requested.

108.3.2.2 Bar Chart Method

1 The department requires the completion and use of an initial bar chart and monthly updates:

1. **Initial Bar Chart.** This schedule identifies and includes:

    1.1. The activities needed to perform and complete the work, activities that might delay contract completion, and critical activities;

    1.2. The planned start and completion dates for each activity, the duration of each activity (stated in working days, and with activities of more than 15 working days in duration broken into two or more activities distinguished by location or some other feature), and the sequencing of all activities;

    1.3. The quantity and the estimated daily production rate for critical activities;

    1.4. An indication of how the schedule accommodates adverse weather days for each month;

    1.5. Dates related to the procurement of materials, equipment, articles of special manufacture, etc.;

    1.6. Dates related to the submission of working drawings, plans, and other data specified for review or approval by the department;

    1.7. Dates related to required inspections of structural steel fabrication, etc.; and

    1.8. Dates related to specified activities by the department and third parties.

2. **Monthly Updates.** Include on the schedule updates planned start and finish dates for each activity shown on the most recent accepted schedule. For newly started or finished activities, include the actual start or finish date. For activities previously started and still ongoing, show the remaining duration and planned finish dates. Next to each activity on the update show the planned (or “target”) dates of performance from the most recent accepted schedule.

108.3.2.3 Critical Path Method

1 Use software compatible with version 6.0 of Oracle Primavera. E-mail the initial schedule and updates to construction@dot.state.wy.us, and indicate the name and version of the software used to produce the attached schedule. Notify the engineer when the schedules have been submitted by e-mail.

2 Within 10 calendar days of receipt of an initial CPM schedule or an updated schedule, the engineer will accept the schedule or request more information. If the latter, provide the information, make the appropriate adjustments, or both, and resubmit the schedule no more than 10 calendar days after the engineer’s request.

3 The department requires that CPM scheduling proceed in three stages:

1. **Initial Bar Chart.** The engineer will use an initial bar chart to monitor progress until accepting the initial CPM schedule. Prepare and complete a schedule for the first 60 calendar days of work that meets the requirements for an initial bar chart contained in Subsection 108.3.2.2, Bar Chart Method. With prior approval, the engineer may accept activity durations of more than 15 working days. Include as well a summary bar chart schedule for the balance of the project; activity durations on the summary chart may exceed 15 working days. Submit an updated version of the bar chart every 14 calendar days until the department accepts the initial CPM schedule.

2. **Initial CPM Schedule.** No more than 30 calendar days after providing the initial bar chart, submit an initial CPM schedule to the engineer for review. Define and sequence activities so as to accurately describe the project and to meet contract requirements with respect to the scope of work, phasing, accommodations for traffic, and interim, milestone, and project completion dates. Use working days to create the schedule

and begin with the date of the Notice to Proceed. Unless otherwise approved by the engineer, also use, provide, or include the following:

2.1. The planned early and late start and finish dates for each activity;

2.2. The duration of each activity, with activities of more than 15 working days in duration broken into two or more activities distinguished by location or other feature;

2.3. A logic diagram in color, depicting no more than 50 activities on each 11 in × 17 in [280 mm × 430 mm] sheet and with each sheet including title, match data for diagram correlation, and a key. In the diagram (which may be a time-scaled, Program Evaluation and Review Technique (PERT) chart), show the sequence of and the scheduling interrelationships among activities;

2.4. Only finish to start interrelationships among activities and without leads or lags;

2.5. Interim, milestone, and project completion dates specified in the contract as the only constraints in the schedule logic;

2.6. The quantity and the estimated daily production rate for critical activities;

2.7. Activities related to the procurement of materials, equipment, articles of special manufacture, etc.;

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

2.9. Activities related to required inspections of structural steel fabrication, etc.;

2.10. Activities related to specified activities by the department and third parties;

2.11. A narrative report indicating the workdays per week, holidays, number of shifts per day, number of hours per shift, and how the schedule accommodates adverse weather days for each month;

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

2.13. Sixty-day look ahead bar charts by early start.

3. **Monthly Updates.** Update and e-mail the schedule each month to show the work's status. In the update, provide, or include the following:

3.1. The actual start and finish dates of each activity or remaining durations of activities started but not yet completed;

3.2. A narrative summary of progress during the month, shifts in the critical activities from the previous update; sources of delay; potential problems; work planned for the next 30 calendar days; and revisions to the CPM schedule, including but not limited to additions, deletions, or revisions to activities due to the issuance of a "Contract Amendment" (Form E-61), revisions to activity durations, or revisions to the planned sequence of work or the method and manner of its performance; and

3.3. Paper copies of the tabular sorts for total float and activity by early start and the logic diagram (as requested by the engineer).

108.3.2.4 Schedule Revisions

1 The engineer may request a schedule revision. Circumstances leading to such a request include but are not limited to the following:

1. A delay (actual or projected) of partial or contract completion dates by 14 calendar days or more;

2. A difference between the actual rate of progress and that depicted in the schedule; and

3. Issuance of a "Contract Amendment" (Form E-61) that, by adding, deleting, or revising activities, changes the planned sequence of work or the method and manner of its performance.

2 Submit the revised schedule no more than 10 calendar days after the engineer's request. Within 10 calendar days of receipt, the engineer will accept the revised schedule or request more information. If the latter, provide the information, make the appropriate adjustments, or both, and resubmit the revised schedule no more than 10 calendar days after the engineer's request.

108.3.2.5 MEASUREMENT and PAYMENT

1 Bar chart schedules are incidental to the contract's pay items. The department may withhold the monthly estimate if updates are not submitted as required.

2 The engineer will measure CPM Schedule as a complete unit, and the department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
CPM Schedule	LS	LS	LS

3 The engineer will pay as follows:

1. Half the value of the pay item will be paid with the monthly progress payment made after acceptance of the initial schedule;
2. One-fourth the value of the pay item will be paid when the contractor completes work representing 40 percent of the contract amount, excluding the pay item CPM Schedule; and
3. One-fourth the value of the pay item will be paid when the contractor completes work representing 80 percent of the contract amount, excluding the pay item CPM Schedule.

4 The department may withhold monthly progress payments until the contractor submits the initial CPM schedule.

108.3.3 Preconstruction Conference

1 The engineer will schedule and convene, at a mutually convenient time before the start of work, a preconstruction conference. Before or at the meeting, provide the following, if applicable:

1. A letter providing the names of material suppliers and subcontractors;

2. A list of rented equipment for both the contractor and subcontractors;

3. Available working drawings;

4. Available fabrication schedules;

5. An “EEO Officer Affidavit” (Form E-112) for the contractor and each subcontractor;

6. Copy of the training plan and list of company trainees;

7. Spill contingency and storm water pollution prevention plans in accordance with Subsection 111.3, Erosion and Pollution Controls;

8. A traffic control plan if standard plans are not used. The name of and contact information for the traffic control maintainer and traffic control supervisor;

9. A list of key personnel, including the project superintendent and subordinates authorized to sign contract documents and project records;

10. A list of phone numbers for personnel the engineer should call in case of emergency;

11. A letter designating the cut-off date for the monthly progress payments in accordance with Subsection 109.5, Monthly Progress Payment;

12. A letter accepting or declining partnership with the department in accordance with Subsection 104.1.1, Voluntary Partnering;

13. An organizational chart indicating lines of authority and providing names, phone numbers and qualifications of the individuals responsible for the contractor’s quality control program, and the material sampling and testing;

14. Confidential price quotes;

15. Mobile Machinery Affidavits;

16. Price Adjustment Affidavits; and

17. Other items the engineer may request.

2 The engineer will schedule additional conferences as needed.

108.4 Requirements for Workers, Methods, and Equipment

1 Provide enough qualified workers and enough capable equipment to complete the project in accordance with the contract.

2 Provide workers that are sufficiently skilled to perform the work assigned to them. In writing, the engineer may direct the removal from the project of any person, regardless of employer, who is incompetent, intemperate, disorderly, or insubordinate. Through written notice, the engineer may suspend the work for failure to comply with such a directive or for failure to provide enough qualified workers.

3 Make requests to use other methods or equipment than those specified in writing; do not proceed without the engineer's written approval. Include in the request a description of the proposed alternatives and the reasons for seeking a change. Approval does not relieve the contractor from the requirement to produce work in accordance with the contract. The use of alternative methods or equipment resulting in work that fails to meet contract requirements may lead the engineer to, in writing:

1. Direct a stop to their use;

2. Order the completion of remaining work using the original specified methods or equipment; or

3. Require the removal, at no additional cost to the department, of the unsatisfactory work and its replacement using the original specified methods and equipment.

4 Approval of a change in methods or equipment does not imply approval of a change in pay item prices or the contract completion date.

108.5 Suspension of Work

108.5.1 General

1 The provisions of Subsection 108.5, Suspension of Work, apply to full and partial suspensions. In the case of partial suspensions, they apply to suspended portions of the project; contract requirements governing work on continuing portions of the project remain in effect.

2 Work suspensions may occur due to seasonal conditions from December 1 to March 31 or for other reasons. The contractor may ask the engineer to suspend the project in writing. Do not suspend operations or remove necessary equipment or materials without approval from the engineer on the "Status of Project" (Form E-96).

3 During delays or suspensions, if the traveling surface is a leveling course or nonpaved surface, maintain the roadway for traffic use (snow removal and placing of sand) and the quality of the surface course until the placement of additional courses or temporary surfacing, at no additional cost to the department.

4 If placement of concrete pavement or a full lift of plant mix pavement is not completed before delays or suspension of work, provide, place, maintain, and remove temporary plant mix pavement in accordance with Subsection 401.4.20.3, Temporary Surfacing. If the contract does not include a plant mix pavement mix design, obtain the engineer's approval of the proposed design before use.

5 During suspensions, at no additional cost to the department, store materials and equipment:

1. Outside the clear zone;
2. As far from the travel way as possible;
3. At a location that will not cause maintenance or safety problems for the roadway; and
4. At a location where they will be protected from damage.

6 Maintain living material in new plantings, seedings, and soddings in an acceptable growing condition and protect from injury, at no additional cost to the department.

7 Prevent damage to or deterioration of work already performed.

8 At no additional cost to the department, provide roadway drainage, temporary structures necessary for public travel throughout the project, and required temporary traffic control, and remove and dispose of work or materials used for temporary maintenance, such as temporary surfacing.

9 Repair or replace materials lost or damaged during the suspension at no additional cost to the department.

10 Before suspension, protect slopes without vegetation in accordance with Subsection 215.4.3.9, Erosion Control Agent, at no additional cost to the department. Throughout the suspension, maintain appropriate measures for control of soil erosion, and water and air pollution in accordance with Section 215, Storm Water Pollution Prevention, at no additional cost to the department.

11 The department will maintain and repair damage to portions of the work accepted in accordance with Subsection 113.4, Final Acceptance.

108.5.2 Engineer-Ordered Suspensions

1 The engineer may, by issuing a "Status of Project" (Form E-96), suspend the work wholly or in part due to the existence of conditions unsuitable for prosecution of the work, including but not limited to the following:

1. Failure to correct unsafe conditions;
2. Failure to carry out contract requirements;
3. Failure to carry out directions of the engineer; and
4. Adverse weather.

2 The provisions of Subsection 108.5.4, Repair and Maintenance Related to Nonseasonal Suspensions, apply if the engineer suspends the work because of the preceding items 1, 2, or 3; Subsection 108.5.3, Repair and Maintenance Related to Seasonal Suspensions, applies if the suspension is because of item 4.

108.5.3 Repair and Maintenance Related to Seasonal Suspensions

1 Do not suspend work until having:

1. Prepared and left all (permanent or temporary, vehicular, pedestrian, or other) traffic-carrying roads, approaches, and crossings in a condition

to require only routine maintenance to accommodate safe travel during the suspension;

2. Completed necessary measures to protect the work and the roadway during the suspension;

3. Removed unnecessary temporary traffic control devices;

4. Placed traffic control devices as directed; and

5. Received the signed “Status of Project” (Form E-96).

2 When clauses 1 through 5 have been satisfied, the department will assume responsibility for maintaining traffic carrying surfaces during the suspension, including snow plowing and the placing of sand, except for leveling courses and nonpaved surfaces which will be handled in accordance with Subsection 108.5.1, Suspension of Work, General. The department will maintain traffic control devices and permanent signs.

3 Resume work when conditions are favorable.

4 The department will pay to restore damaged work and traffic-carrying surfaces when the suspension ends, except as specified in Subsection 108.5.1, Suspension of Work, General. The department will pay for materials used at pay item prices or, if the contract does not include appropriate pay items, in accordance with Subsection 109.4, Extra and Force Account Work.

108.5.4 Repair and Maintenance Related to Nonseasonal Suspensions

1 The department will not pay to maintain the project, routes carrying detoured traffic, or for temporary traffic control during a suspension if the contractor suspends work voluntarily for reasons other than seasonal conditions or if actions of the contractor cause the engineer to suspend work. Under these circumstances, make provisions for the continued safe accommodation of traffic.

2 If during a suspension the contractor fails to accommodate traffic or to maintain the project, including temporary traffic control devices, the engineer may direct other organizations to do so. The department will deduct the cost from monies due the contractor or will bill the contractor, as appropriate.

3 Resume work when approved by the engineer. The department will not pay to repair or replace work and the traveling surfaces when the suspension ends.

108.6 Extension to the Contract Completion Date

108.6.1 General

1 The engineer will issue a Monthly Report each month. This report shows the cumulative progress of the work as of the end of the preceding week relative to the contract completion date. The engineer may discontinue the reports during suspensions.

2 If warranted, the engineer will extend the contract completion date by issuing a "Contract Amendment" (Form E-61). The engineer will do so only if an excusable delay extends the scheduled late finish date beyond the lattermost of the contract completion date or its most recent extension. The engineer will not consider a request to revise partial or contract completion dates without notice as specified in Subsection 104.2.7, Contractor-Engineer Notification, and without documentation from the project schedule, including updates, supporting the need for a revision. The engineer will evaluate the information submitted and determine the time extension due, if any.

3 The engineer will not grant an extension for delays incurred to work activities occurring on days not defined as a "working day" in accordance with Subsection 101.5, Definitions. Nor will the engineer grant an extension based on pleas that the contract specified insufficient time for the completion of the project.

4 The granting of a time extension by the engineer relieves the contractor from liability for the payment of liquidated damages during the period of the extension.

108.6.2 Excusable Delays

1 Excusable delays are delays affecting working days that the contractor cannot reasonably foresee or avoid and are not the contractor's fault or responsibility. They include but are not limited to the following:

1. Delays due to floods, tornadoes, lightning strikes, earthquakes, fires, epidemics, or similar natural phenomena;

2. Weather delays as specified in Subsection 108.6.6, Working Day Extensions for Adverse Weather;

3. Extraordinary, unforseen, and unavoidable delays in material deliveries;
4. Delays due to the acts of government entities other than the department;
5. Delays from industry-wide strikes affecting the contractor's (or subcontractors' or suppliers') workforce that are beyond the contractor's power to settle;
6. If time allowances are not specified, or if specified allowances are exceeded, delays caused by the noncompletion of work by utilities or other third parties; and
7. Delays arising from a contract amendment in accordance with Subsection 104.2, Contract Amendments.

108.6.3 Nonexcusable Delays

1 Nonexcusable delays are delays caused by the contractor or that the contractor could reasonably have foreseen or avoided. The engineer will not make an extension to partial or contract completion dates for nonexcusable delays.

108.6.4 Concurrent Delays

1 Concurrent delays are delays occurring at the same time to separate critical activities. When concurrent delays occur, the department will give precedence to nonexcusable over excusable delays in determining extensions to the contract completion date.

108.6.5 Working Day Extensions for Increased Quantities

1 Upon written request from the contractor, the department will allow extensions for increased quantities when final quantities are determined, as shown on the cost summary report generated by the "Monthly Progress Estimate" (Form E-125). The department will base the extension on the ratio of the original contract amount to the total cost of the work performed, computed as follows:

$$TE = \frac{OT}{1.46}\left(\frac{TC}{CA} - 1\right)$$

Where:

TE	=	is the time extension in working days.
OT	=	is the original contract time and does not include time added by “Contract Amendment” (Form E-61) or the months of December, January, February, and March.
1.46	=	is the factor for converting calendar days to working days.
TC	=	is the total cost of the work performed, including cost increases resulting from “Contract Amendments” (Form E-61) for which an extension was not previously allowed, and excluding costs associated with liquidated damages, incentive/disincentive or bonus payments, and costs for “Contract Amendments” for which additional time has already been allowed.
CA	=	is the original contract amount.

2 To determine a revised completion date, the department will add the working days indicated by the formula to the original contract completion date.

108.6.6 Working Day Extensions for Adverse Weather

1 For whole or partial months within the contract time, Table 108.6.6-1, Adverse Weather Days Expected, shows the number of working days included in anticipation of weather that will preclude work. On the Monthly Report, the engineer will show for each month, and for the project to date, the number of actual adverse weather days determined by the engineer and the amount by which this exceeds the number expected.

2 The engineer may extend the completion date if the actual number of adverse weather days exceeds the expected number and the contractor has pursued the work diligently during the month.

Table 108.6.6-1
Adverse Weather Days Expected

Month[1]	Workdays Incorporated in Contract Time in Anticipation of Adverse Weather[2]
January	8
February	8
March	7
April	6
May	4
June	3
July	2
August	2
September	2
October	4
November	5
December	7

(1) Specified in the contract as including working days.

(2) For partial months, the engineer will prorate the number of expected lost workdays due to adverse weather

108.7 Opening Sections of the Project to Traffic

1 The contract may specify or the engineer may direct the opening to traffic of sections of the project before overall completion of the work. Such a partial opening does not constitute acceptance of the work or any part thereof, nor does it waive any provision of the contract.

2 If the contractor does not complete the work on time, the engineer may order all or a section of the project opened to traffic. The contractor retains legal

responsibility and responsibility for the maintenance of such opened sections until final acceptance of the project. Conduct the remainder of the work with minimum delays to traffic.

3 The engineer may require the contractor to finish a section of work in progress before starting additional sections if the opening of such a section is essential to the safety of the public.

4 Maintain the roadway and associated appurtenances in accordance with Subsection 107.12, Responsibility for Safeguarding the Work.

108.8 Failure to Complete Work by the Completion Date

1 The department will assess liquidated damages for each working day that specified work remains uncompleted after the contract completion date (or amended completion date, if applicable), through and including the date on which the engineer agrees with the contractor that the work has reached substantial completion. In addition, the department will charge liquidated damages for days worked and for days the weather would allow the contractor to work during the months of December, January, February, and March.

2 The granting of permission by the department to the contractor to finish the specified work after the contract completion date (or amended contract completion date, if applicable) does not constitute a waiver by the department of its rights under the contract. The department will deduct liquidated damages from money due the contractor or will bill the contractor, as appropriate, at the rates shown in Table 108.8-1, Schedule of Liquidated Damages.

Table 108.8-1
Schedule of Liquidated Damages

Original Contract Amount ($)		
From More Than	**To and Including**	**Charge per Working Day ($)**
0	50,000	250
50,000	100,000	250
100,000	500,000	500
500,000	2,000,000	1100
2,000,000	5,000,000	1500
5,000,000	7,500,000	2200
7,500,000	10,000,00	3000
10,000,000	15,000,000	5000
15,000,000	20,000,000	5750
20,000,000	—	6500

3 After the engineer's agreement with the contractor of the substantial completion of the work, the department will not continue to assess liquidated damages if the finish conference or final inspection, as specified in Subsection 113.4, Final Acceptance, is delayed for reasons beyond the control of or not the fault of the contractor. Nor will the department assess liquidated damages for cleanup or minor work required as a result of the finish conference or final inspection and providing the contractor has shown constant effort in completing the work.

108.9 Termination for Default

1 Using USPS certified mail, "Return Receipt Requested," the engineer will notify the contractor and the surety in writing of the contractor's delay, neglect, or default if the contractor:

1. Fails to start the work as specified;

2. Fails to provide enough qualified workers and equipment to complete the project as specified;

3. Fails to perform the work as specified, or fails to remove and replace unsuitable materials or work;

4. Stops prosecuting the work;

5. Fails to resume discontinued work within a reasonable time from notice by the engineer;

6. Becomes insolvent, or commits an act of insolvency; allows a final judgment against the contractor to stand unsatisfied for 10 or more calendar days; makes an assignment for the benefit of creditors; or

7. Otherwise fails to proceed acceptably.

2 If within 10 calendar days after the contractor has received the department's letter and the contractor or surety does not act in accordance with its terms, the department will terminate the contract and take the prosecution of the work from the contractor. The department may appropriate and use those project materials and equipment it deems suitable, and may enter into an agreement or use other methods as required to complete the contract acceptably. This paragraph binds the contractor's surety company and supersedes the provisions of any surety bond or other surety agreement.

3 The department will deduct all costs incurred by the department as a result of terminating the contract, together with the cost of completing the work as specified, from monies due the contractor. If such costs exceed the remaining amount payable under the contract, the department will hold the contractor and the surety liable for payment of the excess to the department.

4 If the department's action regarding a contract's termination for default is determined to be wrongful, the department's cause for the action will convert to one of termination on the public's behalf, in accordance with Subsection 108.10, Termination on Public's Behalf.

108.10 Termination on Public's Behalf

1 The department may at any time, by written notice, terminate all or part of the contract when the department determines it in the public's interest to do so.

Before such termination, the engineer may require the completion of unaffected parts in accordance with the contract.

2 When all or part of the contract is terminated, the department will pay the pay item price for the actual number of units completed or will compensate the contractor for actual costs incurred for work not started or completed. The department will purchase from the contractor acceptable materials obtained but not used, at the actual costs shown by receipted bills and cost records and delivered as designated by the engineer. Give the engineer access to all books, cost records, correspondence, and papers necessary to determine the relevant prices and amounts.

3 The department intends in this provision to provide for an equitable settlement with the contractor. The department will not pay for loss of anticipated profits under this provision. Termination does not relieve the contractor or the surety of its liability for just claims arising out of work performed. Under termination, title to all property accruing to the commission vests immediately in the state of Wyoming; execute and deliver all necessary papers to the engineer.

SECTION 109
Measurement and Payment

109.1 Measurement of Quantities

109.1.1 Standards

1 The department will measure pay items in the units of measure specified in the contract using methods of measurement and computation that meet generally recognized good engineering practice. Units of the U.S. customary system of weights and measures are defined in 15 U.S. Code, Section 205. Units of the metric system, or SI (the International System of Units), and the standard of practice for its use, are provided in IEEE/ASTM SI 10.

109.1.2 Symbols for Bid and Pay Items

1 The following table shows the symbols used in these *Standard Specifications*, in the "Proposal" (Form E-91), and elsewhere in the contract to indicate the units in which the department will measure bid and pay items:

Table 109.1.2-1
Unit Symbols for Bid and Pay Items

For Contracts Specified in: Inch-Pound Units (U.S. Customary System)		For Contracts Specified in: SI (International System) Units (Metric)	
Bid or Pay Unit	**Symbol**	**Bid or Pay Unit**	**Symbol**
acre	ACRE	hectare	ha
cubic foot	CF	cubic meter	m^3
cubic yard	CY	cubic meter	m^3
cubic yard hour	CYHR	cubic meter hour	m^3h
cubic yard mile	CYMI	cubic meter kilometer	m^3km
each	EA	each	Ea
force account	$$	force account	$$

Table 109.1.2-1
Unit Symbols for Bid and Pay Items, *continued*

For Contracts Specified in: Inch-Pound Units (U.S. Customary System)		For Contracts Specified in: SI (International System) Units (Metric)	
Bid or Pay Unit	**Symbol**	**Bid or Pay Unit**	**Symbol**
gallon	GAL	liter	L
thousand gallons	MG	cubic meter	m^3
hour	HR	hour	h
crew hour	CRWH	crew hour	Crwh
pound	LB	kilogram	kg
foot	FT	meter	m
lump sum	LS	lump sum	LS
mile	MI	kilometer	km
mile-day	MIDY	kilometer-day	kmd
square foot	SF	square meter	m^2
shift	SHFT	shift	Shft
station	STA	station	Sta
square yard	SY	square meter	m^2
short ton (2000 lb)	TON	metric ton	t
short ton mile	TMI	metric ton kilometer	tkm

109.1.3 Measurement Methods

1 Throughout these *Standard Specifications*, the value and units shown in the "Measure to the Nearest" columns in the Measurement and Payment sections indicate the degree of the accuracy to which the engineer will make measurements.

2 The engineer will measure pay items when in place and complete. The engineer will measure the actual work performed, excluding work outside the construction limits unless adjusted by the engineer. The engineer will measure pay item quantities using the following methods:

1. **Area.** Computed from linear distances measured horizontally; the department will not deduct for individual fixtures occupying areas equal to or less than 9 ft^2 [1 m^2]. Throughout these *Standard Specifications* the value and units shown in the “Measure to the Nearest” columns in the Measurement and Payment sections indicate the degree of accuracy to which the engineer will make linear measurements used in calculating area.

2. **Structures.** As specified.

3. **Linear.** Items measured by the foot [meter] will be measured parallel to the surface on which the items are installed. Items measured by the mile [kilometer] will be measured using project stationing.

4. **Lump Sum.** Although actual quantities of the components in a lump sum pay item used in the work may differ from the estimated quantities specified, the department will not change the amount of payment, unless otherwise specified.

5. **Volumes of Excavation, Embankment, and Similar Pay Items.** Computed by volumetric measurements.

6. **Volumes in Hauling Vehicles.** Measured at the point of delivery based on volumes computed using struck capacity. Hauling units may be of any size or type acceptable to the engineer, provided the unit’s body is shaped to enable the ready and accurate determination of the content’s volume.

7. **Converting Between Weights and Volumes.** At the request of the contractor, and with written approval from the engineer, materials paid for by volume may be measured by weight, with the measured units of weight converted to units of volume through use of a conversion factor agreed to before the measurement and payment. Also with advance approval, materials paid for by weight may be measured by volume.

8. **Asphalt Materials.** Measured by the gallon [cubic meter] or short ton [metric ton], subject to correction for foaming, shipping loss, or other reasons for nonuse. Materials will be measured using net weights or converted to weights from volumes. Asphalt volumes will be measured at 60 °F [15.5 °C] or, when measured at other temperatures, corrected to the equivalent volume in accordance with the *Materials Testing Manual*.

9. **Commercial Additives.** Bulk additives will be measured by the short ton [metric ton]. Additives in sacks will be measured using the net weight on the manufacturer's label.

10. **Timber.** Measured by the foot [meter] incorporated.

11. **Equipment Time.** Measured by the actual number of hours the equipment is used in the work, including necessary travel time within the limits of the project.

109.1.4 Weighing Procedures and Equipment

109.1.4.1 General

1 Weigh material obtained from an available source or a noncommercial, contractor-furnished source on computerized scales. Material obtained from a commercial source may be weighed on a computerized or noncomputerized scale.

2 Provide and maintain scales or use certified, permanently-installed commercial scales. The engineer will approve scales for use and document the findings on "Scale Check and Daily Truck Tares" (Form E-71). The department will pay for materials measured or proportioned by weight [mass] after quantities have been weighed on accurate scales and the results properly documented. The department will only pay for the weight [mass] of material incorporated in the work. The department will not pay for quantities weighed on belt scales.

3 Ensure the scale's accuracy to within 0.5 percent of the true weight throughout the scale's range of use. The engineer will verify the scale's accuracy by observing the contractor check the scale before its first use and as often thereafter as the engineer deems necessary. Provide, for this purpose, ten or more 50-pound [25 kg] weights or other calibration devices recommended by the scale's manufacturer.

4 Ensure that vehicles hauling materials to, from, or on the project bear a plainly legible, unique, identification number. The engineer will direct the daily taking of vehicle tare weights and record the results on “Scale Check and Daily Truck Tares” (Form E-71).

5 If applicable, ensure that the system is capable of securing the poises in position and does not allow inadvertent change of position.

109.1.4.2 Documentation

1 If computerized scales are used, provide computer generated weigh tickets. Provide computer generated recap sheets using the same computer and data that produced the individual weigh tickets.

2 The contractor may use the department’s “Weight Ticket” (Form E-72) and “Recap Sheet” (Form E-78).

3 Document the weight [mass] on a separate, sequentially numbered *weigh ticket* containing at a minimum items 1, 2, 3, and 4 in the following list. Provide the ticket to the vehicle driver. At the point of delivery, and before incorporation into the work, the engineer may ask the driver for the load’s ticket; loads without a ticket will be rejected. The department will pay for materials on the basis of daily recap (recapitulation) sheets produced by the contractor and given to the engineer. The department will treat the recap sheets as source documents for the purpose of payment; include the following on each sheet:

1. Project number, hand written or computer generated;
2. Delivery date;
3. Each load’s net weight [mass] and ticket number, with justification for out of sequence numbers;
4. Material type identified by pay item name;
5. Total tons of material delivered to the project;
6. Tons of material voided for the day;
7. Pay tons for the day’s production;
8. Previous pay tons;

9. Total pay tons to date;

10. A signed statement from the contractor attesting to the accuracy and completeness of the facts represented; and

11. A place for remarks.

4 If material is shipped by rail, the supplier's net weight [mass] shown on the invoice may be accepted as documentation for payment. If material is shipped by truck and the invoice shows the combined weight [mass] of the truck and material and the weight [mass] of the empty truck, the supplier's invoice weight [mass] may be accepted as documentation for payment.

109.1.4.3 Scales

1 The engineer may designate the scale's location.

2 Ensure that scale intervals are uniformly spaced throughout the marked length of the beam, dial, or digital readout; do not exceed 0.1 percent of the scale's nominal rated capacity; and denote increments of at least 1 lb [0.5 kg]. Do not use spring balances.

3 Arrange beams, dials, platforms, and other equipment so that they can be viewed safely and conveniently by the operator and inspectors.

4 Ensure sufficient size and capacity of platform scales to enable setting the total tare weight [mass] on the tare bar and determination of the net weight [mass] on the second bar and to enable the simultaneous weighing of a tractor and at least one hauling unit; additional hauling units may be weighed separately while attached to the tractor. Install and maintain scales so that the platform is level, with rigid bulkheads at each end. Hauling units may be weighed separately if the total weight [mass] of the tractor and all hauling units weighed together is within 0.5 percent of the sum of the combined unit weight [mass] of the individual units. Place all axles on the scales when weighing a hauling unit separately.

5 The department will not allow the use of strain gauges on platform scales.

6 Use pressure-activated load cell systems. Ensure a gross carrying capacity sufficient to support a fully loaded weighing container without loss of accuracy and to maintain the loaded scale's center of gravity between the load supports. A weighing container may be supported by a single load cell or multiple load cells with a scale lever system or multiple load cells. Use cell supports designed to

prevent lateral or other nonaxial forces; cells sealed for environmental protection; and systems designed to resist the following:

1. Moisture;
2. Leakage;
3. Damage from overload or sudden impact;
4. Drift from high voltage or high temperature; and
5. Line noise or radio frequency interference.

7 Ensure a convenient means, either automatically or by the operator, for checking both the load cell circuit and the signal conditioning and load display circuit. Ensure that digital weight [mass] indicators have sufficient range so as to be capable of displaying the scale's capacity when fully loaded. Ensure that digital readouts can be easily read under normal operating conditions.

109.1.4.4 Corrections for Inaccuracy

1 The engineer will order the use of scales registering more than 0.5 percent over true weight [mass] stopped immediately. For payment, the weights [mass] of all loads and materials received since the time the scale was last verified as accurate on "Scale Check and Daily Truck Tare" (Form E-71) will be reduced by the percentage of error greater than 0.5 percent of true. The engineer will allow the scale's return to use only after the scale has been adjusted and verified as accurate.

2 Adjust scales registering less-than-true weights [mass]; the department will not pay additionally or otherwise correct for loads or materials weighed on such scales.

109.1.4.5 Payment

1 The cost of providing facilities and equipment for the accurate weighing or proportioning of materials is incidental to the associated pay items in the contract. Include the cost in, and distribute reasonably among, the unit bid prices for associated items.

109.2 Scope of Payment

1 The department provides either direct or incidental payment for contract work, under the pay items shown in the “Proposal” (Form E-91).

1. **Direct Payment.** Payment is provided directly under a pay item shown in the “Proposal” (Form E-91) when one of the following applies:

    1.1. The work is measured in the Measurement and Payment subsection of the specification ordering the work, and the “Proposal” (Form E-91) contains a pay item for the work with the same three-digit number as the section of the *Standard Specifications* or the same first digit of the number as the division of the supplementary specification or special provision ordering the work.

    1.2. The Measurement and Payment subsection of the specification ordering the work references another section for measuring and paying for the work, and the “Proposal” (Form E-91) contains a pay item for the work from the referenced section.

2. **Incidental Payment.** Work required to safely and satisfactorily provide or accomplish a pay item or items but which is not directly measured and paid for, or for which the contract does not include a pay item, is an incidental obligation of the contractor. The department does not directly pay for such work; instead, payment is included under the associated pay items in the “Proposal” (Form E-91). This includes instances when the specification ordering the work:

    2.1. References another specification for performing the work and

    2.2. Does not reference another specification for direct payment of the work.

2 The department will pay, and the contractor agrees to accept, the compensation provided for by the contract’s pay items as full payment for furnishing all resources needed to perform the work in a complete and acceptable manner and for all risk, loss, damage, or expense arising from the conduct or nature of the work.

3 Include the work, materials, labor, equipment, tools, and incidentals required to complete the construction of an item of work in accordance with the contract, in the pay item established in the contract for the work.

4 If the Measurement and Payment clause in the contract relating to a unit bid price in the "Proposal" (Form E-91) requires that the unit bid price cover and be considered compensation for a certain item of work or material essential to the item, the department will not measure or pay for this same work or material under any other pay item in the contract.

5 Payment for adhering to agreements included in the contract is incidental to the associated pay items in the contract; include the cost of adherence in, and distribute reasonably among, the unit bid prices for associated items in the bid.

6 The department will pay for the actual quantities of work performed and accepted, or material furnished, in accordance with the contract. The department will not pay for work performed in excess of that specified, staked, ordered, or otherwise authorized.

7 The department will not pay for an item until material requirements have been met and the engineer has received the required certifications in accordance with Subsection 800.1, Manufactured Product Certifications.

8 For pay items that include the word "Reset" in the title, the removal of existing items that will be reinstalled is incidental to the ordered item of work. The department will measure and pay directly for removing other items in accordance with the Measurement and Payment section of the specifications ordering the work.

109.3 Compensation for Altered Quantities

109.3.1 General

1 If the accepted quantities for an item of work vary from the quantities estimated in the "Proposal" (Form E-91), the department will pay for the accepted quantities at the pay item prices. Except as provided in Subsection 104.2, Contract Amendments, the department will not allow for increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the contractor from any cause, including directly from alterations or indirectly from unbalanced allocation by the bidder of overhead expense among the pay times.

2 The department will reimburse the contractor, at the documented actual cost, for work or materials already placed or furnished in accordance with the contract but that becomes unnecessary because of a later alteration in quantities.

3 The department will reimburse the contractor for increases in material costs for overruns of plan quantity for: corrugated metal pipes, steel piling, dowel bars, tie bars for concrete pavement, corrugated guardrail, wood and steel posts for guardrail, reinforced concrete pipes, geotextiles, geogrid, paving fabric, wood and steel fence posts, fence wire, seed, and mulch.

4 To qualify for a price adjustment, the following will apply:

1. Order materials any time after the award of the contract and within the time period indicated in the quote. The engineer will notify the contractor in writing of any known quantity changes by the award date. Otherwise, use quantities shown in the contract.

2. Take delivery of materials, and provide for handling and storage of materials.

3. At the preconstruction conference, provide the engineer with confidential prices and proof that the order was placed within the timeframe indicated in the quote for the qualifying item. Ensure the information submitted contains the bid item number on all price quotes. If information is not submitted at the preconstruction conference, no price adjustments will be made.

4. Materials cannot have a fixed price.

5. The original contract or adjusted quantity, as described in this subsection or by contract amendment, overruns by more than 25 percent. In this case, a price adjustment will be made to the quantity over 100 percent.

6. The original contract or adjusted quantity, as described in this subsection or by contract amendment, overruns, and the price of material changes by more than plus or minus 15 percent from the confidential quote submitted at the preconstruction conference. In this case, a price adjustment will be made to the quantity over 100 percent.

5 Notify the engineer when an overrun of a qualifying item appears necessary.

6 Obtain three competitive price quotes from suppliers on WYDOT Form E-18, Supplier's Quote for Adjustment. Submit Form E-18 to the engineer within three working days of notification.

7 If Form E-18 is not submitted within the time specified, no adjustment to the unit price will be made.

8 The engineer will:

1. Use the lowest quote to determine if an adjustment is required;

2. Determine the new unit price by taking the original unit bid price or price amended by contract amendment, subtracting the original material cost submitted at the preconstruction conference, or time of contract amendment, and adding the new material cost;

3. Notify the contractor in writing as to whether the material qualifies for a price adjustment; and

4. Pay for overrun quantity under a new bid item reflecting the new unit cost and overrun quantity.

9 Notify the department in accordance with Subsection 104.2.7, Contractor-Engineer Notification, within 10 calendar days if the engineer's decision is not acceptable.

109.3.2 Eliminated, Reduced, or Unused Pay Items

1 The engineer may choose to eliminate a pay item or reduce the quantity of a pay item. When the engineer notifies the contractor that a pay item will not be used or reduced, the department will reimburse the contractor for actual work done and all costs incurred (including mobilization of materials) before the notification or effective date of the "Contract Amendment" (Form E-61). If materials have been delivered to the project and cannot be returned to the supplier, the department will pay for the materials at the invoice price plus 5 percent for overhead and take ownership. The department will not pay for lost or anticipated profits resulting from the elimination or nonuse of a pay item.

1. **Minor Items.** The engineer may reduce the quantity of or eliminate a minor pay item by writing a notice to the contractor or by using a "Contract Amendment" (Form E-61); such action does not invalidate the contract.

2. **Major Items.** The engineer may eliminate or reduce the quantity of a major pay item by using a "Contract Amendment" (Form E-61).

109.3.3 Crushed Aggregate

1 If the original quantity of crushed aggregate material as estimated in the contract, or as altered by a "Contract Amendment" (Form E-61) or in writing by the engineer, is later reduced more than 2 percent, and the engineer fails to notify the contractor of the reduction in writing before the material is produced, the department will reimburse the contractor for the actual cost of producing the difference in quantities. The department requires documentation substantiating the cost and approval by the engineer before such reimbursement.

2 The department will not pay for the production of more material than requested. Excess material produced from a department-furnished source will remain the property of the department.

109.4 Extra and Force Account Work

109.4.1 General

1 The department may direct the contractor to perform unforeseen work necessary to complete the project and pay for such work as specified in the remainder of this subsection and in the order of precedence given.

109.4.2 Contract Prices

1 The engineer will use the contract unit prices if they are representative of the work to be performed.

109.4.3 Negotiated Prices

1 The engineer and the contractor may negotiate new unit or lump sum prices by using a "Contract Amendment" (Form E-61) before the work is performed.

109.4.4 Force Account

1 The engineer may direct the contractor to perform work under force account. The department's payment to the contractor for such work is compensation-in-full and will be determined as follows:

1. **Labor.** For the time that workers and their immediate working foremen are engaged specifically and solely in force account work, the department will pay the cost of those employees' wages at the

rates shown on the payroll (but not more than the rates for comparable work performed by current employees on the project), plus 66 percent to cover overhead, property damage and liability insurance, workers' compensation insurance premiums, unemployment insurance contributions, and social security taxes. The department will also pay the actual costs of health, pension, and other bona fide fringe benefits required by collective bargaining agreements or otherwise applicable to the personnel involved. The department will pay based on the actual hours of labor, to the nearest recorded one-half hour each day.

2. **Materials.** The department will pay for the actual cost of materials approved for use by the engineer and incorporated into the work, including transportation charges (exclusive of equipment rentals), plus 15 percent. The department will not issue payment without receipt of invoices substantiating the material and transportation costs. If materials are taken from the contractor's stock, provide a statement certifying that the materials were taken from stock, that the quantity claimed was used, and that the price and transportation claimed represent actual costs.

3. **Equipment.** The department will pay for the rental of equipment approved by the engineer. The engineer requires fully operational equipment of a size and capacity to perform the work. The engineer may approve the use of equipment not meeting this requirement if furnished by the contractor at reduced prices that are mutually agreed upon. The contractor and the engineer will agree on whether to use equipment already available on the project or to lease equipment.

   The department will pay for equipment based on actual hours of use, recorded to the nearest one-half hour each day. If the total period of operation within a day is less than one hour, the department will consider the time as one full hour.

   Furnish an "Equipment Rental Rate Determination" (Form E-67B), with the "Equipment Data" portion of the form completed for each item of equipment used.

   In determining payment rates, the department will pay for rental of the contractor's own equipment at rates given in the *Rental Rate Blue Book for Construction Equipment*, volumes 1-3, published by Equipment Watch, adjusted both regionally for Wyoming and for equipment age.

For each piece of equipment, the department will establish its payment rate on the "Equipment Rental Rate Determination" (Form E-67B) submitted by the contractor, using *Blue Book* rates; it will maintain that initial rate for the duration of the project.

In determining equipment rental rates, the department will include power control units and basic attachments and accessories already on the rented equipment, even if a particular attachment is not actually used. The department will pay for additional accessories that may be needed using the rental rate calculation procedure for the basic equipment plus the *Blue Book* operating costs.

Exclusive of costs for the operator, the department calculates the hourly rental rate for a piece of equipment by adding two distinct components, both derived from the *Blue Book*—a rental rate and an operating rate, as follows:

3.1. **Rental Rate.** Includes depreciation, taxes, major overhaul and repairs, overhead, interest, regional adjustment, equipment age adjustment, insurance, and storage. The hourly rental rate is computed by dividing the equipment's *Blue Book* monthly rate by 176, to establish the hourly rate, and then multiplying by Wyoming's regional adjustment factor and the rate adjustment factor for the equipment's age, as follows:

$$\text{rental rate (hourly)} = \frac{\text{monthly rate}}{176} \times \text{regional adj.} \times \text{age adj.}$$

3.2. **Operating Rate.** Includes fuel, lubricants, labor service and maintenance, field repairs, tires, and other expendable items needed for continuous and efficient operation. Computed as:

$$\text{operating rate} = \text{Blue Book est. operating cost per hour}$$

3.3. **Total Hourly Rental Rate.** The sum of a piece of equipment's rental and operating rates, exclusive of operator costs:

$$\text{total hourly rate} = \text{rental rate} + \text{operating rate}$$

The department will not adjust the total hourly rate for fuel costs or horsepower differences from standard engine ratings.

If the equipment is not located on the project, and is leased from an outside agency for the force account work only, then the department will use the lease agreement rate or lump sum price as the rental rate. If the equipment is located on the project, and is leased from an outside agency for contract work other than force account work, the department will determine a rental rate in accordance with preceding paragraphs 3.1, 3.2, and 3.3.

For equipment present on the worksite as a part of normal project work, the department includes mobilization costs in the mobilization item on the "Proposal" (Form E-91) and will not pay additional mobilization for use of the equipment on force account work.

The department will pay actual "move in" and "move out" transportation costs for a piece of equipment not available on the project, if the equipment is moved by another vehicle. The department will pay the total hourly rental rate for equipment moved to the project site under its own power and for equipment moved within the limits of the project.

The department may, for its own convenience, approve payment for equipment standby time. The department will pay for such time at 50 percent of the equipment's rental rate; it will use the standby rate when the engineer has ordered that equipment be made available for force account work but the equipment is idle for reasons not the fault of the contractor. The engineer will determine the standby duration when initially approving the equipment for standby time. The department will not pay for more than 8 hours per day or 40 hours per week of standby, nor will it pay for standby on Sundays or holidays.

4. **Miscellaneous.** The department will not pay additionally for items or services already covered by or inherent to the contracted scope of work (such as general superintendence, use of small hand tools, or the provision of storage facilities).

5. **Documentation.** The engineer will document force account work on the "Daily Force Account Record" (Form E-67A); review and sign this record each day. After completing the work, prepare and give the engineer the original and one copy of the "Force Account Record" (Form E-67), detailed as follows:

5.1. Date, daily hours, total hours, rate, and extension for each classification of laborers and foremen;

5.2. Date, daily hours, total hours, rental rate, and extension for each code designation unit of machinery and equipment;

5.3. Quantities of materials, prices, and extensions, supported with invoices;

5.4. Transportation charges for materials, supported with invoices; and

5.5. Total cost of the work.

6. **Subcontract Work.** If the engineer directs the performance of work by force account that the contractor then subcontracts, the department will pay in accordance with the provisions of this subsection, Subsection 109.4.4, Force Account. As reimbursement for its own administrative expenses, the contractor may add 5 percent to the amount of the subcontractor's billing for the work.

7. **Invoice Work.** If the engineer and the contractor agree that an item of work is minor in nature or requires a specialist, the work may be paid for based on a contractor or subcontractor invoice. The department prefers invoices itemized by labor, material, and equipment rental costs but may accept non- or partially itemized invoices if full itemization is impractical or not standard practice for the work or service. As full reimbursement for its own administrative expenses, the contractor may add 5 percent to a subcontractor's invoice.

7.1. **Minor Work.** The value of force account work performed as invoice work will not be allowed to exceed 100 percent of the dollar value established in the contract for the pay item Force Account Work. No single invoice or type of work will be allowed to exceed 50 percent of the dollar value established in the contract for the pay item Force Account Work.

7.2. **Specialist Work.** If the engineer and the contractor agree that an item of work or service requires skills, tools, or equipment unavailable within the contractor's or authorized subcontractors' organizations, the contractor may use a specialist to perform the work or service. If a contractor is required to perform specialized fabrication or machining in a shop facility away from the project, the department may accept the charges for that portion of the contractor's work as an invoice billing to which 5 percent has been added. The department will base its payment for specialty work or service on current market price.

109.4.5 Payment

1 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Force Account Work	$$	0.01 $$	0.01 $$

109.5 Monthly Progress Payment

109.5.1 General

1 The department will make payments at least once each month. Additional payments may be made if the work total exceeds $5,000 and a request is made by the contractor. Payments will be based on the engineer's estimates of the value of work performed and materials complete-in-place, in accordance with the contract, and for materials delivered, in accordance with Subsection 109.6, Payment for Material on Hand. The contractor may choose cut-off dates of the 1st, 10th, or 20th of the month for the progress payments.

109.5.2 Contractor's Payment to Subcontractors

1 The department requires the contractor to pay subcontractors promptly for their work upon receipt of payment for the associated work from the department. After the first monthly progress payment to the contractor, the engineer will make no further payment until the contractor submits for each subcontractor performing work the previous month one of the following:

1. **Certification of Subcontract Payment.** A fully executed "Certification of Subcontract Payments" (Form E-139) indicating the subcontractor's receipt of payment.

2. **Good Cause Documentation.** Documentation accepted in writing by the engineer that demonstrates good cause for not making the required payment.

2 The department requires the contractor to obtain an executed “Certification of Subcontract Payments” (Form E-139) from each subcontractor within 10 calendar days of the subcontractor’s receipt of a payment. If within this period the subcontractor fails to submit the executed form and the engineer accepts in writing the contractor’s documentation of the failure, the department will consider the failure good cause for the contractor to withhold further payment to the subcontractor until the executed form is submitted. Notify the subcontractor of this action in writing.

3 Within 14 calendar days, upon completion of a subcontractor’s work and after he or she has met the requirements of the subcontractor agreement with the prime contractor, pay the full amount due, including retainage.

4 Submit a final Form E-139 to the department for all subcontractors.

109.5.3 Contractor-Subcontractor Disputes

1 If an issue involving payment by the contractor to a subcontractor becomes the subject of dispute, the party (contractor or subcontractor) raising the dispute is responsible for promptly submitting a written description of the dispute to the engineer. State clearly who the dispute is between, the reason for the dispute, the dollar amount involved, and other pertinent information.

2 Upon receipt of the written notice, the engineer will withhold the amount in dispute from the next monthly progress payment. The contractor and subcontractor are responsible for settling their dispute. Upon written notification to the engineer that the dispute is settled, signed by all parties involved in the dispute, the department will pay the disputed amount in the next monthly progress payment.

3 If the contractor and the subcontractor fail to resolve the dispute, the department will consider both parties in default of the contract. The department may deny the parties future bid envelopes, in accordance with Subsection 102.3, Bid Envelope and Electronic Bid System Device, and it may not approve their performance of future subcontract work, in accordance with Subsection 108.1, Subletting of Contract.

109.6 Payment for Material on Hand

1 The department may pay for materials stockpiled or stored for later use on the project and for which the contractor provides acceptable documentation indicating the material meets contract requirements. Stockpiled or stored materials may be located on the project or at acceptable, bonded facilities elsewhere, which the department reserves the right to inspect. The department will not make such payment without a written request received at least 10 calendar days before the date of the next scheduled progress payment and may not pay more than 65 percent of the item's original bid extension. Include with the written request the following information as appropriate:

1. **Purchased Materials.** Support material and shipping costs by invoices, freight bills, or other information required by the engineer. The engineer may exceed the 65 percent limit if adequate documentation can be provided.

2. **Stockpiled Aggregate.** Submit a production statement supporting the crushing and transport costs, if applicable.

2 Payment for stockpiled or stored materials does not constitute acceptance, and the department may later reject materials for which it has made such payment.

109.7 Mobilization

109.7.1 General

1 The department will pay for the costs of mobilizing the resources needed to prepare for the start of work. Mobilization includes but is not limited to the following:

1. Moving personnel, equipment, supplies, and incidentals to the site;

2. Establishing offices, buildings, and other facilities at the site;

3. Other preparatory work and operations; and

4. Performance Bond.

109.7.2 MEASUREMENT and PAYMENT

1 The engineer will measure Mobilization by the lump sum.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Mobilization	LS	LS	LS

1. On the first estimate following award, 10 percent of the Mobilization pay item or 1 percent of the original contract amount, whichever is less, will be paid.

2. When 5 percent of the original contract amount is earned, 25 percent of the amount bid for Mobilization or 2½ percent of the original contract amount, whichever is less, will be paid.

3. When 10 percent of the original contract amount is earned, 50 percent of the amount bid for Mobilization or 5 percent of the original contract amount, whichever is less, will be paid.

4. When 25 percent of the original contract amount is earned, 60 percent of the amount bid for Mobilization or 6 percent of the original contract amount, whichever is less, will be paid.

5. When 50 percent of the original contract amount is earned, 70 percent of the amount bid for Mobilization or 7 percent of the original contract amount, whichever is less, will be paid.

6. When 70 percent of the original contract amount is earned, 100 percent of the amount bid for Mobilization or 10 percent of the original contract amount, whichever is less, will be paid.

7. Upon completion of all work on the project, payment on any amount bid for Mobilization in excess of 10 percent of the original contract amount will be paid.

8. The total sum of all payments will not exceed the original contract amount bid for Mobilization, regardless of the fact that the contractor may have shut down the work on the project or moved equipment away from the project and then back again.

109.8 Final Quantities

1 After the project has been accepted in accordance with Subsection 113.4, Final Acceptance, the engineer will prepare final quantities, in which all prior monthly progress payments are subject to correction, and it will then be given to the contractor for approval. The engineer will send the contractor for review a copy of the final quantities using USPS certified mail, “Return Receipt Requested.” Notify the department in accordance with Subsection 104.2.7, Contractor-Engineer Notification, within 30 calendar days of receipt if the final quantities are not acceptable.

109.9 Final Payment and Executed Forms

1 The department will advertise the project as complete after the physical work is complete and the contractor has submitted all documentation required by the contract and agreed with the final estimated quantities. Forty-one days after the department first advertises the project as complete, the department will pay the contractor the remaining sum due.

109.10 Royalties

1 The department will make royalty payments directly to the owner of the source of those materials it acquires.

2 The department will deduct from its payments to the contractor the royalty paid for the following:

1. Material remaining in the base of depleted aggregate stockpiles when waste, contamination, or overhaul is evident in the judgement of the engineer or
2. Borrow source material used in excess of the quantities required.

3 Such a deduction will not be made if the department uses the remaining aggregate piles for other projects.

SECTION 110
Wages and Condition of Employment

110.1 Scope

1 Adhere to the requirements for wages and conditions of employment incorporated into the contract by way of supplementary documents in the "Proposal" (Form E-91), and physically incorporate these same requirements into all subcontracts.

110.2 Equal Employment Opportunity

1 Meet specified equal employment opportunity obligations and cooperate with the department in their reviews of activities related to these obligations.

110.3 Preference for Wyoming Citizens

1 On projects funded solely by the State of Wyoming, employ only Wyoming workers. After informing the state employment office nearest to the worksite of the project's need for labor, the contractor may use nonresident workers if:

1. Qualified resident workers are unavailable and
2. The state employment office has provided a letter substantiating its inability to supply resident workers and the contractor has submitted a copy to the engineer.

2 "Worker" for this purpose means a person employed to perform skilled or unskilled manual labor for wages in any capacity and does not include independent contractors. "Resident" means a citizen of the United States who has lived in Wyoming for at least one year immediately preceding his or her application for employment.

110.4 Certified Payrolls

1 Submit weekly payrolls to the engineer as appropriate for the contract's funding source. The department may suspend monthly progress payments if payroll submissions are more than 14 calendar days late.

1. **Federal Aid Contracts.** Submit payrolls and the "Statement of Compliance" (Form WH-348) for the contractor and subcontractors, in accordance with the "Required Contract Provisions, Federal-Aid Construction Contracts" (Form FHWA-1273).

2. **State Funded Contracts.** When required by a wage grievance or the need to document force account costs, submit payrolls for the contractor and subcontractors.

SECTION 111
Environmental Requirements

111.1 Protection of the Environment

1 In accordance with Subsection 107.1, Applicable Laws, become familiar with and adhere to all laws relevant to minimizing damage to the environment and risks to human health. If a requirement of Section 111, Environmental Requirements, conflicts with an environmental or pollution control requirement of another federal, State of Wyoming, or local agency, the more restrictive requirement applies.

2 Implement best management practices to minimize pollution and soil erosion. Promptly revegitate disturbed areas. Notify the engineer promptly upon receiving notice, in any form, of noncompliance with a pollution or erosion control requirement, and modify or cooperate in modifying the manner of work to bring about compliance. Cooperate with inspections by federal or state agencies to determine the status of the project with regard to environmental issues.

111.2 Forest Protection

1 Prevent and suppress forest fires. Notify forest officials promptly of the location and extent of any fire, and cooperate with requests from forest officials for help in fire control efforts.

111.3 Erosion and Pollution Controls

111.3.1 General

1 Do not pollute surface waters or wetlands with sediment or other harmful materials.

2 Service and fuel equipment away from streams and riparian areas. Ensure staging areas are a minimum of 150 ft [50 m] from riparian areas. Dispose of fuels, oils, bitumens, salts, cement, or other potential surface or ground water contaminants in a licensed disposal site only. Prepare a spill contingency plan for petroleum products, solvents, and other hazardous materials to be used or stored at the worksite and submit to the engineer at the preconstruction conference; include plans for emergency fills in surface waters as appropriate and in accordance with Subsection 111.5.3, Emergency Fills.

3 Maintain a collection system for garbage, rubbish, and salvaged material collected from the project. Remove such waste and dispose of at licensed landfills or other recognized salvage sites only; do not use the right-of-way, adjoining property, or material sources for disposal.

4 Do not disturb lands or waters outside the construction limits without authorization from the engineer. If provision of a waste site is specified, obtain environmental clearances in accordance with Subsection 106.3.3, Contractor-Furnished.

5 Do not change the substrate composition (type and size) of the streambed. Separate the top 1 ft [0.3 m] of stream bottom substrate from deeper soil layers and stockpile separately. Replace substrate layers in the same order in which they were removed.

111.3.2 Storm Water Pollution Prevention Plan

1 Implement the storm water pollution prevention plan (SWPPP) to incorporate temporary and permanent erosion control features into the project at the earliest practical time.

2 When not obtained by the department, prepare an SWPPP in accordance with Subsection 215.4.2, Storm Water Control, and submit at the preconstruction conference. Include in the plan all temporary and permanent erosion control features needed throughout the worksite, including haul roads and material sources. Keep the plan current as work progresses.

111.3.3 Payment

1 If temporary erosion or pollution control measures become necessary due to the contractor's negligence, carelessness, or failure to install permanent control features as scheduled, the engineer may order the contractor to perform such work at no additional cost to the department. If temporary control measures become necessary for other reasons, the engineer may order the contractor to perform the work and the department will pay at pay item prices or, if the contract does not include appropriate pay items for the work, in accordance with Subsection 109.4, Extra and Force Account Work.

2 Disturbances less than 1 acre [1047 m^2] that do not require a permit will not require a storm water pollution prevention plan (SWPPP) and will be eliminated in accordance with Subsection 109.3.2, Eliminated, Reduced, or Unused Pay Items.

111.4 Air Pollution Control

111.4.1 General

1 Provide and use methods to control air pollution. Equip, operate, and maintain bituminous mixing plants to meet applicable particulate emission standards.

111.4.2 Payment

1 The cost of implementing air pollution control measures is incidental to the associated contract pay items. When specified and used to control air pollution, the engineer will measure and pay for water or dust control agent in accordance with Section 209, Watering, and Section 221, Dust Control Agent.

111.5 Surface Waters and Wetlands

111.5.1 General

1 The U.S. Army Corps of Engineers regulates the placement of permanent or temporary fill in or near surface waters and wetlands in accordance with Section 404 of the federal Clean Water Act. The department will obtain the applicable permit when needed. Review carefully the terms of the permit in relation to the contract. If any proposed element or activity of the work exceeds the encroachment authorized by the permit, give the engineer a work plan at least 21 calendar days before starting the work that shows the approximate dimensions and proposed methods of implementing or constructing features or elements such as but not limited to the following:

1. Surface water diversions;
2. Temporary stream crossings;
3. Cofferdams; and
4. Dewatering systems.

2 Upon receipt of the proposed work plan, the engineer will contact the U.S. Army Corps of Engineers to obtain authorization for the revised encroachment. If the Corps refuses to authorize the revision, then perform the work within the original encroachment boundaries at no additional cost to the department.

3 Do not begin work affecting areas outside the limits authorized by the original 404 permit until receiving a copy of the amended permit from the engineer.

4 When working in or near surface waters or wetlands, minimize disruptions, restrictions, or damage to or of the quality or supply of downstream public waters. Ensure equipment entering or working over water is pressure washed and leaks are repaired before use. Do not ford or operate equipment in surface waters or wetlands except to install or remove encroachments or to perform brief, necessary work. Ensure that machinery and equipment do not leak lubricants, coolants, or fuel.

5 Pressure wash equipment, and allow it to dry before moving it between watersheds.

111.5.2 Temporary Encroachments

1 Do not allow, to an extent greater than specified, temporary encroachments to reduce waterways, increase depth of flow, cause bank erosion or bottom scour, or inhibit the movement of fish or other wildlife. Use cofferdams, silt barriers (staked or floating booms), bypass flumes, or sediment pads to minimize turbidity. Be ready to remove temporary encroachments if warranted by flood or threat of flood.

2 Use commercially available dikes, commercially available cofferdams, or clean gravel for temporary encroachments. Obtain clean gravel fill material from a non-streambed, contractor-furnished source in accordance with Subsection 106.3.3, Contractor-Furnished. Do not use a source located within a surface water. Ensure a coarseness equal to or greater than the gradation of the natural streambed and that 90 percent of the material is greater than 0.05 in [0.6 mm]. Remove fine material that would unacceptably increase turbidity.

3 Release fish trapped by temporary fills, culverts, or other work into nearby unrestricted or open surface waters.

4 Remove temporary encroachments as soon as practical; do so in a manner that minimizes disturbance. After removing the temporary encroachments, dispose of fill and other waste materials in accordance with Subsection 111.3.1, Erosion and Pollution Controls, General, and return the affected environment, such as stream banks, bottoms, and wetlands, to their configuration before disturbance. Remove temporary pilings or sheeting to a depth of at least 3 ft [1 m] below the streambed.

111.5.3 Emergency Fills

1 When it becomes necessary to temporarily place fill material in surface waters or wetlands to avoid flooding or retain spilled hazardous wastes, obtain after the fact permits and certifications from the U.S. Army Corps of Engineers and WDEQ. Give the engineer copies of these documents when available.

2 To the extent possible, place emergency fill in accordance with Subsection 111.5.2, Temporary Encroachments; remove the material and restore the affected site in accordance with that same subsection. When approved by the engineer, the department will pay for this work in accordance with Subsection 109.4, Extra and Force Account Work.

SECTION 112
Archaeologic, Paleontologic, and Historic Sites

112.1 Discovery of Potential Sites

1 Upon discovering evidence of a potential archaeologic, paleontologic, or historic site, stop work in the area and notify the engineer. The engineer will contact the proper authorities, who will conduct a field inspection to evaluate the findings. Cooperate fully in facilitating this evaluation. The engineer will notify the contractor of the results and of when work in the area may resume. For delays due to the discovery, the engineer may make an extension to the contract completion date in accordance with Subsection 108.6, Extension to the Contract Completion Date.

112.2 Cultural Clearances

1 The department will obtain and provide the cultural clearances and permits for the specified right-of-way and for material, plant, and similar sites and facilities as described in Subsection 106.3.2, Department-Furnished. Before using sites other than those provided, obtain such clearances and permits, in accordance with Subsection 107.2, Permits, Licenses, and Taxes, and Subsection 106.3.3, Contractor-Furnished.

SECTION 113
Acceptance

113.1 Acceptance of Aggregate

1 The department will accept the gradation of crushed or screened aggregates used for pavements, bases, subbases, chip seals, and stockpiled materials with a gradation specification based on random samples taken at the direction of the engineer and a quality level analysis of the test results. Quality level analysis is a method of analyzing aggregate gradation test results to determine compliance with the contract requirements. The quality level analysis will include an evaluation for outlier test results using the department's computer software.

2 The engineer will determine the quality level, acceptance, and pay factor for each lot. Lot and sublot sizes are specified in the respective technical sections. The engineer will include partial lots with less than three samples with the previous lot for quality level analysis. All test results for a lot will be analyzed to determine the pay factor for the lot. The lowest pay factor computed for any one sieve will be used to adjust the pay for that lot. Acceptance procedures will not apply to sieve designations with requirements of 100 percent passing, 97 to 100 percent passing, and 95 to 100 percent passing. Only the P_L (percent within lower limits) will be calculated for the sieve designations requiring 90 to 100 percent passing, and the P_U (percent within upper limits) will be set at 100.

3 The maximum obtainable pay factor will be 1.05.

4 A lot containing material that does not meet the contract requirements will be:

1. Accepted if the pay factor is at least 0.75 or
2. Rejected if the material fails to obtain at least a 0.75 pay factor.

5 To avoid a pay factor less than 1.00, the contractor may remove defective material and replace it with new material, which the department will sample, test, and evaluate in accordance with this specification.

6 Without testing, the engineer may isolate and reject material that is obviously defective. Do not continue producing material that does not meet contract requirements. If two consecutive lots have a pay factor less than 1.00, change procedures to meet the requirements.

7 The engineer will compute the quality level analysis and pay factor as follows:

1. Determine the arithmetic mean, $\bar{x}$.

   Where: $\sum$ = summation

   x = individual test value

   n = total number test values

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

2. Compute the sample standard deviation, *s*.

$$s = \sqrt{\left(\frac{1}{n-1}\right)\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

3. Compute the upper quality index, Q_U.

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

   Where: SL_U = upper specification limit or target value of job mix plus allowable deviation.

   target value for Q_U = the single specification value with allowable deviations.

4. Compute the lower quality index, Q_L.

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

   Where: SL_L = lower specification limit or target minus allowable deviation.

5. Determine P_U (the percent within the upper specification limit corresponding to a given Q_U) from Table 113.1-1, Quality Level Analysis by the Standard Deviation Method. If an SL_U is not specified or if the upper specification limit for the sieve being evaluated is 100 percent, P_U is 100.

6. Determine P_L (the percent within lower specification limit corresponding to a given Q_L) from Table 113.1-1, Quality Level Analysis by the Standard Deviation Method. If an SL_L is not specified, P_L will be100.

7. Determine the quality level (the total percent within the specification limits).

$$\text{quality level} = (P_U + P_L) - 100$$

8. Using the quality level from the preceding step, determine the pay factor from Table 113.1-2, Pay Factors. To obtain a given pay factor, meet or exceed the value in the table for the computed quality level. Pay factors greater than 1.0 do not apply when quality incentives are not included in the respective technical specifications for a pay item.

8 Testing frequency indicates the minimum number of tests required for the specified quantity of aggregate produced. For example, 1/1000 ton [1/1000 t] is equivalent to one test minimum required for each 1000 ton [1000 t] of aggregate produced.

Table 113.1-1
Quality Level Analysis by the Standard Deviation Method

PU or PL percent Within Limits for Positive Values of QU or QL	Upper Quality Index QU or Lower Quality Index QL				
	n = 3	n = 4	n = 5	n = 6	n = 7
100	1.16	1.50	1.79	2.03	2.23
99		1.47	1.67	1.80	1.89
98	1.15	1.44	1.60	1.70	1.76
97		1.41	1.54	1.62	1.67
96	1.14	1.38	1.49	1.55	1.59
95		1.35	1.44	1.49	1.52
94	1.13	1.32	1.39	1.43	1.46

Table 113.1-1
Quality Level Analysis by the Standard Deviation Method, *continued*

PU or PL percent Within Limits for Positive Values of QU or QL	Upper Quality Index QU or Lower Quality Index QL				
	n = 3	n = 4	n = 5	n = 6	n = 7
93		1.29	1.35	1.38	1.40
92	1.12	1.26	1.31	1.33	1.35
91	1.11	1.23	1.27	1.29	1.30
90	1.10	1.20	1.23	1.24	1.25
89	1.09	1.17	1.19	1.20	1.20
88	1.07	1.14	1.15	1.16	1.16
87	1.06	1.11	1.12	1.12	1.12
86	1.04	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00
83	1.00	0.99	0.98	0.97	0.97
82	0.97	0.96	0.95	0.94	0.93
81	0.96	0.93	0.91	0.90	0.90
80	0.93	0.90	0.88	0.87	0.86
79	0.91	0.87	0.85	0.84	0.83
78	0.89	0.84	0.82	0.80	0.80
77	0.87	0.81	0.78	0.77	0.76
76	0.84	0.78	0.75	0.74	0.73
75	0.82	0.75	0.72	0.71	0.70
74	0.79	0.72	0.69	0.68	0.67
73	0.76	0.69	0.66	0.65	0.64
72	0.74	0.66	0.63	0.62	0.61
71	0.71	0.63	0.60	0.59	0.58

Table 113.1-1
Quality Level Analysis by the Standard Deviation Method, *continued*

PU or PL percent Within Limits for Positive Values of QU or QL	Upper Quality Index QU or Lower Quality Index QL				
	n = 3	n = 4	n = 5	n = 6	n = 7
70	0.68	0.60	0.57	0.56	0.55
69	0.65	0.57	0.54	0.53	0.52
68	0.62	0.54	0.51	0.50	0.49
67	0.59	0.51	0.47	0.47	0.46
66	0.56	0.48	0.45	0.44	0.44
65	0.52	0.45	0.43	0.41	0.41
64	0.49	0.42	0.40	0.39	0.38
63	0.46	0.39	0.37	0.36	0.35
62	0.43	0.36	0.34	0.33	0.32
61	0.39	0.33	0.31	0.30	0.30
60	0.36	0.30	0.28	0.27	0.27
59	0.32	0.27	0.25	0.25	0.24
58	0.29	0.24	0.23	0.22	0.21
57	0.25	0.21	0.20	0.19	0.19
56	0.22	0.18	0.17	0.16	0.16
55	0.18	0.15	0.14	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11
53	0.11	0.09	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00

Note: For values of Q_U or Q_L less than zero, P_U or P_L equals 100 minus the table value for P_U or P_L. If the value of Q_U does not correspond exactly to a figure in the table, use the next highest figure.

Table 113.1-2
Pay Factors

Pay Factor	Required Quality Level for a Given Sample Size n and Pay Factor				
	n = 3	n = 4	n = 5	n = 6	n = 7
1.05	100	100	100	100	100
1.04	90	91	92	93	93
1.03	80	85	87	88	89
1.02	75	80	83	85	86
1.01	71	77	80	82	84
1.00	68	74	78	80	81
0.99	66	72	75	77	79
0.98	64	70	73	75	77
0.97	62	68	71	74	75
0.96	60	66	69	72	73
0.95	59	64	68	70	72
0.94	57	63	66	68	70
0.93	56	61	65	67	69
0.92	55	60	63	65	67
0.91	53	58	62	64	66
0.90	52	57	60	63	64
0.89	51	55	59	61	63
0.88	50	54	57	60	62
0.87	48	53	56	58	60
0.86	47	51	55	57	59
0.85	46	50	53	56	58
0.84	45	49	52	55	56
0.83	44	48	51	53	55
0.82	42	46	50	52	54

Table 113.1-2
Pay Factors, *continued*

Pay Factor	Required Quality Level for a Given Sample Size n and Pay Factor				
	n = 3	n = 4	n = 5	n = 6	n = 7
0.81	41	45	48	51	53
0.80	40	44	47	50	52
0.79	38	43	46	48	50
0.78	37	41	45	47	49
0.77	36	40	43	46	48
0.76	34	39	42	45	47
0.75	33	38	41	44	46

113.2 Acceptance of Asphalt Materials

1 The engineer may conditionally accept cutback and emulsified asphalt materials at the source based on test reports for each tanker/pup delivered. Asphalt binder will be accepted in accordance with Subsection 401.2.1, Performance Graded Asphalt Binder.

2 Asphalt material used on the project that does not meet the contract requirements for the designated type and grade may at the direction of the engineer be:

1. Rejected and the contractor required to remove and replace all material affected by the nonspecification material at no additional cost to the department;

2. Accepted after evaluation in accordance with the applicable technical section and left in place with no payment made for the asphalt material used; or

3. Accepted at a reduced unit price in accordance with the applicable Materials Program's current *Schedule of Price Adjustments for Asphalt Materials* in effect at the time of the award of the contract. The reduced unit price is based on the price paid to the supplier or refinery for asphalt materials delivered to the project. Submit written documentation of these prices to the engineer. If prices are not submitted, the engineer will use unit bid price for asphalt materials.

113.3 Unacceptable Work and Materials

1 The department considers the following unacceptable:

1. Work, materials, or both not in accordance with the contract;
2. Work performed contrary to the engineer's orders;
3. Work outside the construction limits;
4. Materials placed without authorization; and
5. Extra work performed without authorization.

2 Work done contrary to the instruction of the engineer, work performed without subcontract approval, or any extra work done without authority will be considered as unacceptable. If the quality of the unauthorized work is acceptable to the engineer, the work may be left in place without payment.

3 The engineer will not allow continued production of out-of-specification material or work.

4 Remove rejected work and materials, including all portions of the work in which unacceptable materials have been incorporated, at no additional cost to the department. Rejected work and the traffic control to replace the work will not be paid for. The contractor may reuse removed material if it is adjusted to meet the contract requirements. If the contractor fails to remove, replace, or correct unacceptable work as requested, the engineer may direct other organizations to perform these activities and deduct the cost from monies due the contractor or bill the contractor, as appropriate.

5 The engineer may isolate and reject obviously defective material without regard to testing procedures.

113.4 Final Acceptance

113.4.1 General

1 The department considers acceptance final and conclusive except as regards to latent defects, fraud, or gross negligence or with regard to the department's rights under any warranty or guarantee.

113.4.2 Finish Conference

1 Either party may request a finish conference when the work has reached the point of substantial completion and the other party is notified in writing. The department requires the contractor's project superintendent, at a minimum, to attend. The engineer and chief project inspector will attend for the department, along with others as necessary. Inspect the project together and discuss what still needs work before the contractor can request final acceptance. The engineer will provide a written punchlist of these items. The contractor may demobilize when the work required on the punchlist has been satisfactorily completed and approved by the engineer or as directed by the engineer.

113.4.3 Final Clean-up

1 Before requesting final inspection, clean the grounds within the construction limits. Remove rubbish, excess materials, temporary structures, and equipment, and leave the project in a condition acceptable to the engineer.

113.4.4 Final Inspection

1 Final acceptance of the project follows and is contingent on the results of a final inspection by the district engineer. Provide the engineer with a written request for a final inspection. Make the request after satisfactory completion of the punchlist, in accordance with Subsection 113.4.2, Finish Conference. The engineer will notify the contractor if the final inspection discloses incomplete or unsatisfactory work. Correct or complete the work immediately; the district engineer will then conduct another inspection. When the physical work is complete, the district engineer will give the contractor written notice of final acceptance as of the date of the inspection, and the department will assume responsibility for the project. The district engineer will send written notice of final acceptance to the contractor using USPS certified mail, "Return Receipt Requested."

2 In writing, the contractor may request final acceptance of a portion of the work when that portion is complete and the use of that unit or portion is deemed necessary by the engineer for the convenience, safety, or both, of traffic. Final acceptance of a portion of the work does not amend the contract.

SECTION 114
Laboratory, Personnel, and Correlation

114.1 General

1 The department does not require that technicians employed by an AASHTO-accredited laboratory and performing tests in that facility be qualified or have a certification. Obtain field samples with qualified or certified technicians.

114.2 Mix Design

114.2.1 Laboratory

1 The department requires that laboratories performing mix designs obtain and maintain AASHTO accreditation for all tests and procedures, and in all fields, pertaining to mixes used in the project. The department will not accept mix designs from a laboratory or source lacking appropriate accreditation. The department will accept the submission of mix designs from a laboratory without all necessary accreditations when those tests and procedures for which it is not accredited are performed by another facility having the necessary accreditation and the accreditation documentation is submitted along with the mix design.

114.2.2 Correlation of Laboratory Test Results

1 Implement the following procedures to control equipment or procedural bias.

1. Make test results from the "AASHTO Materials Reference Laboratory" Proficiency Sample Program available on request.

2. Provide the mix design test results to the Materials Program. The department will compare contractor and department mix design results using the precision statements in accordance with the *Materials Testing Manual*.

3. If the difference between the contractor's and department's test results are within the limits of the precision statements, the department will use the contractor's mix design to approve the job mix formula, establish the target asphalt content, and establish the voidless unit weight for density control.

4. If the difference between the contractor's and department's test results exceed the precision statements, the department will begin resolving the discrepancy in accordance with Subsection 114.2.3, Resolving Test Discrepancies. Until the source of discrepancy is identified and the problem is resolved, the results of the mix design performed by the Materials Program may be used to approve the job mix formula, establish the target asphalt content, and establish the voidless unit weight for density control.

114.2.3 Resolving Test Discrepancies

1 To identify the source(s) of discrepancy between the findings of the two labs, the contractor and the department will proceed as follows:

1. The engineer, the contractor, and personnel from the contractor's mix design laboratory and the Materials Program will review testing procedures, equipment, and other applicable information. If the parties reach mutual agreement, the Materials Program will record the resolution in writing and document the results in the project file.

2. If the parties cannot agree on a resolution, mutually select a third-party laboratory. The results of the third-party testing will determine which laboratory bears responsibility for the discrepancy.

3. The department will pay the cost of the third-party testing and resolution if the contractor's results are confirmed. The department will not pay the cost if the department's results are confirmed.

114.3 Field Testing Laboratory and Personnel Requirements

114.3.1 General

1 Provide a quality control supervisor to serve all parties as the point-of-contact for quality control and quality acceptance issues. At a minimum, give the supervisor authority to coordinate activities for mix design, quality control, and quality acceptance testing; to review and interpret test reports; and to make recommendations for the control process, including mix properties.

2 When testing is required, ensure the presence at the production site of a certified or qualified technician during production of aggregate or plant mix pavement.

3 All test results are to be reviewed and signed by a certified technician.

4 Ensure testing personnel use WYDOT testing procedures as outlined in the *Materials Testing Manual*.

114.3.2 Personnel

1 The department requires that sampling and testing of materials in the field for quality control, quality acceptance, and verification be performed by a certified or qualified technician, defined as follows:

1. **Certified Technician.** The holder of a current certification from the Wyoming Materials Technician Certification Program. The department will not consider or accept test results performed by technicians without certification in accordance with Table 114.3.2-1, Testing Certification Requirements.

Table 114.3.2-1
Testing Certification Requirements

Tests	Minimum Certification
Aggregate gradation	Aggregate
Coarse Aggregate Angularity	Aggregate
Fine Aggregate Angularity	Aggregate
Liquid Limit	Aggregate
Plastic Limit	Aggregate
Sand Equivalent	Aggregate
In-Place Density	Asphalt
Mix Verification Sampling	Asphalt and Aggregate
Asphalt Content	Asphalt

2. **Qualified Technician.** A person who has satisfied each of the following steps:

   2.1. Received training in procedures and methods for sampling and testing by a certified technician, as verified by a "QC/QA Testing Technician Qualification," (Form TTQ-1) signed by the certified technician and submitted to the engineer.

   2.2. Performed, under the direct supervision of a certified technician and for the tests the technician will be responsible for, the correlation process in accordance with Subsection 114.3.3, Correlation. By "direct supervision" the department means that the supervising technician is physically present during the testing and without other assigned responsibilities than to oversee the trainee's performance.

   2.3. Obtained and submitted a letter signed by the supervising certified technician that documents the name of the trainee, the trainee's employer, the date of training, and the date of the correlation process. Submit the letter to the Materials Program, the engineer, and the contractor.

   2.4. Obtained a qualification card from the Materials Program. The Materials Program will issue a person one card in a lifetime and the card will expire on January 31 following issue. A qualified technician may choose to follow the procedures necessary to become a certified technician, with all the rights thereof. Once a qualification card expires, the department will no longer consider or accept test results from the technician until he or she become certified.

114.3.3 Correlation

114.3.3.1 General

1 For aggregate and density tests, use correlation testing, performed by the technicians responsible for the quality acceptance tests and verification tests, to ensure results free from equipment and procedural bias.

2 Before performing correlation tests on the project, hold a meeting between the quality control supervisor, other personnel responsible for the quality acceptance and verification testing, and the technicians performing tests. At a minimum, address the following topics:

1. Testing personnel and their qualifications;
2. Equipment;
3. Time frames of correlation testing;
4. Test intervals;
5. Variables or options allowed by testing procedures (i.e. shaking time for sieve analysis, core drying, and soaking times, etc.); and
6. Where and how referee samples will be stored.

3 Document the meeting discussions and outcomes, obtain the signature of all attendees, and submit to the engineer, who will keep the documentation in the project file.

4 The department will use statistical evaluation procedures in accordance with the *Materials Testing Manual* to decide if both groups of samples represent the same sample population. If the statistical evaluation procedures indicate that the samples from the contractor's and department's testing represent the same sample population, quality acceptance testing may begin and the referee samples discarded.

5 If the samples from the contractor's and department's testing do not represent the same sample population, the department will begin resolving the discrepancy in accordance with Subsection 114.3.4, Resolving Field Test Discrepancies.

6 Perform additional correlation tests—using the entire procedure—if either the contractor or the department suspects equipment or testing bias. Perform new correlation tests if new equipment or personnel (department or contractor) are introduced during testing.

114.3.3.2 Aggregate Gradation

1 Before performing the correlation testing for aggregate gradation and starting production, split at least one sample and perform gradation tests to give a preliminary indication of equipment or test bias.

2 Correlate aggregate test results in accordance with the *Materials Testing Manual* using samples taken during the first production lot. If combined samples of aggregate can be obtained during crushing, correlation can be performed then. Use the following procedures to correlate the results of the contractor's and department's aggregate testing:

1. Use five sets of test results for the correlation.

2. Three individual samples cut from the belt or taken from a correlated sampling device by the contractor in the presence of the engineer represent a test set.

3. From each test set, test one sample for aggregate gradation; do so independent of the department.

4. From each test set, the department will test one sample for aggregate gradation, independent of the contractor.

5. For each test set, the department will keep the third sample as the referee sample.

6. The engineer will perform the statistical evaluation after five test sets have been completed.

114.3.3.3 Density

1 Correlate results from the contractor's and department's density tests during placement of the test strip. Use the following procedures:

1. The engineer will mark seven randomly selected locations using a table of random numbers and with the exclusion of locations within 12 in [300 mm] of the pavement edge.

2. Take one pair of core samples from each sample location, in the presence of the engineer.

3. The department and the contractor will dry the cores to constant weight [mass] with a nondestructive method.

4. Test one sample from each of the seven pairs of dry cores for bulk specific gravity and density; do so independent of the department.

5. The engineer will test the other sample from each of the seven pairs of dry cores independent of the contractor.

6. The engineer will perform the statistical evaluation after the seven pairs of tests have been completed.

114.3.4 Resolving Field Testing Discrepancies

1 Resolve discrepancies as follows:

1. Meet with department personnel and review testing procedures, equipment condition, and equipment calibrations in an attempt to solve the problem.

2. When the cause of the discrepancy has been identified and corrected, repeat the correlation procedure.

3. If the second correlation determines that the contractor's and department's test results represent different sample populations, conduct referee testing.

4. The Materials Program will conduct the referee tests using the retained referee samples for aggregate gradations and the department's cores for density testing.

5. The Materials Program will make its results available within five working days of receiving the samples.

6. If the samples represent a quality acceptance lot, the engineer will use test results that correlate with the Materials Program test results for the quality acceptance calculations.

DIVISION 200

Earthwork

SECTION 201
Clearing and Grubbing

201.1 DESCRIPTION

1 This section describes the requirements for clearing, grubbing, removing, and disposing of vegetation and debris.

201.2 MATERIALS—Vacant

201.3 EQUIPMENT—Vacant

201.4 CONSTRUCTION

201.4.1 General

1 The engineer will establish right-of-way and construction lines and designate vegetation and other objects to remain. Protect from harm or defacement any vegetation and objects designated to remain.

201.4.2 Clearing and Grubbing

1 Clear or grub surface objects, trees, shrubs, plants, stumps, roots, and other protruding obstructions not specified to remain.

2 Fell and remove timber in a way that minimizes damage to riparian habitat.

3 Except in urban areas, stumps outside slope stake limits may remain in place if cut flush with the ground. In urban areas, cut stumps flush and grind to below grade.

4 Backfill with suitable material and compact holes left by removed stumps and other obstructions, in accordance with Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control.

5 Unburned refuse and debris become the property of the contractor; remove it from the right-of-way.

201.4.3 Mulching

1 Incorporate brush and existing vegetation that can be used as mulch into the topsoil in accordance with Subsection 207.4.1, Topsoil, Construction, General.

201.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Clearing and Grubbing by the acre [hectare] or the complete unit. The engineer will use one or more of the following methods:

    1.1. **Area Basis.** By the acre [hectare], within the limits specified or staked by the engineer.

    1.2. **Lump-Sum Basis.** No measurement.

2. Clearing Trees ____ in [mm] by the each. Trees less than 4 in [100 mm] in diameter will be classified as brush. Trees will be classified and measured in accordance with Table 201.5-1, Nominal Tree Size Measuring.

Table 201.5-1
Nominal Tree Size Measuring

Diameter of Tree at Height of 24 in [600 mm] (in [mm])	Pay Item Size Designation
4 to 8 [100 to 200]	6 in [150 mm]
Over 8 to 12 [201 to 300]	10 in [250 mm]
Over 12 to 24 [301 to 600]	18 in [450 mm]
Over 24 to 36 [601 to 900]	30 in [750 mm]
Over 36 to 60 [901 to 1500]	48 in [1200 mm]
Over 60 [over 1500]	60 in [1500 mm]

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Clearing and Grubbing	LS, ACRE [LS, ha]	LS, ft [LS, 0.5 m]	LS, 0.01 ACRE [LS, 0.005 ha]
Clearing Trees ____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 202
Removal

202.1 DESCRIPTION

1 This section describes the requirements for removing and disposing of obstructions or appurtenances not specified to remain; salvaging material; backfilling trenches, holes, and pits; and removing and resetting mailboxes.

202.2 MATERIALS

1 Provide mailbox components as specified. Provide galvanized nuts, screws, bolts, and hardware.

202.3 EQUIPMENT

1 If the contract includes pay items Milling Plant Mix or Profile Milling Plant Mix, remove the existing pavement using a power-operated milling machine. Provide a machine equipped to perform the following:

1. Remove a strip of material at least 6 ft [1.8 m] wide and 2 in [50 mm] thick during a single pass.
2. Prevent the escape of dust from the operation into the atmosphere.
3. Establish a profile grade by referencing from either the existing pavement or from an independent grade control, and with a positive means of controlling cross slope elevations.
4. For Profile Milling Plant Mix, ensure the machine is equipped with a 30-foot [10 m] (minimum) mobile reference (ski), unless otherwise approved by the engineer.

2 Other equipment providing the same or better results may be used for removal, with the approval of the engineer.

3 Cut bituminous pavement with a saw. Other equipment may be used if cuts are demonstrably equivalent, with the approval of the engineer.

4 Cut concrete using a saw with diamond blades.

202.4 CONSTRUCTION

202.4.1 General

1 Raze, remove, and dispose of buildings, foundations, structures, fences, and other obstructions as specified. Do not remove utilities and items for which other provisions have been made.

2 Backfill basements, cavities, and trenches left by structure removal to the level of the surrounding ground. Compact backfill in embankment areas in accordance with Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control.

3 Backfill holes created by the removal of posts. Place and compact backfill material in 8-inch [200 mm] lifts until even with the existing ground surface. Backfill holes in plant mix surfaces with new hot plant mix surfacing material or other material approved by the engineer in thicknesses equivalent to the depths of the existing surfacing material.

4 Without damage, remove materials specified for salvage in pieces that can be transported, and stockpile them at specified locations. Replace with new material, at no additional cost to the department, those materials specified for salvage that are damaged during removal, transport, or stockpiling operations.

5 Materials removed and not specified for salvage, recycling, or incorporation into the work become the property of the contractor. Do not dispose of removed materials within the right-of-way, construction permit areas, or pits.

202.4.2 Removal of Structures

1 Do not remove structures used by traffic until provisions have been made to maintain traffic flow.

2 Remove substructures to a depth of 3 ft [1 m] below the streambed, if applicable. Remove items not in a streambed to a depth of 12 in [300 mm] below the natural ground surface. Where portions of existing structures lie entirely or partially within the limits of a new structure, remove as necessary to accommodate construction.

3 If specified, dismantle bridges designated for salvage and matchmark the members.

4 Steel and timber bridge components may contain hazardous materials; the contractor is responsible for mitigation.

5 Dismantle, transport, and dispose of structural steel bridge components in compliance with governing regulations. Transport the structural steel bridge components to a recycling facility. Give the engineer documentation of the facility's receipt.

6 Do not burn timber bridges in place.

7 Remove existing structures or obstructions without damaging new work, appurtenances, or existing roadway that is to remain in place. If blasting is necessary, give the engineer the following information at least 14 calendar days before blasting begins:

1. A blasting plan that includes the credentials of the person doing the blasting.
2. Provisions for protecting appurtenances that are to remain in place.
3. Provisions for protecting property and the public from damage.

202.4.3 Removal of Guardrail, Barrier, Bridge Railing, and Pedestrian Railing

1 Removal of existing guardrail and barrier includes rail, posts, spacer blocks, associated hardware, bridge rail connections, and end anchorages. Remove concrete post foundations, anchorage blocks, and barrier foundations.

2 Removal of bridge railing and pedestrian railing includes rail, posts, associated hardware, and anchor bolts, if specified. Bridge railing components may contain hazardous materials; the contractor is responsible for mitigation.

202.4.4 Removal of Pipe, Flared End Sections, and Storm Sewer Systems

1 Remove and clean pipes and flared end sections, storm sewer systems, manholes, and inlets specified for salvage.

202.4.5 Removal of Surfacing, Concrete, Sidewalks, Curbs, Gutters, Median, Double Gutter, Etc.

1 Remove concrete, plant mix, base course, sidewalks, curbs, gutters, double gutters, median, etc., specified for removal using one or more of the following methods:

1. **Concrete Removal.** Break concrete into pieces of approximately 10 ft^3 [0.3 m^3] or less. Provide a site and dispose of the pieces.

   Saw-cut concrete pavement full-depth. Repair at no additional cost to the department, spalling, cracking, breaking, or similar damage of the existing pavement or appurtenances that are to remain in place.

2. **Milling Plant Mix and Profile Milling Plant Mix.** Use a milling machine for removal when Milling Plant Mix or Profile Milling Plant Mix are specified pay items.

   Remove the plant mix to the grade and width and at the locations specified.

   When Profile Milling Plant Mix is specified, milling depths will vary across the roadway's length, width, or both.

   Work may include transition milling into structures, into project tie-ins, at box culverts, and at the beginning and end of project transitions.

   Conduct milling operations parallel to the travel lanes, unless otherwise approved by the engineer.

   Correct vertical differences greater than ⅜ in [10 mm] between adjacent peaks and valleys of the milled surface. Correct surface irregularities resulting from milling activities using cold milling or other operations, at no additional cost to the department.

   Stockpile removed material not designated for recycling or incorporation into reused base or surfacing at a specified site. Place the material without operating equipment on the stockpiles.

3. **Surfacing, Subgrade, and Miscellaneous Materials.** Use suitable means to remove ballast, gravel, plant mix material, crushed base, sub-base materials, or other surfacing materials; stockpile or dispose of them at specified sites. If removed materials will be incorporated or stockpiled as reused surfacing or base, remove without contamination from underlying materials.

4. **Cutting Plant Mix Pavement or Base.** If surfacing is to be removed next to surfacing that is to remain, cut the pavement along the limits of removal.

   Make a vertical cut deep enough to allow removal of the pavement and base, if applicable, without leaving a ragged edge or damaging the adjacent pavement. Vary the depth of cut as dictated by changes in the thickness of the pavement.

202.4.6 Removing and Resetting Mailboxes

1 As necessary, move and maintain mailboxes to ensure accessibility by mail carriers during construction.

2 Mount reset mailboxes on new posts, unless the old posts and mountings comply with contract requirements. Whenever possible, reset existing mailboxes. Erect replacement mailboxes as furnished by the department. Return posts and mailboxes that are removed and not reused to the landowner.

202.4.7 Removal of Fence, Snow Fence, and Signs

1 When fence removal includes salvage, roll salvaged wire into rolls no larger than 3 ft [1 m] in diameter.

2 Backfill and compact holes left after the removal of posts, anchors, and other components.

3 If the snow fence anchors will not come out of the ground, cut the anchors off 6 in [150 mm] below the ground level. Backfill and compact the hole to match the existing ground elevation.

202.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Cutting Bit Pvmt and Cutting Concrete by the foot [meter]. In contracts without a pay item for Cutting Bit Pvmt or Cutting Concrete, this work is incidental to the associated removal pay item.

2. Milling Plant Mix by the short ton [metric ton], square yard [square meter], or cubic yard [cubic meter].

3. Profile Milling Plant Mix by the short ton [metric ton], square yard [square meter], or cubic yard [cubic meter].

4. Removal of Bit Curb, Removal of Curb, and Removal of Curb and Gutter by the foot [meter].

5. Removal of Bridge Rail, Removal of Guardrail and Barrier, and Removal of Pedestrian Rail by the foot [meter].

6. Removal of Cattle Guards by the each.

7. Removal of Concrete, Removal of Concrete Median, and Removal of Concrete Pavement by the square yard [square meter] or cubic yard [cubic meter] or as a complete unit.

8. Removal of Crushed Base and Removal of Surfacing by the short ton [metric ton], square yard [square meter], or cubic yard [cubic meter].

9. Removal of Double Gutter and Removal of Sidewalk by the foot [meter] or square yard [square meter].

10. Removal of Fence by the foot [meter].

11. Removal of Inlets and Removal of Manholes by the each.

12. Removal of Pipe by the foot [meter] of pipe removed (including flared-end sections) or by the each.

13. Removal of Pipe FE Section by the each, for removal of the flared-end section only.

14. Removal of RC Box Culverts as a complete unit.

15. Removal of Signs and Removal of Sign Structures as a complete unit.

16. Removal of Snow Fence Panels by the each.

17. Removal of Storm Sewer by the foot [meter] or as a complete unit.

18. Removal of Structures and Obstructions by the complete unit; payment is full compensation for the removal of all structures and obstructions within the right-of-way or other specified locations.

19. Removal of _______ Bridges by the each.

20. Reset Mailbox (____) by the each.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Cutting Bit Pvmt	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Cutting Concrete	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Milling Plant Mix	SY, CY, TON [m^2, m^3, t]	0.1 ft, 0.1ft, 0.05 ton [0.05 m, 0.05 m, 0.05 t]	SY, CY, 0.05 TON [m^2, m^3, 0.05 t]
Profile Milling Plant Mix	SY, CY, TON [m^2, m^3, t]	0.1 ft, 0.05 ton [0.05 m, 0.05 t]	SY, CY, 0.05 TON [m^2, m^3, 0.05 t]
Removal of Bit Curb	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Removal of Bridge Rail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Removal of Cattle Guards	EA [Ea]	EA [Ea]	EA [Ea]
Removal of Concrete	LS, SY, CY [LS, m^2, m^3]	LS, 0.1 ft, 0.1 ft [LS, 0.05 m, 0.05 m]	LS, SY, CY [LS, m^2, m^3]
Removal of Concrete Median	LS, SY, CY [LS, m^2, m^3]	LS, 0.1 ft, 0.1 ft [LS, 0.05 m, 0.05 m]	LS, SY, CY [LS, m^2, m^3]

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Removal of Concrete Pavement	LS, SY, CY [LS, m^2, m^3]	LS, 0.1 ft, 0.1 ft [LS, 0.05 m, 0.05 m]	LS, SY, CY [LS, m^2, m^3]
Removal of Crushed Base	SY, CY, TON [m^2, m^3, t]	0.1 ft, 0.1 ft, 0.05 ton [0.05 m, 0.05 m, 0.05 t]	SY, CY, 0.05 TON [m^2, m^3, 0.05 t]
Removal of Curb	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Removal of Curb and Gutter	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Removal of Double Gutter	FT, SY [m, m^2]	0.1 ft, 0.1 ft [0.05 m, 0.05 m]	FT, SY [0.5 m, m^2]
Removal of Fence	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Removal of Guardrail and Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Removal of Inlets	EA [Ea]	EA [Ea]	EA [Ea]
Removal of Manholes	EA [Ea]	EA [Ea]	EA [Ea]
Removal of Pedestrian Rail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Removal of Pipe	EA, FT [Ea, m]	EA, 0.1 ft [Ea, 0.05 m]	EA, FT [Ea, 0.5 m]
Removal of Pipe FE Section	EA [Ea]	EA [Ea]	EA [Ea]
Removal of RC Box Culverts	LS	LS	LS

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Removal of Sidewalk	FT, SY [m, m^2]	0.1 ft, 0.1 ft [0.05 m, 0.05 m]	FT, SY [0.5 m, m^2]
Removal of Signs	LS	LS	LS
Removal of Sign Structures	LS	LS	LS
Removal of Snow Fence Panels	EA [EA]	EA [EA]	EA [EA]
Removal of Storm Sewer	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, 0.5 m]
Removal of Structures and Obstructions	LS	LS	LS
Removal of ______ Bridges	EA [EA]	EA [EA]	EA [EA]
Removal of Surfacing	SY, CY, TON [m^2, m^3, t]	0.1 ft, 0.1 ft, 0.05 ton [0.05 m, 0.05 m, 0.05 t]	SY, CY, 0.05 TON [m^2, m^3, 0.05 t]
Reset Mailbox (___)	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 203
Excavation and Embankment

203.1 DESCRIPTION

1 This section describes the requirements for excavation, hauling, disposal, placing, shaping, grading, and compaction of material.

2 Excavation classifications are as follows:

1. **Borrow Special Excavation** is a pit-run, granular material taken from specified material sources.

2. **Muck Excavation** consists of the removal and disposal of saturated soils or saturated mixtures of soils and organic matter from within the construction limits but not associated with culvert installations. Soils or mixtures of soils will be classified as muck excavation only if they cannot be excavated using the same equipment and procedure as used for unclassified excavation.

   Classification and removal of unsuitable materials associated with culvert installations is specified in Section 206, Excavation and Backfill for Culverts.

3. **Rock Excavation** consists of the removal and disposal of igneous, metamorphic, or sedimentary rock, which cannot be excavated without blasting or the use of conventional excavating equipment. The limits of rock excavation are based on seismic velocities as defined in the contract and the structural characteristics of the bedrock. Excavation outside these limits is unclassified excavation as defined below.

4. **Unclassified Excavation** consists of the excavation and placement or disposal of materials encountered in the work, including excavation from material sources, not classified under other contract pay items.

203.2 MATERIALS—Vacant

203.3 EQUIPMENT—Vacant

203.4 CONSTRUCTION

203.4.1 General

1 In this section the term “borrow source” refers to the source for excavation materials. For borrow sources, adhere to the requirements of Subsection 106.3, Sources, Sites and Haul Roads.

2 Construct embankments when air temperatures allow compaction to the specified densities. Suspend work during sustained periods of freezing that induce frost in the embankment or excavation.

3 Before beginning excavation activities, construct required fencing in accordance with Section 607, Fences.

4 Before beginning excavation activities, construct contour diversion ditches in accordance with Subsection 215.4.3.7, Contour Diversion Ditches.

5 Perform grading during daylight. Grading may be allowed after dark, provided adequate lighting equipment is provided for the safety of the traveling public and the work force and for inspection.

6 Conform to the neat lines and elevations staked by the engineer. Do not waste excavated materials without approval from the engineer. Conduct grading and related operations without disturbing the terrain outside of the construction limits. Restore disturbed terrain outside of the construction limits and seed with the specified seed mixture at no additional cost to the department.

7 The engineer may require additional excavation where rock, unstable soil, or other unsuitable material is encountered below subgrade. If the material at grade can be finished and compacted, excavation below grade will not be required. Obtain material for backfilling to subgrade from other grading areas. Dispose of unsuitable material at a specified waste site or incorporate into other portions of the work, as approved by the engineer.

8 Give five working days advance notice before beginning excavation in any borrow source. Do not remove material before cross-sectioning or digital terrain modeling of the site by the engineer.

9 Sequence roadway construction and excavation from borrow sources to minimize the waste of material. If more borrow material is used than is required, causing an excess of excavation material, the excess quantity will be deducted from the

excavation volume measured in the borrow source or sources. The department will deduct from monies due the contractor for the royalties on borrow source materials used in excess of the quantities required. Leave borrow areas in a smoothed condition satisfactory to the engineer and conducive to accurate measurements after the excavation is completed.

10 Do not place rocks, broken concrete, or other solid materials in embankments where piling will be installed.

11 If embankment material can be placed on only one side of abutments, wing walls, piers, or culvert head walls, perform compaction without causing overturning or placing excessive pressure against the structure that would cause movement. Until the superstructure is in place, do not place the fill next to a bridge abutment higher than the bottom of the backwall. When embankment material is placed on both sides of a concrete wall or box-type structure, bring the embankment up equally on both sides of the structure.

12 Dispose of excess or unsuitable excavated material (including rock and boulders) that cannot be used in embankments, as specified or approved by the engineer.

13 Construct roadway embankments with loose layers 8 in [200 mm] thick, thoroughly mixed to provide uniform moisture distribution and compacted as specified before placing the next layer. Before compacting, use spreading equipment to obtain a uniform thickness. While compacting, level and manipulate to ensure uniform density. Control water use to obtain the required density. Route construction equipment uniformly over the entire surface of each layer.

14 When the excavated material consists mainly of rock larger than 8 in [200 mm], place the material in maximum lifts of 3.0 ft [1.0 m]. Work each lift for moisture distribution; compact, level and smooth with suitable equipment. Do not construct lifts within 24 in [600 mm] of the finished subgrade. Construct the balance of the embankment with approved material placed and smoothed in accordance with Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control.

203.4.2 Benching Requirements

1 When placing embankment material on or against slopes steeper than 1V:4H, bench the existing slope as the new embankment material is brought up in layers. Cut each bench 5 ft [1.5 m] horizontally into the original ground line from the vertical side of the previous cut. Compact materials from the benching with the embankment material.

203.4.3 Embankment and Cut Areas with Moisture and Density Control

203.4.3.1 General

1 Construct fill in embankments and cut areas with moisture and density control. Perform compaction when soil moisture content is within plus 2 percent to minus 4 percent of the optimum moisture content. Determine maximum densities by Method A or Method C as specified in the *Materials Testing Manual*.

2 When embankment material cannot be tested using Method A or Method C as specified in the *Materials Testing Manual*, place and compact the material using construction methods in accordance with Subsection 203.4.1, Excavation and Embankment, Construction, General, and locate the material at least 24 in [600 mm] below the finished subgrade.

3 In embankment and cut areas, place and compact material above the 6 in [150 mm] scarified layer of moisture and density control to at least 95.0 percent of maximum density.

4 Reprocess and recompact to the specified density embankments damaged by hauling operations or improper drainage, at no additional cost to the department.

5 Remove and replace newly constructed embankments that are soft, yielding, or otherwise unacceptable, at no additional cost to the department.

203.4.3.2 Cut Areas

1 Treat cut areas for moisture and density control to at least the depth of the plane from ditch-bottom to ditch-bottom, not to exceed a depth of 24 in [600 mm] below the finished subgrade. Scarify the lower 6 in [150 mm] of the moisture and density control layer, adjust the moisture content, and compact the material to at least 90.0 percent of maximum density.

203.4.3.3 Embankment Areas

1 Remove sod, vegetation, and topsoil from embankment foundations, and scarify the surface to a depth of 6 in [150 mm]. Adjust moisture content, and compact material to at least 90.0 percent of maximum density.

203.4.4 Embankments Without Moisture and Density Control

1 Construct embankments specified as not requiring moisture and density control in accordance with Subsection 203.4.1, Excavation and Embankment, Construction, General. Consolidate the material to a uniform consistency by routing the hauling and leveling equipment over each lift. Add water to each lift if the natural moisture is insufficient to aid in the placement compaction. Compact the soil when moist.

203.4.5 Finishing

1 Sequence finishing work with other operations. Where practical, round the tops of cut slopes to blend with the adjacent terrain.

2 Cut subgrade shoulders and ditch bottoms to eliminate scalloped or ragged lines and grade to drain.

3 Trim inslopes and backslopes to eliminate unsightly humps or hollows, and blend at pipe ends, drilled shaft foundation, and erosion control devices.

4 Remove and dispose of piled boulders, unsuitable material, and other debris as approved by the engineer.

5 Perform finishing operations at a right angle to the slope. Hand raking may be required where finishing work cannot be performed by machine.

203.5 MEASUREMENT and PAYMENT

203.5.1 General

1 All classifications of excavation will be measured by the engineer in its original position using volumetric measurements in accordance with Subsection 101.5, Definitions. The volumes will be computed when the work is completed. Volumes for authorized excavation below subgrade elevation will be computed by this same method. The volume calculation will be adjusted to remove topsoil quantities.

2 The engineer will measure materials actually excavated, except for excavation resulting from benching operations. Additional excavation required by the engineer, in accordance with Subsection 203.4.1, Excavation and Embankment, Construction, General, will be measured for payment.

3 Where it is impractical to measure material by volumetric measurement methods because of the erratic location of isolated deposits, the engineer will use acceptable methods involving three-dimensional measurements.

4 For excavation that requires repeated handling before final placement, the engineer will measure each approved handling, including that of materials to be stockpiled and preserved for later use in the work. When repeat handling is for the contractor's convenience, no additional measurement will be made.

5 The engineer will measure:

1. Borrow Special Excavation by the cubic yard [cubic meter] or by the short ton [metric ton]. When payment is by weight [mass], the weight [mass] of water added before measuring will not be deducted.
2. Muck Excavation by the cubic yard [cubic meter].
3. Rock Excavation by the cubic yard [cubic meter] using volumetric measurements. The engineer will not measure overbreak.
4. Unclassified Excavation by the cubic yard [cubic meter].

6 In embankment and cut areas, the 6 in [150 mm] of material scarification, adjustment of moisture content, and recompaction to 90.0 percent will not be measured for payment directly and is considered incidental to the various classifications of excavation.

7 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Borrow Special Excavation	CY, TON [m^3, t]	0.1 ft, 0.05 ton [0.05 m, 0.05 t]	CY, 0.05 TON [m^3, 0.05 t]
Muck Excavation	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Rock Excavation	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Unclassified Excavation	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]

203.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Clearing and Grubbing in accordance with Section 201, Clearing and Grubbing.
2. Contour diversion ditches in accordance with Section 210, Equipment Work, or Subsection 109.4, Extra and Force Account Work.
3. Haul in accordance with Section 204, Haul.
4. Topsoil Storing in accordance with Section 207, Topsoil.
5. Water in accordance with Section 209, Watering.

SECTION 204
Haul

204.1 Description

1 This section describes the requirements for transporting material from an original or specified location to a final location.

204.2 MATERIALS—Vacant

204.3 EQUIPMENT—Vacant

204.4 CONSTRUCTION

204.4.1 General

1 Haul specified materials from their original location to a final location specified.

2 As necessary, obtain permits for haul operations on local roads.

204.4.2 Wet Haul

1 The term “wet haul” means that all commercial additives, water, bituminous materials, lime, or cement have been blended with the aggregates for final processing and laydown.

204.4.3 Dry Haul

1 The term “dry haul” means material hauled from its original source to a plant or storage site or from storage sites to the roadway for final processing without additives.

204.5 MEASUREMENT and PAYMENT

1 Material moved within the material sources or mixing sites will not be measured for Haul payments.

2 Natural filler will be included in Haul computations.

3 Within the construction limits, the engineer will compute Haul quantities on the basis of transporting the materials along the highway’s centerline or baseline

without regard to lateral distance from such line to the outer limits of the highway right-of-way or contiguous construction limits

4 On multi-lane highways, Haul will be computed along the survey center line, without regard for lateral or median crossover distance.

5 Except from contiguous areas, Haul from outside the right-of-way will be computed along the shortest practical route, from the loading point to a point of entrance on the center line or base line, and then along the center line or base line to the point of disposition. The contractor's choice to use a longer route will not affect this computation. If a shorter route is used, the computation will be based on the actual distance.

6 The engineer will measure Haul by the following:

1. **Cubic Yard-Mile [Cubic Meter-Kilometer]**. In determining cubic yard-mile [cubic meter-kilometer] Haul, the engineer will assume that material is hauled the shortest distance from excavation to deposit. Quantities will be computed as the distance, as described above, that each cubic yard [cubic meter] is hauled.

2. **Short Ton-Mile [Metric Ton-Kilometer]**. In determining short ton-mile [metric ton-kilometer] Haul, the engineer will compute and measure the distance, as described above, that each short ton [metric ton] of material is hauled.

   The weight [mass] of dry haul materials used to determine dry haul quantities may be computed in accordance with Paragraph 2.1, Dry Haul/Wet Haul Combination, within Subsection 204.5, Measurement and Payment.

   The haul of commercial additives, bituminous materials, lime, or cement to the plant site will not be measured.

   Material lost through dryers or dust control equipment, left in stockpiles, rejected, or lost in bases of stockpiles will not be measured. Measurements for short ton-mile [metric ton-kilometer] Haul will be based on the final pay quantity of the item in its final location on the roadway or in a stockpile. No addition or deduction will be made for natural aggregate moisture.

2.1 **Wet Haul/Dry Haul Combination.** When Haul is a combination of wet and dry haul, the dry haul quantity will be computed from the wet haul scale weight [mass] with deductions for any additives, blended or processed into the material. Natural aggregate moisture and water added during crushing operations will not be added into the weight [mass] quantity for computing the dry haul.

7 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Haul	CYMI [m^3km]	yd^3, 50 ft [m^3, 10 m]	0.1 CYMI [0.1 m^3km]
Haul	TMI [tkm]	0.05 ton, 50 ft [0.05 t, 10 m]	0.1 TMI [0.1tkm]

SECTION 205
Haul Road Maintenance and Restoration

205.1 DESCRIPTION

1 This section describes the requirements for the maintenance and restoration of public roads used to haul construction materials.

205.2 MATERIALS—Vacant

205.3 EQUIPMENT—Vacant

205.4 CONSTRUCTION

1 Before using the haul roads, conduct an inspection with the engineer to determine the condition of the existing roadway, drainage structures, and other appurtenances. Visually record the route's condition both before and immediately after completing hauling operations. Submit the tapes, and any other photographic evidence, for incorporation into the project files and for determination of repairs necessary due to hauling operations.

2 Maintain the road to its existing condition before hauling or better as directed by the engineer. Ensure that hauling operations do not jeopardize the safe movement of traffic at the posted speed limit.

3 Upon completion of hauling operations, restore the haul road to the original condition. The engineer will determine the type and quantity of restoration that will be required.

4 Restore and leave haul roads as they were before execution of the contract.

5 If legal load limits were exceeded, restore damaged haul roads at no additional cost to the department.

205.5 MEASUREMENT and PAYMENT

205.5.1 General

1 The engineer will measure equipment operation, labor, and materials required for haul road maintenance or restoration and for which no other applicable pay

items are included in the contract as Haul Road Maintenance and Restoration in accordance with Subsection 109.4, Extra and Force Account Work.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Haul Road Maintenance/ Restoration	$$	0.01 $$	0.01 $$

205.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for work and materials for the maintenance or restoration of haul roads with appropriate pay items when established in the contract and in accordance with the applicable requirements in the contract.

SECTION 206
Excavation and Backfill for Culverts

206.1 DESCRIPTION

1 This section describes the requirements for the excavation, disposal of materials, and backfilling needed to install pipe culverts, structural plate pipe, box culverts, storm sewer systems, pipe siphons, water lines, sanitary sewer lines, and other conduits.

206.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	Subsection
Admixtures	801.4
Aggregate	803
Fly Ash	801.2
Portland Cement	801.1
Water	814.1

2 Use existing material for backfill; do not use material with frozen lumps, chunks of highly plastic clay, stones, or other materials that could damage the structure.

206.3 EQUIPMENT—Vacant

206.4 CONSTRUCTION

206.4.1 Excavation

206.4.1.1 Culvert Excavation

1 Culvert excavation includes excavation for box culverts, pipe culverts, structural plate stock passes, or similar structures that require a uniform-width channel bottom and sloped sides. Vertical limits of culvert excavation are from the base of the bottom slab of box culverts or the grade required to set the invert of pipe culverts at the specified flowline to the top of the existing ground (which is the natural terrain surface in fill areas and the final subgrade line in cut areas). Longitudinal limits are 24 in [600 mm] beyond each end of the installation; the engineer may stake excavation beyond the longitudinal limits.

206.4.1.2 Trench Excavation

1 Trench excavation includes excavation for storm sewer systems, sanitary sewer lines, pipe siphons, water systems, utility lines, or similar installations where the contract specifies a trench with vertical sides. Vertical limits of trench excavation are from the base of the bottom slab of box culverts or the grade required to set the invert of pipe culverts at the specified flowline to the top of the existing ground (which is the natural terrain surface in fill areas and the final subgrade line in cut areas).

2 Excavate trenches to the specified line, grade, and width and with sides as nearly vertical as practical. When necessary, shore, sheet, and brace sides to prevent sliding or sloughing. Alternatively, the engineer may allow sloping of the trench walls above the top of the pipe being installed.

3 Unless excavation is required for the installation of bed course material, or the engineer requires excavation below the pipe for foundation improvement, excavate the trench to grade so that the pipe may be installed on undisturbed earth.

4 Excavate for manholes, inlet or outlet structures, and other structures associated with various types of conduit in the same manner as for conduit, with approximately 12 in [300 mm] clearance outside of each footing or wall.

206.4.1.3 Culvert / Trench Subexcavation

1 The engineer may require additional excavation when unsuitable foundation conditions are encountered at the bottom of a channel or trench or when it is impractical to excavate to the established grade.

2 Excavation below the grade required to set a culvert at the specified flowline will be classified as culvert subexcavation.

206.4.2 Disposal of Excavated Materials

1 Dispose of excavated material by one of the following methods:

1. Stockpile for use as backfill.
2. Incorporate into other portions of the work.
3. Handle as waste.

2 Do not stockpile material for backfilling so that it interferes with construction or channel drainage. Transport excess material suitable for embankment construction to specified sites or as approved by the engineer. Waste and dispose of material unsuitable for use elsewhere on fill slopes or at specified locations. Do not place waste material next to a channel or on flood plain where flood waters can wash the material into a channel.

206.4.3 Protection of Structures

1 Protect excavations from saturation or erosion, and dewater sites where standing or running water would interfere with proper installation of the structure or pipes.

206.4.4 Structure Foundation

1 If bedding material is not specified, install the conduit on undisturbed material. Where channels or trenches have been excavated below the established grade, place and compact backfill in loose layers approximately 8 in [200 mm] thick for the full length of the installation. Compact the last 6 in [150 mm] layer of material below the bottom of structures or bedding and other backfill material to at least 95.0 percent of maximum density and within plus 2 percent to minus 4 percent of optimum moisture content, in accordance with Subsection 203.4.3, Embankments and Cut Areas with Moisture and Density Control.

206.4.5 Backfilling

206.4.5.1 General

1 Place backfill in loose layers approximately 8 in [200 mm] thick. Compact each layer to at least 95.0 percent of maximum density and within plus 2 percent to minus 4 percent of optimum moisture content, in accordance with Subsection 203.4.3, Embankments and Cut Areas With Moisture and Density Control. Do not damage structures, culverts, or coating while backfilling and compacting. To avoid damage or lateral displacement, place and compact backfill layers equally on the sides of structures or culverts.

2 Do not place backfill against box culverts or other cast-in-place structures until the concrete has cured for 14 calendar days or test cylinders indicate an achieved compressive strength equal to at least 80.0 percent of design strength.

3 When placing bedding and backfill below the springing line of a conduit, tamp or ram the material between the culvert and the channel bottom.

4 Place backfill over water and sanitary sewer lines by hand to an initial depth of 12 in [300 mm]. Do not drop material directly on pipe; place on both sides of the trench and allowed to flow over the pipe. Compact uniformly on both sides of the pipe to a height of approximately 12 in [300 mm] above the top of the pipe.

206.4.5.2 Flowable Backfill

1 When specified, backfill culvert excavations to the depth and width specified and at least 12 in [300 mm] over the top of the conduit or structure with a flowable backfill.

2 Design the flowable backfill mix in accordance with Table 206.4.5-1, Flowable Fill Requirements.

Table 206.4.5-1
Flowable Fill Requirements

Parameter	Property or Limit
Cement, minimum or Cement and fly ash, minimum	100 lbs/yd^3 [60 kg/m^3] 50 lbs cement/yd^3 [30 kg/m^3] and 80 lbs fly ash/yd^3 [50 kg/m^3]
Water(1) estimated	50 gal/yd^3 [250 L/m^3]
Aggregate estimated	3000 lbs/yd^3 [1800 kg/m^3]
Air entraining admixture	Optional
Air content, maximum	15 percent
Slump, minimum	6 in [150 mm]
20-day compressive strength, minimum	50 psi [345 kPa]
28-day compressive strength, maximum	100 psi [690 kPa]

(1) Provide the correct amount of water to allow the mix to flow properly without excessive segregation.

206.5 MEASUREMENT and PAYMENT

206.5.1 General

1 The engineer will measure:

1. Culvert Subexcavation and Trench Subexcavation by the cubic yard [cubic meter] based on the neat lines for the installation.

2. Flowable Backfill by the cubic yard [cubic meter] of material placed, based on the batch ticket quantities.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Culvert Subexcavation	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Flowable Backfill	CY [m^3]	0.25 yd^3 [0.25 m^3]	CY [m^3]
Trench Subexcavation	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]

206.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Excavation beyond longitudinal limits (described in Subsection 206.4.1.1, Culvert Excavation) as Unclassified Excavation, in accordance with Section 203, Excavation and Embankment.

2. Backfill and bedding materials not excavated at the installation site by the short ton [metric ton] or cubic yard [cubic meter] for the types of materials used, in accordance with the applicable sections of these standard specifications.

SECTION 207
Topsoil

207.1 DESCRIPTION

1 This section describes the requirements for removing, storing, and placing topsoil.

207.2 MATERIALS

1 Topsoil is soil suitable for the growth of grass or other cover crops, reasonably free of hard dirt, clay, rocks, or other materials that would inhibit germination or growth. Provide topsoil that is a fertile, friable material; loam; or sandy clay loam. Do not provide topsoil that is saline or sodic or contains noxious weeds, toxic substances, stones or sticks greater than 1 in [25 mm] in diameter, or similar objectionable matter.

207.3 EQUIPMENT—Vacant

207.4 CONSTRUCTION

207.4.1 General

1 Before removing topsoil, clear and mulch overlying brush, grass, crops, and other suitable material, and incorporate them into the topsoil. Mulch the material by chopping with brush chopper or shredding with a rotary blade mower.

2 In this section the term “borrow source” refers to the source for topsoil materials. For borrow sources, adhere to the requirements of Subsection 106.3, Sources, Sites and Haul Roads.

207.4.2 Topsoil Storing

1 Topsoil storing consists of removing and stockpiling topsoil within the limits of the project, in uniform piles, and out of the way of other activities.

2 Clear and grub stockpile sites in accordance with Section 201, Clearing and Grubbing. Ensure the sites are firm, smooth, and well drained.

207.4.3 Topsoil Placing

1 Before topsoil placement, construct embankment or cut slope areas to the specified lines and grades, and scarify all areas to a depth of approximately 6 in [150 mm]. Place topsoil to a uniform depth commensurate with the quantity available and the area to be covered.

2 After spreading, remove clods, stones, and other foreign materials that hamper effectiveness, appearance, or reclamation operations. Do not remove mulch.

3 When weather warrants, apply a fine spray of water to prevent topsoil erosion.

207.4.4 Topsoil Borrow

1 Topsoil borrow is topsoil either obtained from a borrow source outside the project limits and hauled directly to its final location or obtained within the limits of the project and hauled across a balance station in the earthwork for final placement.

207.5 MEASUREMENT and PAYMENT

207.5.1 General

1 The engineer will measure:

1. Topsoil Borrow by the cubic yard [cubic meter], using volumetric measurements of the borrow source. When Topsoil Borrow is handled repeatedly for the contractor's convenience, no additional measurements will be made.

   The department will pay royalty costs for Topsoil Borrow except when the topsoil is obtained from a contractor-furnished source.

2. Topsoil Placing and Topsoil Storing by the cubic yard [cubic meter], using volumetric measurements.

   2.1 **Topsoil Storing.** The quantity placed in stockpile will be the total quantity for payment.

   2.2 **Topsoil Placing.** The difference between the quantity originally put in the stockpile and that remaining after all required placement will be the total quantity for payment.

2 Topsoil stripped from its original position within the project limits and placed directly in its final position will be measured as Topsoil Placing unless it is hauled across an earthwork balance station, in which case it will be measured as Topsoil Borrow. Quantities will be determined from preliminary and final volumetric measurements of the stripped area.

3 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Topsoil Borrow	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Topsoil Placing	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Topsoil Storing	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]

207.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for Water in accordance with Section 209, Watering.

SECTION 208
Vacant

SECTION 209
Watering

209.1 DESCRIPTION

1 This section describes the requirements for furnishing water for application to soil or aggregate.

209.2 MATERIALS

1 Furnish water from specified sources or from sources approved by the engineer.

209.3 EQUIPMENT

1 Apply water in a fine, uniform spray during finishing and seeding operations using pressure-controlled spray bars or nozzles.

2 Provide water meters to measure water used and for royalty purposes.

3 Use department-certified tanks, department-certified distributors, or certified water meters. For meters used to determine quantities for payment or measurement, provide a copy of the test report and certification that the meters have been calibrated within the preceding 12 months and are accurate to within plus or minus 3 percent.

209.4 CONSTRUCTION

209.4.1 General

1 If the contractor elects to use water sources other than those specified, provide documentation to the engineer for the water source site and the associated haul road in accordance with Subsection 106.3.3, Contractor-Furnished. A "Contract Amendment" (Form E-61) will not be required. Costs associated with the change in water source will be at no additional cost to the department.

2 Apply water as follows:

1. **Embankment Construction**. Distribute over the full width of each layer of embankment material without puddling or saturation.

2. **Aggregate Courses**. Immediately before mixing and, if required, during placing of the material.

3. **Finishing**. In a uniform, fine spray across the full width of the course.

4. **Seeding**. In a spray that does not wash or erode the seeded areas.

5. **Dust Control**. When using water to control dust for the protection and safety of traffic, for abatement of air pollution, or for other purposes, apply enough to eliminate the dust.

209.4.2 Prewetting

1 The engineer may allow wetting of materials before excavation.

2 Before prewetting, submit a detailed plan showing the method and equipment to be used. Show the proposed location of water lines and sprinklers, the quantity of water to be applied by each sprinkler, the rate of application, and other pertinent data. Base the plan on soil classification, estimated efficiency, and in-place moisture data from adequate predrilling and sampling for the full depth of each area to be prewet. Multistage prewetting operations may be used.

3 Apply water at a rate that provides optimum moisture content to the depth of excavation. Do not prewet material already over optimum moisture capacity.

4 Prevent or correct excessive runoff through leveling, constructing contour diversion ditches in accordance with Subsection 215.4.3.7, Contour Diversion Ditches, or constructing dikes.

5 During and after prewetting, check the depth of water penetration and moisture content using the methods prescribed in the *Materials Testing Manual*. Submit test results for incorporation into the project files.

6 Stop prewetting and take corrective measures if it appears that impervious layers or other conditions are interrupting penetration and water is being wasted.

209.5 MEASUREMENT and PAYMENT

1 The engineer will measure Water by the 1000 gallons [cubic meter], using tank volumes, distributor volumes, or water meters.

2 Water wasted or used contrary to the contract will not be measured. The department will deduct from monies due or the contractor will reimburse the department for royalties on water wasted or used contrary to the contract.

3 When specified, the department will pay for all water obtained from the source or sources indicated in the contract.

4 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Water	MG [m^3]	0.1 MG [0.1 m^3]	0.1 MG [0.5 m^3]

SECTION 210
Equipment Work

210.1 DESCRIPTION

1 This section describes equipment for hourly work.

210.2 MATERIALS—Vacant

210.3 EQUIPMENT

210.3.1 Backhoe

1 Provide self-propelled backhoes equipped with buckets sized to be capable of handling the material to be moved, commensurate with the power and size of the backhoe, and at least the manufacturer's rated bucket size.

2 Provide equipment specifications if requested by the engineer. Backhoe types are:

1. **Type I—Backhoe.** A two-wheel drive backhoe with a manufacturer's weight specification of up to and including 15,000 lb [6800 kg].
2. **Type II—Backhoe.** A four-wheel drive backhoe with a manufacturer's weight specification of up to and including 15,000 lb [6800 kg].
3. **Type III—Backhoe.** A two-wheel drive backhoe with a manufacturer's weight specification of more than 15,000 lb [6800 kg].
4. **Type IV—Backhoe.** A four-wheel drive backhoe with a manufacturer's weight specification of more than 15,000 lb [6800 kg].

210.3.2 Bulldozer

1 Provide tractors mounted on tracks and with an engine rating of at least 110 flywheel hp [82 flywheel kW]. Equip each with a blade at least 8 ft [2.4 m] wide. When specified, equip with a rear-mounted ripper.

210.3.3 Excavators

1 Provide excavators equipped with buckets sized to meet the following criteria:

1. Capable of handling the material to be moved.
2. Commensurate with the power and size of the excavator.
3. At least the manufacturer's rated bucket size.

2 Excavator work that requires an extended stick will be specified.

210.3.4 Loader

1 Provide wheeled or tracked loaders equipped with buckets sized to meet the following criteria:

1. Capable of handling the material to be moved.
2. Commensurate with the power and size of the loader.
3. At least the manufacturer's rated bucket size.

210.3.5 Motor Grader

1 Provide diesel-powered motor graders with an engine rating of at least 80 flywheel hp [60 flywheel kW] and with at least four driving wheels. Equip each with a power-operated blade at least 12 ft [3.6 m] long and with at least one scarifier with all teeth in place.

210.3.6 Roller

1 Provide roller equipment that is self-propelled or towed appropriately. A towed roller and separate power unit are considered a single roller unit. If requested, provide equipment specifications, including weights, horsepowers, and tire pressures. The following are roller types:

1. **Type I—Equipment Roller.** A scraper with a minimum capacity of 12 yd^3 [9 m^3], a ballast weight of at least 18 ton [16 t], and tires inflated to at least 60 psi [400 kPa]. Use larger equipment if the required compaction density is not achieved.

2. **Type II—Light Pneumatic Roller.** A roller 60 in [1500 mm] wide with seven pneumatic tires of equal size and diameter mounted on two axles attached to a rigid frame, an empty operating weight from 9000 lb to 18,000 lb [4000 kg to 8000 kg], and tire contact pressure of at least 45 psi [300 kPa].

3. **Type III—Sheep's Foot Roller.** A roller 60 in [1500 mm] wide with one or two steel drums at least 60 in [1500 mm] in diameter and with studded tamping feet. Provide a roller with feet that project at least 7 in [175 mm] from the drum surface, are spaced from 6 in to 10 in [150 mm to 250 mm] measured center to center in any direction, and have a surface area from 4 in² to 12 in² [2600 mm² to 7700 mm²]. Operate with enough load to produce a ground pressure of at least 300 psi [2 MPa].

4. **Type IV—50 Ton [45 Mg] Pneumatic Roller.** A roller with four pneumatic tires mounted on a frame with a ballast body and enough capacity to produce an operating weight from 30 ton to 60 ton [27 t to 54 t]. Provide a roller with tires uniform in size and capable of an inflation pressure of at least 150 psi [1 MPa] and with wheels loaded equally.

5. **Type V—Segmented Tamping Roller.** A self-propelled, segmented-wheel tamping roller with drive and guide rolls at least 65 in [1650 mm] in diameter and at least 26 in [650 mm] wide. Provide either a three- or four-wheel type, weighing at least 19 tons [17 t] and powered by an engine with at least 270 brake hp [201 brake kW].

6. **Type VI—Vibratory Roller.** A self-propelled, smooth-wheel, two-axle vibratory roller no more than 60 in [1500 mm] wide overall, with a minimum net weight of 3000 lb [1350 kg], and a minimum vibratory frequency of 4000 vibrations per minute. Provide a roller with a compression roller at least 30 in [750 mm] in diameter and 36 in [900 mm] in width.

7. **Type VII—Vibratory Roller.** A vibratory-type roller weighing at least 10,000 lb [4.5 t] and self-propelled or towed by a tractor. Equip with a single or dual steel vibratory drum, each with a minimum vibratory frequency of 1100 vibrations per minute and a minimum width of 60 in [1500 mm]. A towed roller and separate power unit are considered a single roller unit.

210.3.7 Scraper

1 Provide self-propelled scrapers with two or four drive wheels that are self-loading or have additional power equipment to load to capacity.

210.3.8 Truck

1 Provide trucks equipped with dump bodies capable of hauling highway materials; load to the manufacturer's recommended struck capacity.

210.4 CONSTRUCTION

1 Ensure the availability of equipment within the time frames needed and in coordination with other work.

210.5 MEASUREMENT and PAYMENT

210.5.1 General

1 The engineer will not measure standby time. Unit payment includes supervision, operator and labor costs, fuel, oil, lubricants, maintenance, and other related items.

2 The engineer will measure:

1. Backhoe work by the hour, computed as the actual hours of operation multiplied by the lowest pay factor from Table 210.5.1-1, Backhoe Pay Factor, for the provided equipment's engine or bucket size rating.

Table 210.5.1-1
Backhoe Pay Factor

Backhoe Type	Pay Factor
I	1.0
II	1.15
III	1.0
IV	1.15

2. Bulldozer work by the hour, computed as the actual hours of operation multiplied by the pay factor from Table 210.5.1-2, Bulldozer Pay Factor, for the provided equipment's horsepower [kilowatt] rating.

Table 210.5.1-2
Bulldozer Pay Factor

Minimum Flywheel hp [kW]	Pay Factor[1]
701 and over	1.5
501 - 700	1.3
326 - 500	1.15
225 - 325	1.0
190 - 224	0.8
120 - 189	0.65
80 - 119	0.5
Less than 80	0.45

(1) Includes a ripper when specified. When a ripper is not specified and is required or approved for use by the engineer, an additional 0.15 will be added to the above pay factor.

3. Excavator work by the hour, computed as the actual hours of operation multiplied by the lowest pay factor from Table 210.5.1-3, Excavator Pay Factor, for the provided equipment's metric ton size rating.

Table 210.5.1-3
Excavator Pay Factor

Excavator Size (metric ton)(1)	Pay Factor	Minimum Bucket Size yd^3 [m^3]
50 and over	1.75	4.0 [3.0] and over
40 - 49	1.5	3.0 - 4.0 [2.3 - 3.0]
35 - 39	1.25	2.5 - 3.0 [1.9 - 2.3]
29 - 34	1.0	2.0 - 2.5 [1.5 - 1.9]
20 - 28	0.9	0.6 - 2.0 [0.5 - 1.5]
Less than 20	0.85	Less than 0.6 [0.5]

(1) The industry does not use English equivalent weight for excavators.

4. Loader work by the hour, computed as the actual hours of operation multiplied by the lowest pay factor from Table 210.5.1-4, Loader Pay Factor, for the provided equipment's engine or bucket size rating.

Table 210.5.1-4
Loader Pay Factor

Minimum Flywheel hp [kW]	Pay Factor	Minimum Bucket Size yd^3 [m^3]
270 and over [200 and over]	1.00	5.0 and over [3.8 and over]
216 to 269 [160 to 199]	0.85	4.0 [3.1]
170 to 215 [126 to 159]	0.75	3.5 [2.7]
160 to 169 [118 to 125]	0.70	3.0 [2.3]
135 to 159 [100 to 117]	0.65	2.5 [2.0]
134 and under [99 and under]	0.60	None

5. Motor Grader work by the hour, computed as the actual hours of operation multiplied by the pay factor from Table 210.5.1-5, Motor Grader Pay Factor, for the provided equipment's horsepower [kilowatt] rating.

Table 210.5.1-5
Motor Grader Pay Factor

Minimum Flywheel hp [kW]	Pay Factor[(1)]
250 and over	1.25
200 - 249	1.00
150 - 199	0.90
135 - 149	0.80
125 - 134	0.75
124 and under	0.70

(1) Pay factor includes the blade, scarifier, or both.

6. Roller, Type __________ work by the hour, computed as actual hours of use.

7. Scraper work by the cubic yard hour [cubic meter hour], computed as the actual hours of operation multiplied by the provided equipment's manufacturer-rated capacity in cubic yards [cubic meters], multiplied by the appropriate pay factor from Table 210.5.1-6, Scraper Pay Factor.

Table 210.5.1-6
Scraper Pay Factor

Type of Scraper	Manufacturer's Rated Volume in yd^3 [m^3]		
	0 to 21 [0 to 16]	**22 to 31 [17 to 24]**	**31.1 and over [24.1 and over]**
Single-Engine/ Single-Engine Auger	1.00	1.00	1.00
Tandem-Powered/ Single-Engine Auger	1.10	1.20	1.25
Push-Pull[(1)]	1.25	1.50	1.75
Elevating	1.00	1.00	1.00

(1) Two tandem powered standard scrapers operating in tandem.

8. Truck work by the cubic yard hour [cubic meter hour], computed as the actual hours of operation multiplied by the equipment's capacity (from manufacturer-rated struck capacity or field measurements).

3 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Backhoe	HR [h]	0.5 h	0.5 HR [0.5 h]
Bulldozer	HR [h]	0.5 h	0.5 HR [0.5 h]
Excavator	HR [h]	0.5 h	0.5 HR [0.5 h]
Loader	HR [h]	0.5 h	0.5 HR [0.5 h]
Motor Grader	HR [h]	0.5 h	0.5 HR [0.5 h]
Roller, Type _____	HR [h]	0.5 h	0.5 HR [0.5 h]
Scraper	CYHR [m^{3}h]	yd^3, 0.5 h [m^3, 0.5 h]	0.5 CYHR [0.5 m^{3}h]
Truck	CYHR [m^{3}h]	yd^3, 0.5 h [m^3, 0.5 h]	0.5 CYHR [0.5 m^{3}h]

210.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Additional power equipment required to load scrapers to capacity by equipment hours in accordance with Section 210, Equipment Work, for the equipment used or in accordance with Subsection 109.4, Extra and Force Account Work.

2. Equipment used to load trucks by equipment hours in accordance with Section 210, Equipment Work, for the equipment used or in accordance with Subsection 109.4, Extra and Force Account Work.

SECTION 211
Culvert Cleaning

211.1 DESCRIPTION

1 This section describes the requirements for removing, hauling, and disposing of debris, silt, and obstructions from existing culverts.

211.2 MATERIALS—Vacant

211.3 EQUIPMENT—Vacant

211.4 CONSTRUCTION

1 Unplug and flush clean existing culverts as specified. Dispose of material removed at a contractor-furnished site.

2 Do not damage culverts, appurtenances, or property or create a public hazard or nuisance. If damage occurs, repair in accordance with Subsection 107.8, Protection and Restoration of Property, Markers, and Landscape.

211.5 MEASUREMENT and PAYMENT

1 The engineer will measure Culvert Cleaning by the each.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Culvert Cleaning	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 212
Structure Excavation and Backfill

212.1 DESCRIPTION

1 This section describes the requirements for excavation and backfill for the construction of bridge foundations, retaining walls, bin walls, and other structures and for the disposal of excess materials.

2 Structure excavation will be classified as follows:

1. **Dry excavation** is material removed from above the water line.
2. **Wet excavation** is material removed from below the water line.

212.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	**Subsection**
Pervious Backfill Material	803

2 Provide backfill material consisting of clean gravel from sources other than surface water sources and free from large or frozen lumps, wood, rocks, or other potentially harmful matter.

212.3 EQUIPMENT—Vacant

212.4 CONSTRUCTION

212.4.1 General

1 Where practical, construct structures in open excavation. Shore or brace, and protect with cofferdams, where necessary. Forms may be omitted, with the approval of the engineer, when the site is dry and footings can be placed without cofferdams. Fill the excavation with concrete to the top of the footing, in accordance with Section 513, Structural Concrete. Provide and place additional concrete required because of eliminating the forms, at no additional cost to the department. If additional excavation depth is required by the engineer, the department will pay for additional Class B concrete.

2 Restore channels to as near original condition as possible.

212.4.2 Depth of Footing

1 Excavate for footings to the specified elevations. If the material encountered at the specified elevation is unsuitable for foundation, the engineer will require additional excavation. Fill with class B concrete to the specified elevation for the bottom of the footing.

212.4.3 Preparation of Foundations for Footings

1 When excavations for footings are in rock or other hard foundation material, cut the final surface level and remove loose debris. Clean seams and fill with concrete, mortar, or grout.

2 When placing concrete on an excavated surface other than rock, avoid disturbing the bottom of the excavation. Place concrete immediately after removal of foundation material to grade.

212.4.4 Cofferdams

1 Construct cofferdams to protect fresh concrete against damage from a sudden rising of the stream and to prevent damage to the foundation by erosion. When required, provide cofferdams, as water tight as possible, designed to safely satisfy the requirements of the site and construction. Construct earthen cofferdams using clean material from sources other than surface water sources. To provide clearance, straighten, reset, or enlarge cofferdams that tilt or move sideways during sinking. Provide interior clearance of at least 24 in [600 mm] between forms and cofferdam to allow for construction, inspection, and pumping.

2 When dewatering is not feasible before placing concrete, it may be necessary to construct a concrete foundation seal in accordance with Subsection 513.4.11.6, Cofferdam Seals.

3 After completion of the substructure, remove cofferdams, including all sheeting and bracing, without disturbing or damaging the finished concrete.

212.4.5 Evacuation of Water from Structural Excavation

1 Pump water from inside foundation enclosures during and at least 24 hours after concrete placement. Use a suitable sump pump located away from the

concrete work. Do not start pumping to dewater sealed cofferdams until the seal is sufficiently set to withstand the hydrostatic pressure.

212.4.6 Inspection

1 Notify the engineer after excavation is complete. Do not place concrete until the depth of the excavation and the character of the foundation material is approved.

212.4.7 Backfill

1 If necessary, wash material to remove fines that would make stream water turbid.

2 Backfill excavated areas to the surface of the surrounding ground or stream bed, and compact the areas to the same density as adjacent material. Backfill material placed below water level does not require compaction. Neatly grade the top of the backfill material to blend with the adjacent area.

3 To prevent forward movement, first place the backfill material in front of such structures, or bring it up evenly with the material behind. Deposit backfill material behind abutments, wingwalls, retaining walls, and similar structures in horizontal layers, approximately 8 in [200 mm] loose in thickness, and compact it to the same density as adjacent material. Step or adequately roughen excavation slopes next to concrete components to prevent wedging action during backfilling. Do not jet backfill material behind abutments, wingwalls, or retaining walls.

4 When placing backfill around piers, deposit material equally on both sides to the final elevation.

5 Place backfill to drain water away from structural elements.

6 Do not place backfill that would cause unequal stresses in abutments, retaining walls, wingwalls or other structures until the concrete has cured for 14 calendar days or test cylinders indicate an achieved compressive strength equal to at least 80.0 percent of design strength.

212.4.8 Pervious Backfill Material

1 Provide pervious backfill material of the same grading at any one location. Where otherwise at risk of erosion, cover pervious backfill with at least 12 in [300 mm] of approved material.

212.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Dry Excavation and Wet Excavation for structures in its original position by the cubic yard [cubic meter] and by computing the theoretical volume within the vertical planes 18 in [450 mm] outside of the footings and the horizontal planes at the bottom of the footing and the existing ground line. The existing ground line is the natural ground line, roadbed excavation line, or roadbed embankment line, whichever is in place at the time of excavation. The measurement will include the volume for additional excavation required by the engineer or required as a result of slips, slides, cave-ins, or silting beyond the contractor's control.

2. Pervious Backfill Material by the cubic yard [cubic meter] based on the actual volume of material used.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Dry Excavation	CY [m^3]	0.1 ft [0.05 m]	0.1 CY [0.1 m^3]
Pervious Backfill Material	CY, TON [m^3, t]	0.1 ft, 0.05 ton [0.05 m, 0.05 t]	0.1 CY, 0.05 TON [0.1 m^3, 0.05 t]
Wet Excavation	CY [m^3]	0.1 ft [0.05 m]	0.1 CY [0.1 m^3]

SECTION 213
Overburden

213.1 DESCRIPTION

1 This section describes the requirements for removing and replacing overburden material from a material source.

213.2 MATERIALS—Vacant

213.3 EQUIPMENT—Vacant

213.4 CONSTRUCTION

213.4.1 General

1 Strip topsoil in accordance with Section 207, Topsoil, and stockpile separately from the overburden stockpiles.

2 Strip material sources to the depth and extent necessary for the production of a quality material. Portions of the material source to be used and overburden stockpile locations may be designated by the engineer. Place overburden in neat, uniform stockpiles, located to not interfere with the removal of material from the source.

213.4.2 Replacing Stripped Material

1 After the construction materials are removed, place the overburden over the material source area before placement of topsoil. Place the material uniformly, and smooth it to blend with the surrounding terrain. Place topsoil in accordance with Section 207, Topsoil.

213.5 MEASUREMENT and PAYMENT

213.5.1 General

1 The engineer will measure:

1. Overburden Removal by the cubic yard [cubic meter] using volumetric measurements.

2. Overburden Placing by the cubic yard [cubic meter] computed as the difference between the original volume in the stockpiles and the volume remaining in the stockpiles upon completion of the work.

   If overburden is stripped from its original position and placed directly in its final position, it will be measured as Overburden Placing. The quantity will be determined from preliminary and final volumetric measurements of the stripped area.

2 The engineer will not make additional measurements if overburden stockpiles are moved to facilitate material source operations, except when the stockpile locations were directed by the engineer.

3 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Overburden Placing	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Overburden Removal	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]

213.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for removal and placement of topsoil in accordance with Section 207, Topsoil.

SECTION 214
Lime Treated Subgrade

214.1 DESCRIPTION

1 This section describes the requirements for constructing one or more courses of a mixture of soil, lime, and water.

214.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	**Subsection**
Hydrated Lime	820
Water	814.1

2 Use existing subgrade soil or approved borrow material, as specified, with deleterious materials removed.

214.3 EQUIPMENT

214.3.1 General

1 Correct equipment leaks immediately, or remove the equipment from the work area.

214.3.2 Lime Spreaders

1 Use lime spreading equipment capable of spreading lime uniformly at the specified rate and keeping the slurried lime in suspension.

214.3.3 Water Distribution

1 Use equipment capable of uniformly distributing the required water. Do not use water pumps on water distributors.

214.3.4 Mixing

1 Use a self-propelled rotary mixer, except that disc harrows, motor graders, and other equipment may be used to supplement the mixing performed by the

rotary mixer. Use mixing equipment capable of mixing to a compacted depth of at least 10 in [250 mm].

2 Provide a traveling mixing plant for incorporating the lime into the soil designated for treatment. Ensure that the traveling mixing plant is capable of spreading the lime slurry in an even, traverse layer, providing a homogeneous mixture of lime and subgrade, and metering the lime at the desired application rates for the volume of material to be treated per layer.

214.3.5 Compaction

1 Use compaction equipment that is self-propelled. Finish roll with a pneumatic tire roller, a smooth steel-wheeled roller, or a combination of both.

214.4 CONSTRUCTION

214.4.1 General

1 Perform lime stabilization when the air temperature is 45 °F [10 °C] or above. Do not mix the lime with frozen soils or soils containing frost. Do not apply lime when wind conditions are such that excessive loss of lime occurs or when blowing lime becomes hazardous to traffic, workers, or adjacent property owners.

214.4.2 Soil Preparation

1 Shape the subgrade surface of the prepared roadbed subgrade to be treated to the staked lines, grades, and cross section. Excavate subgrade material in cut sections to the required depth, and incorporate excavated material into the roadway embankment. Place excavated subgrade material in a windrow adjacent to the section to be treated, stockpile, or waste.

2 When lime treatment depth is more than the contractor's equipment is capable of handling, excavate material above the bottom layer to be treated in excess of what the contractor's equipment can treat, and place it in a windrow or stockpile. When practical, place the excavated material in a windrow adjacent to the area to be treated, and place it on the roadway as each treated layer is completed.

3 Cut drains through the shoulders adjacent to the excavated areas to drain the roadbed. Cut drains through the windrows at sufficient intervals to prevent ponding of water. Move the windrows when necessary to allow the subgrade to dry.

4 Scarify the subgrade to be lime treated to the specified depth and width and partially pulverize it. Control the depth of scarification to ensure that the surface of the roadbed below the scarified material remains undisturbed and matches the required cross section. Before the stabilization work, remove unsuitable material including stones retained on a 3 in [75 mm] sieve.

214.4.3 Application of Lime

214.4.3.1 General

1 Apply the lime dry or as a slurry at the specified rate. Base the volume of lime on air-dry weight [mass], and calculate the spread as the quantity of lime required for each square yard [square meter] of treated surface for each compacted layer.

2 Allow only the equipment needed for the lime treatment operations on the applied lime before mixing is completed.

3 Immediately discontinue procedures that result in displacement of the lime.

214.4.3.2 Dry Application

1 If the dry process is used, take necessary precautions to minimize the amount of air-borne hydrated lime.

214.4.3.3 Lime Slurry Application

1 Adjust lime slurry proportions and application rates so that the specified application rate of lime is maintained while meeting moisture content requirements. When necessary, process materials to be treated so that the existing moisture content is adjusted sufficiently to allow the addition of moisture from the lime slurry.

2 When approved by the engineer, lime slurry may be applied directly to the subgrade materials to be treated. Before approval, submit a detailed plan for lime slurry application in writing. Include equipment to be used in spreading the lime slurry, anticipated lime slurry proportions, and mixing and delivery methods in the plan.

214.4.4 Mixing

1 Immediately after the lime has been spread, mix it thoroughly into the soil with water added as necessary for the full depth of treatment. Incorporate the lime thoroughly and uniformly into the soil layer to the full depth of treatment so that the result is a homogenous, friable mixture of soil and lime. Mix the lime by a traveling mixing plant with a single pass to the depth specified.

2 Place and compact the lime treated material within 48 hours after mixing. When it is not practical to place the mixed material within 48 hours, place it in a windrow, or spread it over the road and seal the surface with a steel-wheel or pneumatic-tired roller to prevent the loss of moisture.

214.4.5 Placing, Compacting, and Finishing

1 After mixing each layer of material, place them in the approximate section and compact to a density of at least 95.0 percent of the maximum density at a moisture content of plus or minus 2 percent of optimum. A light sprinkling with water may be required during placement operations to maintain the specified moisture content.

2 Accompany compaction by finish grading work to eliminate irregularities and maintain the staked lines, grades, and cross section.

3 When, after treatment, additional subgrade materials need to be added to the grade to reach the staked lines and grades, use lime treated materials. Lightly scarify the surface of the treated subgrade before placing additional material required for finish grading. Process and compact the subgrade materials in accordance with the requirements described in this section, Section 214.4.5, Placing, Compacting, and Finishing.

4 Lightly scarify and grade the surface of the final layer during finishing operations to eliminate imprints left by the equipment. Use a roller with pneumatic tires to make the final roll on the completed surface.

214.4.6 Protection and Curing

1 When compaction and finish grading are completed, cure the treated subgrade for a minimum of 24 hours before allowing highway traffic and construction equipment on the lime treated subgrade. Repair damage to the treated subgrade due to traffic and construction equipment.

214.5 MEASUREMENT and PAYMENT

214.5.1 General

1 The engineer will measure:

1. Hydrated Lime (Subgrade) by the short ton [metric ton].
2. Processing (Lime Treated Subgrade) by the station, foot [meter], or square yard [square meter]. Each roadway of a divided highway will be measured separately for payment. When treatment by the square yard [square meter] is specified, the measurement will be made on the top surface area of each layer treated, excluding shoulder slopes.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Hydrated Lime (Subgrade)	TON [t]	0.05 ton [0.05 t]	TON [t]
Processing (Lime Treated Subgrade)	STA, FT, SY [0.005 Sta, m, m^2]	0.05 STA, ft, 0.1 ft [0.001 Sta, 0.5 m, 0.05 m]	0.05 STA, FT, SY [0.5 Sta, m, m^2]

214.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Water in accordance with Section 209, Watering.
2. Unclassified Excavation in accordance with Section 203, Excavation and Embankment, for materials that have proven to be untreatable and are removed upon approval of the engineer.

SECTION 215
Storm Water Pollution Prevention

215.1 DESCRIPTION

1 This section describes the requirements for control of pollutants and discharges of storm water from construction and industrial activities, including temporary and permanent measures to control erosion.

215.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	**Subsection**
Burlap Bag Curbs	806.8
Cover Crop Seed	806.1
Erosion Control Agent	806.5
Mulch, Straw, or Hay	806.2
Silt Fence	805
Wire Staples	806.4
Woven Wire Backing	812.3

2 Provide silt fence posts with a nominal wood size of 2 in × 2 in [50 mm × 50 mm] or steel T-post weighing at least 1.25 lb/ft [2 kg/m]. Tie the silt fence to the post with wire, cord, staples, pockets, or other approved means.

3 Provide erosion bales with approximate external dimensions of 18 in × 18 in × 36 in [450 mm × 450 mm × 900 mm], weighing from 40 lb to 70 lb [20 kg to 35 kg] and tightly bound with wire ties or nylon twine. To secure, use 3-foot [0.9 m] wooden stakes with a nominal dimension of 2 in × 2 in [50 mm × 50 mm].

4 Provide excelsior sediment logs made of excelsior that is encased in a tube of polypropylene netting, having a minimum diameter of 12 in [300 mm], a standard length of 10 ft [3.0 m], and a weight of approximately 4.0 lb/ft [5.95 kg/m]. To secure, use 3-foot [0.9 m] wooden stakes with a nominal dimension of 2 in × 2 in [50 mm × 50 mm].

5 Synthetic triangular silt dikes consist of geotextile-wrapped foam or heavy plastic mesh. Provide foam dikes with a minimum height of 10 in [250 mm], sides of equal length, base of 20 in [500 mm], standard length of 7 ft [2.1 m], and with an outer cover of woven geotextile fabric with flaps extending 24 in [600 mm].

Provide heavy plastic mesh dikes with height of 9 in [230 mm], sides of equal length, base of 11 in [280 mm] base, and standard length of 3.6 ft [1.1 m]. To secure, use U-pin wire staples.

6 Provide plastic liner, wooden flumes, metal pipe, plastic pipe, half-round pipe, or erosion control blanket for slope drains.

7 Use non-toxic chemical settling agents for water treatment as necessary.

215.3 EQUIPMENT

1 Where practical, use a spreader truck with a pressurized spray bar to apply the erosion control agent and ensure a continuous, uniform application. Use other equipment in areas not accessible to the pressurized spray bar.

2 Set seed drills to produce uniform rows no more than 8 in [200 mm] apart, and equip them with a positive means for calibration to ensure seed distribution at the specified rate.

215.4 CONSTRUCTION

215.4.1 General

1 Coordinate temporary and permanent soil erosion work. Stage permanent erosion control work to minimize the need for temporary work—the purpose of which is to supplement the permanent work and provide effective control throughout the construction period. Protect locations of exposed, erodible earth with functional erosion control measures installed correctly. Maintain measures to ensure maximum sediment reduction.

2 Complete erosion control work, temporary and permanent, as soon as practical and in conjunction with other construction work and subject to seeding date restrictions. Restore and seed haul roads, material sources, staging areas, and other disturbed areas as work is completed and subject to seeding date restrictions.

3 When permanent soil erosion control is established, remove the temporary measures, spread the accumulated sediment, and seed the disturbed area caused by the removal of the temporary measure as specified for the project reclamation.

215.4.2 Storm Water Control

215.4.2.1 Contractor Storm Water Control

1 Apply and secure approval for an EPA or WDEQ General Permit for Storm Water Discharges Associated With Construction Activities and, where necessary, Industrial Activities, for work within the construction limits. Develop, implement, and monitor a Storm Water Pollution Control Plan for the project, including temporary erosion control measures necessary, in addition to those specified, and associated labor, materials, equipment, and incidentals needed to fully implement the plan and comply with all rules, regulations, and restrictions imposed by EPA or WDEQ as a part of the General Permit Program.

2 Authority to issue permits for lands on the Wind River Indian Reservation resides with the EPA; the Water Quality Division of WDEQ maintains authority elsewhere.

3 Give a copy of the approved General Permit and Storm Water Pollution Control Plan to the engineer before starting work on the project. During work, give the engineer copies of required monitoring reports and necessary Storm Water Pollution Control Plan revisions. This information is not for approval but will be used to document the Contractor Storm Water Control pay item.

4 Throughout the work, implement the Storm Water Pollution Control Plan, modifying as necessary.

5 Temporary soil erosion control details and specified information in Subsection 215.4.3, Temporary Soil Erosion Measures, may be used in developing and implementing a Storm Water Pollution Control Plan. Other methods are available that may be more appropriate depending on the circumstances.

6 Upon project completion, remove and dispose of temporary soil erosion control measures not specified or designated by the engineer to remain as permanent erosion control measures.

7 Upon final acceptance of the project in accordance with Subsection 113.4, Final Acceptance, submit to the WDEQ or EPA a Notice of Termination or request a permit transfer to the department or other specified entity. After approval of the termination or transfer, the department or other entity will accept responsibility for storm water control on the project.

215.4.2.2 Department Storm Water Control

1 When specified, the department will secure, modify, and terminate the NPDES Permit and Storm Water Pollution Control Plan for the project, material sources, or both. The engineer will perform monitoring and reporting requirements.

2 Implement, modify, and remove storm water control measures for the Storm Water Pollution Control Plan, as specified or directed by the engineer.

215.4.3 Temporary Soil Erosion Measures

215.4.3.1 Burlap Bag Curbs

1 Install burlap bag curbs at specified locations and elsewhere as needed to control slope erosion.

2 Use burlap tubes 25 ft [7.5 m] long and filled with sand or suitable excavation material from the project. After filling, sew or tie the tube ends to form a closed unit. Abut the tubes tightly to form a watertight curb. Direct drainage from the curb into embankment protectors or drainage structures.

3 Inspect the burlap bag curbs frequently to ensure that there are no breaks or underwashing.

215.4.3.2 Silt Fence

1 Install silt fences at specified locations and elsewhere as needed to prevent erosion of ditch channels and sheet flows.

2 Use a wire-reinforced silt fence (woven wire) above WDEQ class I waters and in severe snowfall or high wind areas.

3 Build fences and grade fence locations so that water is spread uniformly along the fence. Taper the ends of the fence uphill. Drive posts to a minimum depth of 18 in [450 mm] at a maximum spacing of 8 ft [2.4 m]. Where it is impossible to drive the posts to a depth of 18 in [450 mm], adequately secure the fence to prevent overturning. Attach fabric to each post using at least two ties through the top 8 in [200 mm] of fabric. Embed a minimum of 6 in [150 mm] of the geotextile fabric at the bottom of the fence in a trench. Backfill the trench with soil and compact. Construct the fence to handle the stress of the sediment loading.

4 Maintain the silt fence until the fence is removed or until the final acceptance of the project in accordance with Subsection 113.4, Final Acceptance. Check

the fabric after each rainfall event to ensure it is free of rips, tears, and other types of deterioration, and replace as needed. Remove sediment deposits when the deposit depth reaches one half of the height of the silt fence.

215.4.3.3 Ditch Checks

1 Install ditch checks to control ditch, channel, and inlet erosion. Install ditch checks to ensure that water does not flow around, between, or under the devices.

2 Construct ditch checks of either of the following devices:

1. **Erosion Bales.** Straw or hay bales placed to reduce ditch and channel erosion. Bury bales at least 6 in [150 mm] deep.

2. **Excelsior Sediment Logs.** Stake with wooden stakes placed at intervals of 24 in [600 mm]. Bury logs at least 3 in [75 mm] deep.

3 Tightly butt the devices together. Stake and backfill devices, driving stakes into the ground at least 6 in [150 mm].

4 Inspect ditch checks frequently, and replace deteriorated or damaged devices that are not functioning properly.

5 Use removed devices to mulch areas of sediment disposal in accordance with Subsection 215.4.1, Storm Water Pollution Prevention, Construction, General.

215.4.3.4 Triangular Silt Dike

1 Place synthetic triangular silt dikes to reduce ditch and channel erosion.

2 Attach foam dikes to the ground with wire staples.

3 Prior to installation of the mesh dikes, place erosion blankets or ditch liner as specified. Place plastic panels next, with the upstream panel folded into and pinned to the underlying blanket (liner). Attach to the ground with wire staples spaced at 6 in [150 mm] intervals along the panel lips.

215.4.3.5 Rock Check Dikes

1 Install rock check dikes to control ditch and channel erosion, as specified. Use rock with diameters from 3 in to 6 in [75 mm to 150 mm] intermixed with gravel. To maintain filtering capability, do not use larger rock. Establish the flow line from 6 in to12 in [150 mm to 300 mm] below the side elevations.

2 Do not install rock check dikes within the specified clear zone.

215.4.3.6 Sediment Traps

1 Construct sediment traps to reduce sediment in runoff. Construct sediment traps as close to the source of the sediment as possible. Construct the sediment trap by excavation of a basin, by using a natural terrain depression, or by building a low dam. Determine the size of the sediment trap based on the inflow and as specified.

2 Remove accumulated sediment as necessary to maintain proper sediment trap operation.

215.4.3.7 Contour Diversion Ditches

1 To prevent erosion of construction areas, surface runoff may be diverted to permanent or temporary cross ditches.

2 Use triangular contour diversion ditches as specified for low volume runoff. Use parabolic or trapezoidal contour diversion ditches as specified and when necessitated by higher volume runoff. If high velocities are expected or if runoff is causing erosion to the ditch, line the ditch with erosion control blankets.

3 When using ditches, divert water from a slope by one of the described ditches and then water may be redistributed with a level spreader as specified. Cover the level spreader with geotextile fabric, erosion control blanket, or rock.

4 Inspect ditches frequently for breaks. Remove accumulated sediment as necessary.

215.4.3.8 Slope Drains

1 Use slope drains to convey runoff down unprotected fill slopes. Use slope drains in conjunction with temporary diversion features at the edges of newly constructed slopes.

2 Construct slope drains so that the water funnels into it and does not wash around the drain. Stake or weigh down drains. Compact the soil around the inlet.

3 As the construction progresses, modify slope drains as necessary. Inspect slope drains after each storm for structural integrity, blockage, and stability at the inlet.

215.4.3.9 Erosion Control Agent

1 Apply erosion control agent to specified non-traffic areas of exposed, erodible soils.

2 Before applying, give two copies of the manufacturer's published material specifications and recommended application procedures to the engineer. Before proceeding with the full application, verify agent's performance characteristics at the recommended application rate by testing on a small area designated by the engineer. Unless approved by the engineer, only one product will be used on the project.

3 Before applying the agent, and to ensure penetration, prepare treatment areas by loosening hard-packed soil to a depth of from ½ in to 1 in [13 to 25 mm]. Smooth areas to prevent runoff and puddling.

4 Mix, store, and apply the agent in accordance with the manufacturer's recommendations.

5 Protect slopes left unfinished and without vegetation before suspension of work by one of the two following methods:

1. Applying an erosion control agent.
2. Planting a temporary cover crop, in accordance with Subsection 215.4.3.10, Temporary Cover Crop.

6 If the slopes are not vegetated because of contractor delays, furnish and apply the slope protection at no additional cost to the department.

7 Reclaim by May 31 areas of erodible earth that were not revegetated but could have been before winter suspension. If not reclaimed by this date, apply an additional application of the erosion control agent, at no additional cost to the department.

215.4.3.10 Temporary Cover Crop

1 Plant a temporary cover crop to minimize soil erosion in the following situations:

1. **Topsoil Stockpiles**, if stockpiled before June 15 or to be in place through the winter work suspension.

2. **Open Slopes Steeper than 1V:3H** not permanently seeded prior to work suspension.

3. **Long Term Disturbed Areas** within borrow areas.

2 An erosion control agent in accordance with Subsection 215.4.3.9, Erosion Control Agent, may be placed instead of a temporary cover crop.

3 When soil is free of frost, plant by drilling seeds to a depth from 1 in to 2 in [25 mm to 50 mm]. Steeper slopes may require broadcast seeding. Prepare and use seeding rates for temporary cover crop areas as specified or as approved by the engineer.

4 Use seeds that will produce sterile plants.

215.4.3.11 Chemical Water Treatment

1 Where turbidity caused by fine silt particles in runoff that has passed through other sediment control devices is in excess of allowable limits, chemical settling agents may be required. Use manufacturer recommendations for the following:

1. Injection methods.

2. Locations within the system for addition of the chemical settling agent.

3. Concentration levels.

4. System maintenance.

2 Ensure even mixing of the chemical settling agent with the storm water runoff.

215.5 MEASUREMENT and PAYMENT

215.5.1 General

1 The engineer will measure:

1. Burlap Bag Curb by the foot [meter].

2. Contractor Storm Water Control by the lump sum. The engineer will pay 25 percent of the lump sum price for Contractor Storm Water

Control on the first monthly progress payment. Additional monthly progress payments will be prorated, based on the total project work actually performed as compared to the total original project cost. The total lump sum payment will not exceed the original lump sum bid except by a “Contract Amendment” (Form E-61). Adjustments will only be made for significant added work. Disturbances less than one acre [1047 m^2] that do not require a permit will not require a SWPPP and Contractor Storm Water Control will be eliminated in accordance with Subsection 109.3.2, Eliminated or Unused Pay Items.

3. Department Storm Water Control in accordance with Subsection 109.4, Extra and Force Account Work, for work without individual pay items in the contract.

4. Erosion Bales by the each.

5. Erosion Control Agent by the acre [hectare] or short ton [metric ton].

6. Excelsior Sediment Logs by the foot [meter].

7. Rock Check Dikes by foot [meter].

8. Silt Fence by the foot [meter].

9. Triangular Silt Dike by the foot [meter].

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Burlap Bag Curb	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Contractor Storm Water Control	LS	LS	LS
Department Storm Water Control	$$	$$	$$
Erosion Bales	EA [Ea]	EA [Ea]	EA [Ea]
Erosion Control Agent	ACRE, TON [ha, t]	ft, 0.01 ton [0.5 m, 0.01 t]	0.1 ACRE, 0.01 TON [0.1 ha, 0.01 t]
Excelsior Sediment Log	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Rock Check Dikes	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Silt Fence	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Triangular Silt Dike	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

215.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Contour diversion ditches and sediment traps in accordance with Section 210, Equipment, or in accordance with Subsection 109.4, Extra and Force Account Work.

2. Chemical water treatment in accordance with Subsection 109.4, Extra and Force Account Work.

3. Seeding for temporary cover crop in accordance with Section 216, Seeding, Fertilizer, and Sodding.

4. Slope drains utilizing contract pay items representative of the work and in accordance with the associated technical section in these *Standard Specifications*.

SECTION 216
Seeding, Fertilizer, and Sodding

216.1 DESCRIPTION

1 This section describes the requirements for soil preparation, furnishing and spreading fertilizers, furnishing and drilling or broadcasting seed, mulching, and furnishing and placing sod.

216.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	**Subsection**
Coconut Fiber Ditch Lining	806.4
Erosion Control Blanket	806.4
Erosion Control Netting	806.6
Grass Seed and Fertilizer	806.1
Mulch, Straw, or Hay	806.2
Mulch Tack	806.7
Sod	806.3
U-pin staples	806.4

216.3 EQUIPMENT

216.3.1 Hydraulic

1 For mixing and slurry application, use hydraulic equipment with built-in agitators to keep the various combinations of seed, fertilizer, mulch, mulch tack (when specified), and water mixed homogeneously until pumped. For pumping, ensure a pressure adequate to maintain a continuous, nonfluctuating slurry stream. Provide sprayers equipped with nozzles and hose extensions adequate to obtain a uniform slurry application.

2 Apply mulch tack type AR with a hydraulic seeder capable of producing a coarse spray and calibrated to the specified application rate.

3 Mix mulch tack types MC and GU in a hydraulic seeder equipped with a mechanical agitation system. Use the smallest nozzle available for the equipment in use to ensure accurate distribution.

216.3.2 Dry Mulch

1 Use equipment that does not pulverize or excessively shorten the individual stems of the mulch. After spreading, anchor the mulch in the soil with blunt-notched disks or scalloped rollers manufactured specifically for crimping mulch. Do not use sharpened, smooth disk harrows.

216.3.3 Seed Drills

1 Set drills to produce uniform rows no more than 8 in [200 mm] apart. Equip with a positive means for calibration to ensure seed distribution at the specified rate.

216.4 CONSTRUCTION

216.4.1 General

1 Perform and complete seeding between the time frost leaves the ground in the spring and June 15, or between September 1 and before frost enters the ground in the fall. Complete seeding in stages as the grading and topsoil work are completed. If the weather conditions are favorable, the engineer can extend the spring seeding date to June 30 and start the fall window on August 15. If at least half the project is above 7000 feet in elevation, there will be no restrictions on seeding in the summer.

2 Do not begin or continue reclamation when the wind speed exceeds 20 mph [32 km/h] or there is frost in the ground.

3 Before seeding, complete slopes to the specified line and grade. Spread topsoil uniformly on prepared slopes in accordance with Section 207, Topsoil. Scarify or disc-harrow horizontally the entire seed bed to a depth of approximately 6 in [150 mm], leaving definite furrows and the topsoil in an uncompacted, workable condition for seeding. Leave steep slopes that cannot be scarified in a rough condition similar to scarification.

4 Repair damage to prepared slopes or replace lost material resulting from delays in the work activities, at no additional cost to the department.

5 Coordinate other work, such as fencing, with seeding operations.

6 Spread fertilizer uniformly before seeding, except in locations where hydraulic seeding or hydraulic mulching is specified. Use a method that will not contaminate adjacent surface waters. Apply seed by drilling or broadcasting, followed by mulching.

7 When specified, spread type V fertilizer uniformly and mix into the upper 4 in [100 mm] of topsoil using a disc or other suitable equipment.

8 Within the specified clear zone, remove newly exposed rocks that have diameters greater than 3 in [75 mm].

9 Protect reclaimed areas from damage by construction equipment. Repair areas damaged by traffic or construction equipment, at no additional cost to the department.

216.4.2 Seeding

216.4.2.1 General

1 If requested by the engineer, have seed on the project and available for testing 15 working days before seeding operations begin.

216.4.2.2 Drilling

1 Maintain specified drilling depths for the seeds planted. When the depth is not specified, follow the seed supplier's recommendation.

216.4.2.3 Broadcasting

1 Broadcast seed only where drilling will not be safe or effective. Scarify areas for seed broadcasting in accordance with Subsection 216.4.1, Seeding, Fertilizer, and Sodding, Construction, General. Apply seed at 1½ times the rate specified for areas seeded by drilling. Distribute seed uniformly using mechanical or hydraulic broadcasting devices, then cover by raking or chain-dragging the ground; wherever practical, drag on the contour.

216.4.2.4 Hydraulic Seeding

1 Perform hydraulic seeding as follows:

1. **Slurry Preparation.** Combine seed, mulch, mulch tack (when specified), and water. When the tank is at least one-third full of water, add the mulch and remaining water while agitating continuously to maintain homogeneity. When the tank is full of water, add seed. Continue mixing at least five minutes before applying the slurry. Do not add seed before mulch.

2. **Slurry Proportions.** Mix the materials in the proportions specified.

3. **Area Preparation.** Scarify or rough grade the seeding areas in accordance with Subsection 216.4.1, Seeding, Fertilizer, and Sodding, Construction, General.

4. **Application.** Use the following method:

   4.1. Mix seed, water, and approximately 100 lb/acre [100 kg/ha] of hydraulic mulch, and apply the mixture uniformly.

   4.2. Before the final mulch application, cover seed with approximately ¼ in to ½ in [6 mm to 12 mm] of soil on slopes 1V:2H or flatter. The seed may be covered by dragging with a log chain, chain harrow, or other appropriate mechanical means.

   4.3. Within 48 hours of the completion of seeding, mix the remaining hydraulic mulch (specified amount less the 100 lb/acre [100 kg/ha] used in Step 4.1. above), fertilizer, and mulch tack with water, and apply the mixture uniformly.

216.4.3 Hydraulic Mulching

1 Perform hydraulic mulching within 48 hours after the completion of seeding. Mix the hydraulic mulch, fertilizer, and mulch tack with water, and apply the mixture uniformly.

216.4.4 Sodding

1 Provide machine-cut sod strips with an adhering soil layer from ⅜ in to 1 in [10 mm to 25 mm] thick. Do not install sod that has dried, has a soil layer that breaks, tears or crumbles, or was cut more than 36 hours previously. Keep sod rolls moist and protected from the sun and wind by tarpaulins or shade cloth.

2 Before sodding, ensure the presence of uniformly graded topsoil layer at least 4 in [100 mm] thick; apply fertilizer at the specified rate. Till topsoil and fertilizer to a depth of 4 in [100 mm]; roll and smooth so that the topsoil is firm but not compacted. Rake to remove stones and debris with diameters larger than 1 in [25 mm]. Leave finished grade approximately 2½ in [64 mm] below the top of adjacent curbs and sidewalks. Prior to placing the sod, apply water to the topsoil and fertilizer.

3 Lay sod strips parallel to slope contours and tightly abutted, with the ends staggered to minimize erosion when watering. Water thoroughly. After the water has soaked in, roll the sod to ensure good contact with the topsoil. Regularly water new-lain sod to avoid brown spots and until firmly rooted.

216.4.5 Dry Mulching

1 Spread dry mulch uniformly at the specified rate. Begin application at the top of the slopes, then proceed down the slope.

2 Where steep slopes or other factors prohibit the use of equipment, mulch may be spread by hand or blower and covered with erosion control netting or lightweight erosion control blankets to hold the mulch in place. Do not place mulch that cannot be covered with netting or blankets the same day.

3 Anchor mulch the day of placement and so that at least 25 percent of the stems are vertical after crimping.

216.4.6 Erosion Control Blankets and Coconut Fiber Ditch Lining

216.4.6.1 General

1 Use erosion control blankets and ditch lining to prevent erosion in borrow ditches, drainages, and roadway slopes.

2 Shape, finish, seed, and fertilize areas as specified before placing erosion control blankets or ditch lining (referred to as “blankets” from here on).

3 Prior to installation, do not expose stored rolls of blanket to moisture.

4 To achieve maximum blanket-to-soil contact, roll out blankets evenly and smoothly without stretching. Unroll blankets with netting on only one side so that the netting is on top.

5 Overlap lengthwise blanket edges at least 2 in [50 mm] and with the direction of prevailing winds to minimize overturning. Embed the non-overlapping ends of the initial blankets in 6 in wide × 6 in deep [150 mm × 150 mm] check slots the full width of the blanket.

6 Staple blankets to the ground using U-shaped, industrial quality, bright, basic wire staples with the following dimensions for the site’s soil conditions, as determined by the engineer:

1. **Soil to Moderately Rocky Conditions.** Use 11 gage [3 mm] or larger and at least 6 in × 1 in × 6 in [150 mm × 25 mm × 150 mm].

2. **Extremely Rocky or Densely Compacted Soil.** Use 8 gage [4 mm] or larger and at least 6 in × 1 in × 6 in [150 mm × 25 mm × 150 mm].

3. **Sandy or Unconsolidated Soils.** Use 11 gage [3 mm] or larger and at least 9 in × 2 in × 9 in [225 mm × 50 mm × 225 mm].

7 Drive U-pin staples vertically through the material. Use a single staple common to both blankets at overlapped ends and edges. Place centerline and quarterline staples to form a diagonal grid pattern with equidistant staple locations. Drive staples in all corners.

8 After erosion control blankets are installed, backfill, seed, and fertilize check slots as specified.

216.4.6.2 Ditches

1 Unroll blankets in the direction of water flow, extending up side slopes at least 8 in [200 mm] above the projected water line with ends overlapped at least 6 in [150 mm] and the downstream end on top, creating a “shingle effect.” Offset overlapped edges at least 12 in [300 mm] from the centerline of flow in ditch bottoms. In ditches with a flow gradient greater than 6 percent, embed the full width of the blankets in check slots placed at intervals from 35 ft to 40 ft [10 m to 12 m].

2 Place staples at intervals of 4 ft [1.2 m] along overlapping lengthwise edges and at intervals of 3 ft [1 m] along overlapping ends and the bottom of check slots. Drive staples along the longitudinal centerline and quarterlines of the blankets at alternating intervals of 4 ft [1.2 m]. Drive additional staples on the side slopes at the projected water line.

216.4.6.3 Slopes

1 Unroll blankets in the direction of water flow with ends overlapped at least 4 in [100 mm] and the uphill blanket on top.

2 On slopes of 1V:2H or steeper, or longer than 300 ft [90 m], staple in accordance with Subsection 216.4.6.2, Ditches. On flatter slopes, drive staples at intervals of 6 ft [1.8 m] along overlapping lengthwise edges and at intervals of 4 ft [1.2

m] along overlapping ends and the bottom of check slots. Drive centerline and quarterline staples at alternating intervals of 6 ft [1.8 m].

216.4.7 Erosion Control Netting

1 Seed, fertilize, and mulch areas before placing erosion control netting. Do not crimp straw mulch.

2 Place erosion control netting immediately after mulch.

3 Unroll erosion control netting over mulch and in the direction of water flow.

4 Replace netting damaged after placement, at no additional cost to the department. Overlap adjoining pieces from 2 in [50 mm] to 4 in [100 mm] with the upstream piece on top. Fasten netting with U-pin staples in accordance with Subsection 216.4.6.1, Erosion Control Blankets and Coconut Fiber Ditch Lining, General.

216.4.8 Mulch Tack Type AR

1 Do not apply when rain or snow is forecast within the next 12 hours or when air temperatures are below 35 °F [2 °C]. Do not allow concentrated emulsion or dilute mix to freeze.

2 Mix mulch tack type AR in the following sequence:

1. Fill application equipment with fresh water and start mechanical agitation. Operate at full agitation rate.
2. Add fiber mulch, then seed and fertilizer as specified. Add remaining water at the same time.
3. Minimize agitation and add concentrated co-polymer emulsion at the specified dilution ratio.

3 Apply the mulch tack to prewetted soil immediately after mixing.

216.4.9 Mulch Tack Type MC

1 Mix mulch tack type MC in the following sequence:

1. Fill application equipment with one-third of the water required and start mechanical agitation.

2. Slowly pour the mucilage-gum powder into the tank agitating source. Add the remaining water.

3. Add wood fiber, seed, and fertilizer as specified. Continue agitation for approximately five minutes before application.

2 Apply immediately after mixing.

216.4.10 Mulch Tack Type GU

1 Mix mulch tack type GU in the following sequence:

1. Fill application equipment with one-third of the water required, and start mechanical agitation.

2. Very slowly pour the guar-gum powder into the tank agitating source. Add the remaining water. Mix until gumballs are dissolved.

3. Add wood fiber, seed, and fertilizer as specified. Continue agitation for at least ten minutes before application.

2 Apply immediately after mixing.

216.5 MEASUREMENT and PAYMENT

216.5.1 General

1 The engineer will measure:

1. Coconut Fiber Ditch Lining, Erosion Control Blanket, and Erosion Control Netting by the square yard [square meter] of completed exposed surface area. Overlaps will not be measured.

2. Dry Mulch by the short ton [metric ton] on the basis of air-dry weight [mass].

3. Fertilizer Type I, II, III, IV, and VI, except those quantities required for hydraulic seeding or hydraulic mulching, by the pound [kilogram] of available nitrogen.

4. Fertilizer Type V by the air-dry short ton [metric ton], determined as the actual weight [mass] of the fertilizer less the percentage weight

[mass] due to water in the delivered composted manure (as indicated by the laboratory certificate) or by the cubic yard [cubic meter] based on volumetric measurements.

5. Fertilizer Type VII, except those quantities required for hydraulic seeding or hydraulic mulching, as pounds [kilograms] of available phosphorous.

6. Hydraulic Seeding by the short ton [metric ton] of hydraulic mulch, based on the air-dry weight [mass] of the mulch before the addition of water, fertilizer, mulch tack, and seed. The measurement will include fertilizer, seed, mulch tack, and, unless otherwise specified, water as one payment.

7. Hydraulic Mulch by the short ton [metric ton] of hydraulic mulch, based on the air-dry weight [mass] of the mulch before the addition of water, fertilizer, and mulch tack. The measurement will include fertilizer, mulch tack, and, unless otherwise specified, water as one payment.

8. Mulch Tack Type AR, Mulch Tack Type MC, and Mulch Tack Type GU by the acres [hectares] treated, except those quantities required for hydraulic seeding or hydraulic mulching. The measurement will include guar-gum powder, wood fiber, fertilizer, and, unless otherwise specified, water as one payment.

9. Seeding by the lump sum or the square yard [square meter], complete in place, which includes seed, fertilizer, and mulch.

10. Seeding (PLS), Seeding Special (PLS) by the pound [kilogram] of pure live seed mixture, based on the actual air-dry weight [mass] of the seed applied. The increased application rate of seed for broadcast-seeding will be measured only on authorized areas. The weight [mass] of seed wasted or used without authorization will be deducted from the measurement.

11. Sodding by the square yard [square meter] in place. Topsoil and fertilizer will be measured under the respective pay items.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Coconut Fiber Ditch Lining	SY [m^2]	0.1 ft [0.1 m^2]	SY [m^2]
Dry Mulch	TON [t]	0.05 ton [0.5 t]	0.05 TON [0.05 t]
Erosion Control Blanket	SY [m^2]	0.1 ft [0.1 m^2]	SY [m^2]
Erosion Control Netting	SY [m^2]	0.1 ft [0.1 m^2]	SY [m^2]
Fertilizer Type _____	LB [kg]	lb [0.5 kg]	LB [0.5 kg]
Fertilizer Type V	TON, CY [t, m^3]	0.05 ton, yd^3 [0.05 t, m^3]	0.05 TON, CY [0.05 t, m^3]
Hydraulic Mulching	TON [t]	0.05 ton [0.5 t]	0.05 TON [0.05 t]
Hydraulic Seeding	TON [t]	0.05 ton [0.5 t]	0.05 TON [0.5 t]
Mulch Tack Type _____	ACRE [ha]	ft [0.5 m]	0.1 ACRE [0.1 ha]
Seeding	LS, SY [LS, m^2]	LS, 0.1 ft [LS, 0.05 m]	LS, SY [LS, m^2]
Seeding (PLS)	LB [kg]	lb [0.5 kg]	LB [0.5 kg]
Seeding Special (PLS)	LB [kg]	lb [0.5 kg]	LB [0.5 kg]
Sodding	SY [m^2]	0.1 ft [0.1 m]	SY [m^2]

216.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Topsoil Placing in accordance with Section 207, Topsoil.

2. Water in accordance with Section 209, Watering.

SECTION 217
Geotextiles

217.1 DESCRIPTION

1 This section describes the requirements for furnishing and placing geotextile.

217.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	Subsection
Geotextile and Impermeable Plastic Membrane	805

217.3 EQUIPMENT

1 Meet the following equipment loads when placing and compacting material above a geotextile:

1. A maximum wheel load of 9945 lb [4500 kg].
2. A maximum contact pressure of 60 psi [400 kPa], as calculated from the applied wheel load in pounds [N] and the resulting contact area in square inches [square meters].
3. Lighten equipment loads if ruts are produced greater than 3 in [75 mm] deep.

217.4 CONSTRUCTION

217.4.1 General

1 Submit test results and certification by the manufacturer showing the geotextile performance relative to contract requirements. Submit a test sample 6 ft [2 m] long by the full width of the roll at least 14 calendar days before the use of any geotextile. Obtain this sample from a roll of fabric that is on the project site. Make sure the sample is labeled with the product name, machine direction, lot and batch number, date of sampling, project number, and certification of

compliance. If sewing is specified, submit a seam sample 6 ft × 3 ft [2 m × 1 m] with the seam in the center and parallel to the 6-foot [2 m] length.

2 During shipment and storage, enclose geotextile in heavy-duty wrapping to provide protection from direct sunlight, ultraviolet rays, moisture, temperatures greater than 140 °F [60 °C], mud, dirt, dust, and debris. When storing outdoors, elevate the rolls, and protect them with a waterproof cover. Remove unprotected geotextile from the project.

217.4.2 Installation

217.4.2.1 General

1 Lap geotextile at least 24 in [600 mm] at ends and sides of adjoining sheets. When sheets are sewn together, ensure seam strength and efficiency properties in accordance with Subsection 805.2, Geotextile and Impermeable Plastic Membrane. Overlap seams 24 in [600 mm]. Leave seams exposed for ease of inspection.

2 Place gravel or other specified material on the geotextile so that it is not torn, punctured, or shifted. Limit pile heights of materials to prevent geotextile distortion. Repair tears or punctures by placing a patch of the same type of geotextile over the ruptured area and overlapping at least 3 ft [1 m] from the edge of any part of the rupture or by patching with sewn seams that meet strength requirements in accordance with Subsection 805.2, Geotextile and Impermeable Plastic Membrane.

3 With approval, pegs or pins may be used to fasten geotextile for embankment erosion control until the specified cover material has been placed. Install pegs or pins only at locations that are not detrimental to the finished product. Do not use pegs or pins for other types of installation.

4 Except when used for erosion control and silt fences, place cover material over the fabric daily.

5 Repair ruts exceeding 3 in [75 mm] by filling with additional cover material.

217.4.2.2 Foundation Stabilization

1 When using geotextile for foundation stabilization:

1. Level and smooth the subgrade to remove ruts, depressions, or humps greater than 4 in [100 mm] before installation. Ensure that the surface is free of objects that might tear or puncture the geotextile.

2. Place the geotextile and cover material in lifts of at least 12 in [300 mm].

3. Do not operate equipment directly on the geotextile.

4. Compact cover material with a roller or other equipment.

217.5 MEASUREMENT and PAYMENT

217.5.1 General

1 The engineer will measure Geotextile _____ by the square yard [square meter] of surface area covered, with no allowance for overlaps.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Geotextile _____	SY [m^2]	0.1 ft [0.5 m]	SY [m^2]

217.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for cover material in accordance with Section 203, Excavation and Embankment.

SECTION 218
Impermeable Plastic Membrane

218.1 DESCRIPTION

1 This section describes the requirements for furnishing and placing impermeable plastic membrane.

218.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Impermeable Plastic Membrane	805

218.3 EQUIPMENT—Vacant

218.4 CONSTRUCTION

218.4.1 General

1 During shipment and storage, protect membrane rolls from direct sunlight, ultraviolet rays, moisture, temperatures greater than 140 °F [60 °C], mud, dirt, dust, and debris. When storing outdoors, elevate the rolls, and protect them with a waterproof cover. Remove unprotected membrane from the project.

2 Submit test results and certification by the manufacturer showing the membrane performance relative to requirements. Submit a test sample 6 ft [2 m] long by the full width of the roll at least 14 calendar days before the use of any membrane. Obtain this sample from a roll of membrane that is on the project site. Make sure the sample is labeled with the product name, machine direction, lot and batch number, date of sampling, project number, and certification of compliance.

3 Do not place membrane during wet weather or when the subgrade is wet.

218.4.2 Installation

218.4.2.1 General

1 Overlap longitudinal and lateral joints at least 6 in [150 mm] and glue using a product type, application rate, and curing procedure recommended by the

membrane manufacturer. If joints are not glued, overlap the membrane at least 24 in [600 mm]. Shingle the overlaps so that the exposed edges face the same direction as the flow of drainage. Reinforce and seal blemishes, holes, or scars with waterproof plastic adhesive tape. Replace damaged portions of membrane and unsealed joints, at no additional cost to the department.

2 Do not use pegs or pins to hold membrane in place. Place cover material over membrane daily. Equipment may run—but not turn—directly on membrane when placing membrane or cover material.

3 Replace membrane damaged after installation because of construction activities, at no additional cost to the department.

218.4.2.2 Crushed Base Cushion

1 When specified, provide a crushed base cushion between the membrane and subgrade. Place the cushion at least 4 in [100 mm] thick and in accordance with Section 301, Aggregate Subbase, Base Courses, and Bed Course Material.

218.4.2.3 Trenches

1 For vertical installation in trenches, use backfill from the trench excavation and place to prevent damage to the membrane. For backfill that will come in direct contact with the membrane, provide material that is approved by the engineer before use and is free of objects that might puncture or tear the membrane. Backfill the trench immediately after placing the membrane. Compact and finish backfill in accordance with Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control.

218.5 MEASUREMENT and PAYMENT

218.5.1 General

1 The engineer will measure Impermeable Plastic Membrane by the square yard [square meter] of surface area, including vertical surfaces in trenches, with no allowance for overlaps.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Impermeable Plastic Membrane	SY [m^2]	0.1 ft [0.5 m]	SY [m^2]

218.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for Crushed Base in accordance with Section 301, Aggregate Subbase, Base Courses, and Bed Course Material.

SECTION 219
Rockfall Mesh

219.1 DESCRIPTION

1 This section describes the requirements for furnishing and installing anchors and rockfall mesh on finished backslopes.

219.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	Subsection
Anchors	822.3
Hardware	822.6
Lacing and Fasteners	822.2
Non-shrink Grout	819.1
Polyester Resin Grout	822.4
Rockfall Mesh	822.1
Wire Rope	822.5

2 Provide mesh in an industry-standard color.

219.3 EQUIPMENT—Vacant

219.4 CONSTRUCTION

219.4.1 General

1 Before installing mesh, prune shrubs and trees so that mesh will lie flat. Scale backslopes in accordance with Section 220, Scaling Rock Cuts.

2 Submit copies of the tensile and punching test results along with a sample, 2 ft × 2 ft [0.6 m × 0.6 m], of all types of rockfall mesh to be used on the project. Obtain these samples from a roll of rockfall mesh that is on the project site.

3 At least 14 calendar days before starting the work, submit a plan for the ground anchors that details the following:

1. The proposed construction sequence and schedule.

2. The proposed drilling methods and equipment.

3. The proposed grout, mix design or specifications, and placement procedures.

4. The proposed anchors, plate, washers and nuts, top support wire rope, wire rope clips, thimbles, and rockfall mesh fasteners, all with specifications, including manufacturers' data sheets.

5. Calibration data for each load cell and calibration data for the test jack and master pressure gauges to be used in the work, obtained from calibration tests performed by an independent testing laboratory within 60 calendar days of the submission.

6. The proposed stressing procedures and stressing equipment setup.

4 Begin installation after the engineer has approved the plan in writing.

5 Polyester resin grout may be used in lieu of non-shrink grout, if test data can substantiate that the polyester resin grout meets or exceeds the desired anchor load. Do not use resin grout that exceeds the manufacturer's expiration date. Store resin grout as recommended by the manufacturer.

6 Give the engineer a copy of the record of each day's work on the following work day. Include in the daily records the location and quantity of anchors, grout, rockfall mesh, top support wire rope, hardware, and accessories installed.

219.4.2 Installation

219.4.2.1 General

1 Install anchors vertically or perpendicular to the slope, embedded at least 5.0 ft [1.5 m] into soil or rock. Do not use steel bolt couplings. Extend anchors above the ground through the bearing plate to ensure a sufficient bar length for installation of the end hardware.

2 Secure mesh together at the seams with a 12 in [300 mm] overlap by lacing or fasteners. Space fasteners a maximum of 6 in [150 mm] apart. Place mesh so that the natural curl from the roll is toward the slope face. Do not anchor the face or bottom of the mesh, and extend it above the ditch as specified.

3 Connect the ½-inch [12 mm] top anchor cable to each anchor by wrapping the cable one full circumference around the anchor; hold in place beneath a bearing plate, washer, and nut. Extend the anchor through the bearing plate to ensure a sufficient bar length for installation of the end hardware. Fold at least 12 in [300 mm] of the mesh over the top anchor cable and onto itself; secure by lacing or fasteners.

219.4.2.2 Grouted Anchors

1 Embed grouted anchors at least 4.0 ft [1.2 m] into competent rock and in holes with a diameter of at least 2 in [50 mm], and blow holes clean after drilling with at least 50 psi [345 kPa] compressed air introduced at the back of the hole. Support anchors in the drilled hole with centralizers spaced no more than 18 in [450 mm] apart.

219.4.3 Acceptance

1 The minimum vertical pullout resistance for grouted anchors is 6 tons [53 kN]. Conduct pullout tests on at least 5 percent of the anchors. Acceptance criteria is zero load loss and zero anchor movement while the anchor is held for a 10-minute period at 6 tons [53 kN]. If any anchors fail, the engineer may perform testing on additional anchors. Replace and retest failed anchors, at no additional cost to the department. Test driven anchors as specified.

219.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Driven Anchors and Grouted Anchors by the each.
2. Rockfall Mesh by the square yard [square meter] complete in place.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Driven Anchors	EA [Ea]	EA [Ea]	EA [Ea]
Grouted Anchors	EA [Ea]	EA [Ea]	EA [Ea]
Rockfall Mesh	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]

SECTION 220
Scaling Rock Cuts

220.1 DESCRIPTION

1 This section describes the requirements for the removal and disposal of unstable rocks from cut slopes.

220.2 MATERIALS—Vacant

220.3 EQUIPMENT

1 Scaling (machine) consists of dragging a scaling apparatus suspended from a crane over a slope to remove loose rock, soil, and debris. Provide a scaling apparatus consisting of a series of cleated dozer tracks, blasting mats, or similar equipment. Provide a crane with sufficient reach and lifting capacity to drag the scaling apparatus up and down the slope. If the equipment and methods do not produce the desired results, propose and test changes until results are satisfactory.

220.4 CONSTRUCTION

1 Before starting, install a temporary rockfall barrier in the portion of the cut to be scaled. Scale within the limits of the rockfall barrier. Do not allow traffic to pass through the work zone while scaling. Protect the pavement with blast mats or other protective systems. Repair damaged pavement at no additional cost to the department. Clear the roadway and ditches of rock, and load, haul, and dispose of rock debris to a specified location.

2 Manually scale unstable rock that cannot be removed by machine.

3 During manual scaling, provide a crew on the slope that consists at all times of a working foreman and two scalers. Immediately replace with a foreman or scaler any crew member who leaves. Light mechanical means, such as hydraulic jacks or splitters, may be used to remove unstable rock that cannot be removed by conventional manual methods.

4 Slopes will be inspected to determine whether scaling is complete. If inspection reveals additional hazardous rocks, continue scaling until the engineer is satisfied.

220.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Scaling (Machine) by the actual hours the equipment is used for scaling.

2. Scaling (Manual) by the crew-hour, with a crew defined as a working foreman and two scalers.

2 Setup or standby time of personnel and equipment for either scaling pay item will not be measured directly for payment.

3 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Scaling (Machine)	HR	0.5 h	0.5 HR
Scaling (Manual)	CRWH	0.5 h	0.5 CRWH

SECTION 221
Dust Control Agent

221.1 DESCRIPTION

1 This section describes the requirements for applying dust control agent.

221.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	Subsection
Dust Control Agent	804.4

2 Dust control agent may be either oil or a magnesium-brine solution.

221.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Distributor Truck	407.3

221.4 CONSTRUCTION

1 Before applying dust control agent, furnish the engineer with a copy of the manufacturer's recommendations for application. Apply dust control agent per manufacturer's recommendations.

2 Before application, scarify, reshape, and compact surfaces with hard, crusty, or tire-polished areas or that are poorly shaped. Apply dust control agent to dry or damp surfaces that have been graded and shaped.

3 Once applied, protect dust control agent from heavy truck traffic until cured. Slow automobile traffic may be allowed on the treated surface after complete penetration.

221.5 MEASUREMENT and PAYMENT

1 The engineer will measure Dust Control Agent by the short ton [metric ton].

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Dust Control Agent	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]

DIVISION 300

Aggregate Materials

SECTION 301
Aggregate Subbase, Base Courses, and Bed Course Material

301.1 DESCRIPTION

1 This section describes the requirements for placing one or more courses of aggregate on a prepared surface.

301.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Aggregate	803

301.3 EQUIPMENT

1 Unless otherwise approved by the engineer, use a pugmill capable of thorough and consistent blending to mix aggregate and water for subbases and bases.

301.4 CONSTRUCTION

301.4.1 Bed Course Material

1 Shape the bed course material to coincide with the bottom surface of the item or appurtenance to be constructed on the bed course material. Tamp or compact the bed course material into place. No density requirements will apply.

301.4.2 Subbases and Bases

301.4.2.1 General

1 At least 14 calendar days before placement, submit aggregate samples for determination of optimum moisture content, maximum density, and R-value. Obtain the samples in the engineer's presence.

301.4.2.2 Lot and Sublot Sizes

301.4.2.2.1 Weight [Mass] Measurement

1 A lot is defined as the quantity of material represented by five tests or a maximum of 5000 ton [5000 t], and a sublot is the quantity of base or subbase represented by one test or a maximum of 1000 ton [1000 t].

301.4.2.2.2 Volume Measurement

1 A lot is defined as the quantity of material represented by five tests or a maximum volume of 2500 yd^3 [2000 m^3], and a sublot is the quantity of base or subbase represented by one test or a maximum of 500 yd^3 [400 m^3].

301.4.2.2.3 Area Measurement

1 A lot is defined as the quantity of material represented by five tests or a maximum area as calculated by the following equation:

1. **Inch-Pound (U.S. Customary)**

   1.1. **Step 1.** Determine the number of lots.

   $$\text{Lots} = \frac{Q}{92{,}000} \times th$$

   Where: Lots = Number of lots required
   Q = Total quantity of base or subbase (yd^2)
   th = Lift thickness (in)

   1.2. **Step 2.** Determine the lot size.

   $$\text{Lot Size (yd}^2\text{)} = \frac{Q}{\text{Lots}}$$

   Where: Lots = Number of lots required
   Q = Total quantity of base or subbase (yd^2)

2. **International System (Metric)**

   $$\text{Lot Size (m}^2\text{)} = \frac{2{,}125{,}000}{th}$$

   Where: th = Lift thickness (mm)

2 A sublot is the quantity of base or subbase represented by one test or a maximum of one-fifth of the lot size.

301.4.2.3 Placing

1 During placement of material, the engineer will determine the Liquid Limit (LL) and Plasticity Index (PI) for all gradation samples. Remove from the roadway material exceeding the specified limits for these values in accordance with Table 803.4.4-2, Aggregate Properties, Subbase, and Base, and replaced with material meeting the requirements.

2 Do not allow the compacted thickness of any one layer to exceed 8 in [200 mm]. If the compacted depth of the base or subbase course exceeds 8 in [200 mm], construct the course in two or more layers of approximately equal thickness.

3 Compact each layer to at least 95.0 percent of AASHTO T180 maximum density.

4 Compact material when moisture content is within plus 2 percent to minus 4 percent of optimum.

5 Add water, if necessary, during mixing and apply water over the materials during compaction as necessary to obtain optimum moisture content and maximum density.

301.4.3 Acceptance

1 Aggregate gradation for subbase and base material will be accepted in accordance with Subsection 113.1, Acceptance of Aggregate.

301.5 MEASUREMENT and PAYMENT

301.5.1 General

1 The engineer will measure Pit Run Subbase, Crusher Run Subbase, Crushed Subbase, Subbase, Crushed Base, and Bed Course Material by the ton [metric ton], cubic yard [cubic meter], or square yard [square meter].

1. **Cubic yards [cubic meters].** Volume of material will be computed by using the neat line for width, including one half the taper width where applicable, multiplied by the neat line for thickness, multiplied by the neat line for length of the completed surface.

2. **Square yards [square meters].** Surface area will be computed as the neat line for width, including one half the taper width where applicable, multiplied by the neat line for length of the completed surface.

3. **Weight [mass].** The weight [mass] of natural moisture and the required water for mixing, added to the material before the material is weighed, will not be deducted from the measurement unless it exceeds the maximum moisture content.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Bed Course Material	ton, CY, SY [t, m^3, m^2]	0.05 ton, ft, ft [0.05 t, 0.5 m, 0.5m]	0.05 ton, CY, SY [0.05 t, m^3, m^2]
Crushed Base	ton, CY, SY [t, m^3, m^2]	0.05 ton, ft, ft [0.05 t, 0.5 m, 0.5m]	0.05 ton, CY, SY [0.05 t, m^3, m^2]
Crushed Subbase	ton, CY, SY [t, m^3, m^2]	0.05 ton, ft, ft [0.05 t, 0.5 m, 0.5m]	0.05 ton, CY, SY [0.05 t, m^3, m^2]
Crusher Run Subbase	ton, CY, SY [t, m^3, m^2]	0.05 ton, ft, ft [0.05 t, 0.5 m, 0.5m]	0.05 ton,CY, SY [0.05 t, m^3, m^2]
Pit Run Subbase	ton, CY, SY [t, m^3, m^2]	0.05 ton, ft, ft [0.05 t, 0.5 m, 0.5m]	0.05 ton, CY, SY [0.05 t, m^3, m^2]
Subbase	ton, CY, SY [t, m^3, m^2]	0.05 ton, ft, ft [0.05 t, 0.5 m, 0.5m]	0.05 ton, CY, SY [0.05 t, m^3, m^2]

301.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Water added to the material before the material is weighed in accordance with Section 209, Watering.

2. Haul in accordance with Section 204, Haul.

301.5.3 Determination of Pay Factor

1 The engineer will evaluate aggregate gradation tests for subbases and bases in accordance with Subsection 113.1, Acceptance of Aggregate, and will apply pay adjustments. The maximum pay factor per lot will be 1.00.

SECTION 302
Blended Base and Blended Subbase

302.1 DESCRIPTION

1 This section describes the requirements for furnishing and placing blended base or blended subbase on a prepared surface.

302.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Aggregate	803

2 Reclaimed Asphalt Pavement (RAP)–Existing asphalt pavement milled from the roadway within the project limits.

3 Reclaimed Portland Cement Concrete Pavement (RPCCP)–Existing concrete pavement removed from the roadway within the project limits.

302.3 EQUIPMENT

1 Unless otherwise approved by the engineer, use a pugmill capable of thorough and consistent blending to mix aggregate, RAP, RPCCP, and water for blended bases and subbases.

302.4 CONSTRUCTION

302.4.1 General

1 Remove the existing plant mix pavement, concrete pavement, or both from the roadway; haul it to the plant site; and stockpile it in accordance with Subsection 202.4.5, Removal of Surfacing, Concrete, Sidewalks, Curbs, Gutters, Median, Double Gutter, Etc. Minimize contamination of the milled asphalt pavement or removed concrete pavement. If required, crush the RAP/RPCCP to the maximum size specified, and stockpile it separately.

2 Before blending the virgin crushed base aggregate with RAP/RPCCP, obtain virgin crushed base aggregate samples at the direction of the engineer in accordance with the *Materials Testing Manual*. Sample the virgin crushed base aggregate from the belt immediately before blending it with RAP/RPCCP.

3 Mix the RAP/RPCCP, virgin crushed base aggregate, and water.

4 Haul, place, and compact the blended base or blended subbase in accordance with Subsection 301.4.1.3, Placing.

302.4.1.2 Lot and Sublot Sizes

1 A lot for gradation is defined as the quantity represented by five tests or a maximum of 5000 ton [5000 t] of virgin crushed base, and a sublot is the quantity represented by one test or a maximum of 1000 ton [1000 t] of virgin crushed base aggregate. The sublot size will be dependent on the rate of virgin crushed base aggregate to be incorporated into the blended base or blended subbase using the equation below.

$$LS = \frac{5000}{(V_U / 100)}$$

$$SS = \frac{LS_{BB}}{5}$$

where:

LS	=	Lot Size for Blended Base or Blended Subbase (ton) [t]
SS	=	Sublot Size for Blended Base or Blended Subbase Evaluated (ton) [t]
V_U	=	Percent Virgin Crushed Base (%)

302.5 MEASUREMENT and PAYMENT

302.5.1 General

1 The engineer will measure Blended Base and Blended Subbase by the ton [metric ton], cubic yard [cubic meter], or square yard [square meter].

1. **Cubic yards [cubic meters].** Volume of material will be computed by using the neat line for width, including one half the taper width where applicable, multiplied by the neat line for thickness, multiplied by the neat line for length of the completed surface.

2. **Square yards [square meters].** Surface area will be computed as the neat line for width, including one half the taper width where applicable, multiplied by the neat line for length of the completed surface.

3. **Weight [mass].** The weight [mass] of natural moisture and the required water for mixing, added to the material before the material is weighed, will not be deducted from the measurement unless it exceeds the maximum moisture content.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Blended Base	SY, CY, TON [m^2, m^3, t]	0.1 ft, 0.1 ft, 0.05 t [0.5 m, 0.5 m, 0.05 t]	SY, CY, 0.05 ton [t, m^3, m^2]
Blended Subbase	SY, CY, TON [m^2, m^3, t]	0.1 ft, 0.1 ft, 0.05 t [0.5 m, 0.5 m, 0.05 t]	SY, CY, 0.05 ton [t, m^3,m^2]

302.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Milling Plant Mix in accordance with Section 202, Removal.
2. Removal of Concrete Pavement in accordance with Section 202, Removal.
3. Water in accordance with Section 209, Watering.
4. Haul in accordance with Section 204, Haul.

302.5.3 Determination of Pay Factor

1 The engineer will evaluate aggregate gradation tests for virgin crushed base in accordance with Subsection 113.1, Acceptance of Aggregate, and will apply pay adjustments. The maximum pay factor per lot will be 1.00.

302.5.4 Pay Adjustments

1 The engineer will calculate pay adjustments for blended base and blended subbase as follows:

$$BBPA = BB \times (CBPF - 1) \times LS \times (V_U / 100)$$

where:

BBPA	=	Pay Adjustment for Blended Base or Blended Subbase for evaluated lot ($$)
BB	=	Contract Price per ton for the Blended Base or Blended Subbase pay item ($$)
CBPF	=	Crushed Base pay factor
LS	=	Lot size for Blended Base or Blended Subbase pay item (ton)
V_U	=	Percent virgin crushed base

SECTION 303
Vacant

SECTION 304
Vacant

SECTION 305
Cement Treated Base

SECTION 306
Vacant

SECTION 307
Vacant

SECTION 308
Vacant

SECTION 309
Emulsion Stabilized Base

SECTION 310
Stockpiled Aggregate

310.1 DESCRIPTION

1 This section describes the requirements for furnishing and placing aggregate in stockpiles.

310.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Aggregates	803
Sodium Chloride	803.13.4

310.3 EQUIPMENT

1 Unless otherwise approved by the engineer, use a pugmill capable of thorough and consistent blending to mix water and aggregate or sodium chloride and aggregate.

310.4 CONSTRUCTION

310.4.1 General

1 Furnish, deliver, and place aggregate in stockpiles at designated sites. Ensure that the sites are firm, smooth, and well-drained. When required, clear and grub sites in accordance with Section 201, Clearing and Grubbing. Remove and stockpile topsoil in accordance with Section 207, Topsoil.

2 To prevent the intrusion of soil or foreign material, place a bed of the same aggregate being stockpiled under the stockpile. Make the bed at least 6 in [150 mm] deep, and extend it at least 10 ft [3 m] beyond the edge of the stockpile.

3 To prevent mixing, separate stockpiles of different types or sizes of aggregates by spacing them at least 30 ft [10 m] apart or by using suitable walls or partitions.

4 Do not use stockpiling methods that allow contamination or excessive degradation of the aggregate. The engineer will use gradation tests to evaluate degradation. If

samples fail to meet gradation requirements, the engineer will reject stockpiled aggregates. Change stockpiling procedures to provide the specified gradation.

5 When specified, blend sodium chloride uniformly with the aggregate. Furnish weigh [mass] tickets with each load of sodium chloride.

6 Do not allow sodium chloride to leach into surrounding surface or ground water.

310.4.2 Lot and Sublot Sizes

310.4.2.1 Weight [Mass] Measurement

1 A lot is defined as the quantity of material represented by five tests or a maximum of 5000 ton [5000 t], and a sublot is the quantity of base or subbase represented by one test or a maximum of 1000 ton [1000 t].

310.4.2.2 Volume Measurement

1 A lot is defined as the quantity of material represented by five tests or a maximum volume 2500 yd^3 [2000 m^3], and a sublot is the quantity of base or subbase represented by one test or a maximum of 500 yd^3 [400 m^3].

310.4.3 Acceptance

1 Aggregate gradation will be accepted with Subsection 113.1, Acceptance of Aggregate.

310.5 MEASUREMENT and PAYMENT

310.5.1 General

1 The engineer will measure:

1. Stockpiled _________ and Maint Stockpile Type _________ by the ton [metric ton] or cubic yard [cubic meter]. Natural moisture in the material will not be deducted before measurement and payment. No deduction will be made for the weight [mass] of salt in the mixture. Stockpiles volumes will be measured using volumetric measurements in accordance with Subsection 101.5, Definitions. Aggregate beds will not be measured separately and will be considered incidental to Stockpiled _________ and Maint Stockpile Type _________.

2. Sodium Chloride by the ton [metric ton].

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Maint Stockpile Type ______	ton, CY [t, m^3]	0.05 ton, ft [0.05 t, 0.5 m]	0.05 ton, CY [0.05 t, m^3]
Sodium Chloride	ton [t]	0.05 ton [0.05 t]	0.05 ton [0.05 t]
Stockpiled ______	ton, CY [t, m^3]	0.05 ton, ft [0.05 t, 0.5 m]	0.05 ton, CY [0.05 t, m^3]

310.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Haul in accordance with Section 204, Haul.
2. Clearing and Grubbing in accordance with Section 201, Clearing and Grubbing.
3. Topsoil Storing in accordance with Section 207, Topsoil.

310.5.3 Determination of Pay Factor

1 The engineer will evaluate aggregate gradation tests for stockpiled material in accordance with Subsection 113.1, Acceptance of Aggregate, and will apply pay adjustments. The maximum pay factor per lot will be 1.00.

DIVISION 400

Pavements

SECTION 401
Plant Mix Pavements and Recycled Plant Mix Pavements

401.1 DESCRIPTION

1 This section describes the requirements for construction of one or more courses of plant mix pavement or recycled plant mix pavement placed on a prepared foundation.

401.2 MATERIALS

401.2.1 Performance Graded Asphalt Binder

1 Provide performance graded asphalt binder (PGAB) of the specified grade and meeting the requirements of Subsection 804.1, Performance Graded Asphalt Binder. Use a qualified source of PGAB, in accordance with Subsection 804.1, Performance Graded Asphalt Binder, except as modified in paragraph 7 of this subsection.The department maintains a current list of qualified suppliers, which is available on the WYDOT website.

2 The contractor may use a different grade of binder if:

1. The upper specification temperature is increased or the lower specification temperature is decreased;

2. The engineer receives written notice of the proposed grade change before mix production begins; and

3. Grades are not changed repeatedly.

3 The engineer will test PGAB at the temperatures for the grade specified. The department will not pay extra for grade changes proposed by the contractor.

4 Ensure that asphalt binder and required modifier(s) are blended prior to delivery to the project.

5 The department requires the supplier to perform material testing and provide the Materials Program with test reports for applicable properties in accordance with Subsection 804.1, Performance Graded Asphalt Binder, weekly by e-mail. In the reports, provide all test data for the preceding week, including daily

quality control testing and all specification compliance testing. Present the data in a clear and concise spreadsheet format using computer software that is compatible with Microsoft Excel version 97 and recorded in the units specified in Subsection 804.1, Performance Graded Asphalt Binder.

6 Ensure that each load of PGAB is delivered to the project site, accompanied by a supplier-furnished shipping document that clearly indicates the specification grade of the PGAB, as well as the daily dynamic shear and rotational viscosity test results.

7 If the project estimated quantity shown on the "Proposal," (Form E-91) is less than 100 tons [100 t], the source of the PGAB does not have to be qualified. Submit to the Materials Program a written certification for the project, that lists the grade(s) of PGAB and verifying that the PGAB meets all applicable requirements of AASHTO M320. Accompany the certification with representative test report(s) for the applicable properties in accordance with Subsection 804.1.1, Binder Properties.

401.2.2 Aggregates

1 Provide aggregates in accordance with Section 803, Aggregate.

401.2.2.1 Recycled Plant Mix Pavement

1 Provide aggregates for recycled plant mix pavement in accordance with Section 803, Aggregate, with the gradation bands modified as specified. Use reclaimed asphalt pavement (RAP) from specified sources.

Excess RAP remains the property of the department.

401.2.3 Hydrated Lime

1 Provide hydrated lime in accordance with Section 820, Hydrated Lime.

401.2.4 Burner Fuel

1 Fuel mixing plants with natural gas, Nos. 1 or 2 fuel oil, butane, propane, or used oil. In the case of used oil, comply with 40 CFR 279, "Standards for the Management of Used Oil"; give the engineer copies of tests certified by the supplier showing that applicable requirements have been met.

401.2.5 Truck Bed Release Agent

1 Do not use a solvent or petroleum-based truck bed release agent.

401.3 EQUIPMENT

401.3.1 Milling

1 Produce RAP with a milling machine that meets the requirements of Subsection 202.3, Equipment.

401.3.2 Crushing

1 Crush RAP with compression-type equipment such as jaws, rollers, or cones. Do not use impact or grinding-type crushers.

401.3.3 Mixing Plant

401.3.3.1 General

1 Use a batch or drum plant to make the plant mix. For projects with an estimated need for more than 5000 ton [5000 t], provide a mixing plant with a manufacturer-rated capacity no less than 100 ton/h [100 t/h]. Equip or provide the plant with the following:

1. **Cold feed control system** with adjustable positive controls to ensure that aggregates and RAP, if specified, are blended in the proper proportions. Equip with an automatic plant shut-off or other means of control if the flow from any bin is stopped or restricted. Equip with calibration devices to readily check the aggregate delivery system. If blending aggregates from two or more bins at the cold feed, ensure and use a means of synchronized proportioning.

2. **Control unit** equipped with weighing or metering devices enabling the accurate proportioning of asphalt binder in the mix.

3. **Dryers** to heat and dry aggregate and equipped with a mechanical feeder that maintains uniform production and temperature. During operation, ensure the aggregate is continuously agitated and that flames are properly adjusted to prevent damaging or coating the aggregate

with soot, oil, or other contaminants. Do not burn used oil as fuel if it adversely affects the plant mix, it produces incomplete combustion and resulting fuel condensation, or it causes the malfunction of burner, emission-control, or other equipment.

4. **Dust collection system**, either a wet scrubber or a baghouse, for the heating operation. If a baghouse is used and the fines are reintroduced into the mixture, provide equipment using a positive means of controlling the addition rate, including a calibrated feeder tied to the plant controls and operating from a surge silo. Direct auguring from the baghouse does not constitute a positive means of control.

5. **Scales** in accordance with Section 109, Measurement and Payment, to weigh aggregates, lime, and asphalt binder separately and mixed.

6. **Storage bins** of sufficient capacity to supply the mixer when operating at full speed. Arrange to ensure separate and adequate storage of each aggregate fraction and RAP, if specified. Do not allow bins to overflow; equip enclosed bins with overflow chutes to prevent spillage into other compartments or bins. Equip each compartment with an individual outlet gate that does not leak when closed and that cuts off quickly and completely. Provide separate dry storage for commercial additives and a means to feed the additives into the mixer.

7. **Storage space** sufficient to keep the different aggregate sizes separate until the material is delivered to the collecting conveyor.

8. **Tanks** for storing asphalt binder. Equip with a steam, oil coil, electric, or other system for heating and maintaining the binder at required temperatures without allowing flames to contact the tanks. Equip with a system to ensure the proper and continuous circulation of binder during the operation. Equip with a sampling valve at the discharge line, in accordance with the *Materials Testing Manual*. Equip with, and ensure the availability of, accurately marked dipsticks for measuring the tanks' contents and a chart to convert the dipstick readings to gallons [cubic meters].

9. **Thermometer(s)** of adequate range fixed in the asphalt binder feed line near the charging valve at the mixer unit or near the discharge end of

the storage tank(s). Equip the dryer discharge chute with a temperature recording device that continuously registers the temperature of the heated aggregates. Also, equip the mixer with a temperature recording device that registers and records the temperature of the mixture as it is discharged.

401.3.3.2 Batch Plants

1 In addition to the requirements specified for all mixing plants in Subsection 401.3.3.1, Mixing Plant, General, equip or provide batch plants with the following:

1. **Asphalt binder control system** with a non-tilting bucket equipped with a loose sheet-metal cover. Ensure that the discharge opening or spray bar is at least three-fourths the length of the mixer and discharges directly into the mixer. Ensure adequate heating of the bucket, discharge valves, and spray bar; if used, ensure that steam jackets are drained and connections are constructed to not interfere with the operation of the asphalt binder scales. Ensure the presence of a heated, quick-acting, non-drip charging valve directly over the bucket.

   Ensure that the bucket and indicator dial capacity exceed by at least 15 percent the quantity of asphalt binder to be used in a batch. Provide controls that can be secured at any dial setting and that automatically reset after the addition of asphalt binder to each batch. Place the dial in full view of the operator. Ensure a means to automatically begin the flow of asphalt binder when dry mixing is over and to complete the discharge in 15 seconds or less. Ensure that spray bar openings are sized and spaced to provide a uniform application of asphalt binder for the full length of the mixer.

2. **Screens** to separate aggregates to the specified sizes and with capacities greater than the full capacity of the mixer.

3. **Twin, pugmill-type mixer** capable of producing a uniform mixture. Enclose the mixer box or equip with a hood to prevent the escape of dust. Allow no more than 1 in [25 mm] of clearance between the blades and other fixed or moving parts.

4. **Timing features**, including an accurate time-lock to control a complete mixing cycle and capable of being set at intervals of 5 seconds or less throughout a total cycle of up to 3 minutes. Ensure that the weigh box gate locks after the charging of the mixer and remains locked until the mixer gate closes at the end of the cycle. Ensure that the asphalt binder bucket locks during the interval between the opening of the weigh box gate and the first introduction of asphalt binder (the dry mixing period) and that the mixer gate locks and remains locked during this and the following period of wet mixing

5. **Weigh box or hopper** capable of accurately weighing each aggregate size and with a capacity to hold one full batch without overflowing. Equip with a tight-closing gate to prevent leakage of material while weighing.

401.3.3.3 Drum Plants

1 In addition to the requirements specified for all mixing plants in Subsection 401.3.3.1, Mixing Plant, General, equip or provide drum plants as follows:

2 Weigh cold aggregate and RAP, when specified, continuously on an approved belt scale. Make provisions for determining the cold aggregate's moisture content and correcting the wet weight [mass] to a dry weight [mass]. Provide an automatic printout and digital display of the weight [mass] of the dry aggregate and the asphalt binder prior to mixing and the time of discharge of the mixture. Ensure the plant produces a printout for every 300 tons [300 t] of mix produced or at least two times per day (once in the morning and once in the afternoon), whichever is greater. Provide the engineer with this documentation daily. To ensure the asphalt binder content in the mix, provide a positive interlock between the system for weighing the aggregate and the system for delivering the binder. Provide equipment that will adjust the flow of binder as demanded by changes in the aggregate's weight [mass]. Provide a means to dry and heat the aggregate to meet moisture and temperature requirements; include a temperature recording device at the discharge chute of the dryer. Ensure the production of a uniform mixture of aggregates and asphalt binder.

401.3.4 Hauling Equipment

401.3.4.1 Performance Graded Asphalt Binder

1 Equip tank trucks delivering PGAB with a sampling valve similar to those specified in AASHTO T 40 and mounted on the truck's discharge line. The department provides drawings of suggested mountings in the *Materials Testing Manual*.

401.3.4.2 Plant Mix

1 Ensure that trucks hauling plant mix have tight, clean, smooth, metal beds. As needed, provide trucks with covers to protect the mix from the weather and maintain its temperature.

2 When using a material transfer device (MTD):

1. Obtain permission from the engineer that all bridges have adequate load-carrying capacity;
2. Ensure the MTD is empty when crossing bridges; and
3. Add hot mix directly to the MTD. Do not place material in a windrow in front of the MTD.

401.3.5 Plant Mix Pavers

1 Provide plant mix pavers that are self-propelled, have a heated, vibratory screed, and are capable of spreading and finishing the mix in widths applicable to the typical section and thicknesses specified. Equip the hopper with a distribution system to place the plant mix uniformly in front of the screed. If used, provide screed extensions that are heated, vibratory, in the same horizontal plane, at the same slope as the fixed portion of the screed, and equipped with full-width feed augers.

2 Equip pavers to automatically control the laying of the mix to the specified transverse slope and established longitudinal grade. Provide a paver control system that is automatically actuated from an independent line and grade control reference through a system of mechanical sensors and sensor-directed devices that maintain the paver screed at the proper transverse slope and height to establish the top surface of the compacted plant mix at the specified slope and grade. The independent line and grade control reference may be either of the following:

1. A tightly stretched wire or string line offset, paralleling true line for pavement edge or

2. A mobile reference equipped with a floating string or other device that actuates the automatic screed control in reference to the base on which it is riding.

401.3.6 Rollers

1 Provide self-propelled rollers in accordance with Subsection 210.3.6, Roller, and capable of reversing direction without backlash. Equip pneumatic-tired rollers with covers to maintain tire temperature. Equip vibratory rollers with a variable amplitude and frequency system. Do not use rollers that adversely affect the surface of the plant mix pavement.

401.3.7 Paving Leveler

1 Provide a Type A or Type B leveler, as follows:

1. **Type A.** A leveler attached to and controlled by a plant mix paver. Ensure a length of at least 50 ft [15 m] between caster-type support wheels and a frame of sufficient strength and rigidity to prevent deflection during operation. Equip with a blade mounted semi-rigidly on the frame within the middle third of the longitudinal span. Remove the screed from the paver when used with the leveling frame. Mount the paver ahead of the blade.

2. **Type B.** A plant mix paver with a minimum 20 ft [6 m] electronic reference system or a minimum 50 ft [15 m] traveling string line.

2 If the contract does not specify which type of leveler to use, either is acceptable.

401.3.8 PGAB Storage Tanks

1 Equip PGAB storage tanks with a sampling valve that is similar to those specified in AASHTO T 40, meets the requirements of the PGAB supplier, and is mounted on the discharge line from the tank. The department provides drawings of suggested mountings in the *Materials Testing Manual*.

401.4 CONSTRUCTION

401.4.1 General

1 Before beginning any paving operations, schedule a prepaving conference with the engineer at a mutually agreeable time to discuss the materials, equipment, and procedures.

401.4.2 Weather and Seasonal Limitations

1 Place plant mix pavement surface courses between May 1 and October 15. In writing, the engineer may extend paving start or finish dates.

2 Do not place plant mix on wet surfaces; when weather prevents proper handling, compaction, or finishing; or when the base temperature, surface temperature, or air temperature is lower than specified in Table 401.4.2-1, Air Temperature Limitations.

Table 401.4.2-1
Air Temperature Limitations

Compacted Thickness of Surface Course Being Placed	Air Temperature
Compacted thickness < 1 in [25 mm]	60 ºF [15 ºC]
1 in [25 mm] ≤ compacted thickness < 2 in [50 mm]	50 ºF [10 ºC]
Compacted thickness ≥ 2 in [50 mm]	40 ºF [4 ºC]
Leveling	50 ºF [10 ºC]

401.4.3 Laboratory and Personnel Requirements

1 For quality control testing, quality acceptance testing, and performing mix designs, use a laboratory and personnel in accordance with Section 114, Laboratory, Personnel and Correlation.

401.4.4 Correlation

1 Correlation of laboratories (field testing and mix design) and personnel for aggregate tests and density tests is required in accordance with Section 114, Laboratory, Personnel and Correlation.

401.4.5 Resolution of Testing Discrepancies

1 Resolve discrepancies involving mix designs or field tests in accordance with Section 114, Laboratory, Personnel and Correlation.

401.4.6 Quality Control Testing

401.4.6.1 General

1 Perform quality control testing.

401.4.6.2 Performance Graded Asphalt Binder

1 Ensure that the PGAB supplier performs the quality control procedures specified in Subsection 804.1, Performance Graded Asphalt Binder, and provide documentation in accordance with Subsection 401.2.1, Performance Graded Asphalt Binder.

2 If PGAB is contaminated or mixed with other asphalt materials during storage, test the PGAB at no additional cost to the department. Select an independent, third-party testing laboratory jointly with the engineer. The laboratory will:

1. Obtain three random PGAB samples from the storage container in accordance with AASHTO T 40;
2. Test samples for the applicable properties in Subsection 804.1.1, Binder Properties. Use averaged test results for each property; and,
3. Provide test results to the contractor and the engineer.

401.4.6.3 Plant Mix

1 Provide and maintain a quality control system. Ensure the quality of the plant mix pavement materials and constructed pavements, whether produced and constructed by the contractor or procured from subcontractors or vendors.

2 If, during virgin aggregate production or mix production, the result of a test performed in accordance with Table 401.4.12-1, Testing Requirements, falls outside the specification limits, retest the material immediately. If the result again falls outside the limits, adjust production until test results show the material is within limits.

401.4.7 Quality Acceptance Testing

401.4.7.1 General

1 The engineer is responsible for acceptance of the materials; however, quality acceptance testing is the responsibility of the contractor except as specified in the following subsections.

2 The engineer will determine when to take a sample for quality acceptance, determine the sample location by random numbers, and mark location for acceptance tests. The engineer will not use samples or test results from samples taken in the engineer's absence and will not accept materials represented by such samples.

3 Obtain samples for the acceptance of materials used in the production of plant mix in accordance with Subsection 800.2, Point of Sampling, and the *Materials Testing Manual*.

401.4.7.2 Performance Graded Asphalt Binder

1 The department is responsible for PGAB quality acceptance testing.

2 The Materials Program will randomly select and test one sublot sample per lot for all applicable properties described in Subsection 804.1.1, Binder Properties.

3 If a sample fails to meet the contract requirements, it is either invalid or non-specification.

1. **Invalid Samples** are any one of the following conditions:

   1.1. Mass change percentage exceeds the range from +0.196 to -0.565 when tested in accordance with AASHTO T 240.

   1.2. Contains any visible distillate when tested in accordance with AASHTO T 78.

1.3. No sample submitted or samples have insufficient quantity of PGAB to perform required tests.

The Materials Program will test all other samples in the lot for validity.

2. **Non-specification Samples** are valid but the lowest resulting pay factor is less than 1.00. The Materials Program will test all other samples in the lot only for the properties failing specification. When the difference between specified high- and low-grade temperatures is at least 90 and the sample fails to fully elongate in accordance with AASHTO T 301, the elastic recovery test equals zero.

   The contractor may use, at no additional cost to the department, recovered PGAB for the samples of record when original samples indicate removal and replacement of plant mix pavement. Select an independent, third-party laboratory jointly with the engineer. The laboratory will:

   2.1. Obtain three to five core samples in accordance with ASTM D 5361 from the appropriate portion of plant mix pavement corresponding to the original PGAB sample;

   2.2. Extract and recover PGAB from core samples in accordance with AASHTO T 319 with the test procedure modified to use a toluene-ethanol mixture as the solvent from beginning to end of the extraction. The ethanol will consist of 95 percent ethyl alcohol and 5 percent water;

   2.3. Test recovered PGAB as RTFO residue for the applicable properties in Subsection 804.1.1, Binder Properties, without additional RTFO aging. Use averaged test results for each property; and,

   2.4. Provide test results to the contractor and the engineer.

4 Results for each lot will be used to determine acceptance of that lot. If tested sample(s) meet contract requirements, the Materials Program will dispose of all samples, including referee samples. If not, the Materials Program will keep referee samples for a maximum of 12 months from issue date of the test results.

5 In case of a discrepancy, the referee samples will be available if requested within the time frame specified above, for testing by an independent laboratory. The department will consider third-party testing if the contractor provides certified test data from the supplier that differs statistically from department test results. For this purpose, “statistically different” results are those greater than the difference between the specification value and the value in the row for Pay Factor = 1.00 in Table 401.5.3-1, PGAB Pay Factors. If third-party testing is justified, select the laboratory jointly with the engineer; the department will only consider results for the property in question and will consider as binding only those results that differ statistically from its own—in which case it will use the third-party results to recalculate the pay factor in accordance with Subsection 401.5.3.2, Performance Graded Asphalt Binder. If the recalculation produces an increase in the pay factor, the department will pay for the testing; otherwise, the contractor will pay for the testing.

401.4.7.3 Plant Mix

1 The contractor is responsible for quality acceptance testing as required by Table 401.4.12-1, Testing Requirements, and Table 401.4.12-2, In-Place Density Test Requirements, for the level of control specified. Before using contractor test results for quality acceptance, the department will perform procedures for correlation as described in Section 114, Laboratories, Personnel, and Correlation.

2 Perform quality acceptance testing using the following procedure:

1. **Aggregate Gradation.** Collect two samples. Test one sample for quality acceptance and the engineer may test the other sample for verification.

2. **In-Place Density.** Collect two cores at each location designated by the engineer. Test one sample for quality acceptance and the engineer may test the other sample for verification.

3. **Mix Volumetrics.** Testing for mix volumetrics may be completed off-site at an AASHTO-accredited laboratory using the department procedure for reheated samples in accordance with the *Materials Testing Manual*. If a mobile field lab is used, ensure that it is properly equipped to perform the required testing. When using a laboratory other than the original mix design laboratory, ensure the availability of records documenting the calibration of equipment in accordance

with the AASHTO Accreditation Program and yearly correlation with an AASHTO-accredited laboratory, prior to testing. Ensure that technicians performing the testing adhere to department procedures and include the following tests and parameters:

3.1. Extracted gradation;

3.2. Extracted asphalt binder content;

3.3. Voidless unit weight;

3.4. Percent VMA; and

3.5. Percent air voids.

Use extracted gradation and extracted asphalt binder content for quality control purposes.

Report results, including evaluation, comments, and recommendations, to the engineer and the WYDOT Materials Program no later than two calendar days after sampling.

4. **Moisture Content of Plant Mix and Virgin Aggregate/Hydrated Lime.** The engineer does not need samples for verification.

401.4.7.4 Lot Sizes

1 The department will define lots as follows:

1. **PGAB.** Generally, one lot is 500 ton [500 t] and a sublot is 100 ton [100 t]. For quantities with numerical values not evenly divisible by 500, the lot sizes may vary from 300 ton to 700 ton [300 t to 700 t], with the number of sublots adjusted accordingly.

2. **Plant Mix.** Aggregate gradation, in-place density, and asphalt binder content will be accepted based on a quality analysis for individual lots of material. Each property will be analyzed independently.

2.1. **Virgin Aggregate Gradation.** The quantity of produced plant mix, generally represented by five tests with a tonnage as shown for the specified level of control from Table 401.4.12-1, Testing

Requirements. A sublot is the quantity represented by one test. Tonnage controls lot size and a lot may span several days of production because exact tonnage may vary due to production suspension, construction schedules, or other acceptable reasons. When necessary due to changes in production quantities, changes in JMF, or production suspension, lots consisting from three to seven samples may be used. Include partial lots with less than three samples with the previous lot for analysis.

Include the material for the test strip as required by Subsection 401.4.18, Test Strip, in the first lot. Include material placed for approaches in the lot unless it has a different gradation than the mainline material.

2.2. **In-Place Density.** The quantity of produced plant mix, represented by seven tests with a tonnage as shown for the specified level of control from Table 401.4.12-2, In-Place Density Test Requirements. Although the quantity of material represented may be changed, if necessary, because of changes in production, changes in the JMF, or production suspension, always represent a lot with seven samples. Tonnage controls lot size and a lot may span several days of production. For the purposes of acceptance and determination of a pay factor, the test strip is a lot.

2.3. **Virgin Asphalt Binder Content.** A lot is a day's production of plant mix. Include material placed for approaches unless its asphalt binder content or grade differs from the mainline material. Do not include material for the test strip.

401.4.7.5 Sampling

1 The engineer will direct sampling as follows:

1. **PGAB.** Obtain random PGAB samples from the line between the storage tank and the mixer as directed. Before taking samples, draw and discard at least 1 gal [4 L] of PGAB from the sampling valve.

   The department defines a sample as two 1-quart [1 L] containers representing 100 ton [100 t] or one sublot of PGAB incorporated into the plant mix. Only sample PGAB incorporated into the plant mix, including plant mix supplied by commercial plants; sample randomly and in accordance with AASHTO T 40. The engineer will keep all samples for a lot until receipt of the last sample and will then submit them together to the Materials Program. From each sample, the Materials Program will keep one container as a referee sample. Do not take samples for projects of less than 100 ton [100 t].

2. **Plant Mix.** Obtain a split sample for the engineer's use in verifying plant mix specified as levels of control 2 or 3 and in-place density I at the same time when sampling for acceptance.

   2.1. **Virgin Aggregate Gradation.** Collect one sample to represent each sublot. The engineer will determine timing of the sample procurement at random. Collect samples from the belt or conveyor in accordance with the *Materials Testing Manual*. If using a mechanical sampler, correlate with belt samples in accordance with the *Materials Testing Manual* procedure.

   2.2. **In-Place Density.** Perform core sampling and testing in accordance with the applicable procedures in the *Materials Testing Manual*. The engineer will mark the sample location for the quality acceptance and verification cores with a 12 in × 12 in [300 mm × 300 mm] square painted at least 12 in [300 mm] from the pavement or ribbon edge. Obtain the samples from within the painted square.

   2.3. **Virgin Asphalt Binder Content.** If required in accordance with Table 401.4.12-1, Testing Requirements, determine the volume of asphalt binder remaining in the storage tank at the end of the day in the presence of the engineer. The engineer will convert to weight [mass] using methods from the *Materials Testing Manual*.

   2.4 **Mix Volumetrics.** The engineer will determine the location for random sampling. Samples may be obtained from the paver auger, the windrow, or the paver hopper. Collect three samples of plant-produced material from each location. Test one and give two to the engineer. The engineer may test one for verification and will keep the other as a referee sample. After the first four sample locations, collect two or three samples thereafter, as required by the engineer. Test one for quality acceptance, the engineer may test one for verification, and, if requested, retain the third sample as a referee sample.

401.4.8 Verification

1 The engineer or an AASHTO-accredited laboratory contracted by the department will perform the verification testing using different personnel from those performing the quality control and quality acceptance testing.

2 If specified, supply one field laboratory in accordance with Subsection 106.5, Field Laboratory, for use by department personnel in verification testing. Keep this laboratory independent of the laboratory used for quality control and quality acceptance testing; do not share equipment.

3 The engineer will verify testing procedures by testing one sample randomly from the sublot samples obtained to represent each acceptance lot. The differences between the contractor's quality acceptance test result and the engineer's corresponding verification test result will be evaluated in accordance with the values in the *Materials Testing Manual* and applied as follows:

1. **Equal to or less than the allowable difference**, the contractor's test results will be used for quality acceptance or

2. **Exceeds the allowable difference**, the engineer will test the remaining verification samples from the lot. Once the tests have been completed, the results will be evaluated using the statistical evaluation procedures for the correlation of testers to decide if both groups represent the sample population. If the contractor's and engineer's results represent the same sample population, the contractor's test results will be used for quality acceptance.

   If the contractor's and the engineer's results do not represent the same sample population, the engineer's verification test results will be used for acceptance for the lot, and a new correlation will be performed on the next lot. The contractor's test results will not be used for quality acceptance until the correlation is completed and is acceptable.

401.4.9 Independent Assurance

1 The engineer's office will make independent assurance tests results available.

1. **Aggregate Gradation, In-Place Density, and Asphalt Binder Content.** The Materials Program will conduct an independent assurance program in accordance with the current WYDOT *Independent Assurance Manual*. Differences between quality acceptance, verification, and independent assurance tests will be evaluated and findings of bias will be investigated immediately.

2. **Mix Volumetrics.** The department may perform mix volumetrics testing; if so, it will use the same methods specified in Subsection 401.4.7, Quality Acceptance Testing, and if required, Subsection 401.4.11, Corrective Action Plan. Respond to the results as specified in these two subsections.

401.4.10 Documentation and Reporting

1 Submit all quality control and quality acceptance test results to the engineer. Use department forms in accordance with the *Materials Testing Manual*.

401.4.10.1 Quality Control Charts

1 Provide quality control charts that include the control limits, each individual quality control test result, and the moving average of the last four tests in the control charts.

1. **Testing Requirements—All Levels of Control.** Make control charts accessible to the engineer at the field lab, if available, otherwise at a mutually agreeable location.

   Record quality control test results on the control chart immediately after completing the test. Density results may be recorded at the end of the day. Record the following parameters on the control chart:

   1.1. Gradation of the control sieves in the JMF;

   1.2. Virgin asphalt binder content;

1.3. Total asphalt binder content; and

1.4. In-place density.

2. **Testing Requirements—Level of Control 2 and 3 Only.** In addition to the above parameters, record the following on the control chart:

   2.1. Percent voids in the mineral aggregate and

   2.2. Percent air voids.

401.4.10.2 Quality Acceptance

1 Submit results of quality acceptance tests to the engineer the day after sampling. Prepare a weekly summary depicting results of all tests performed during the week, and give it to the engineer the following Monday or Tuesday if Monday is a holiday.

401.4.11 Corrective Action Plan

1 Take immediate corrective action when the production of material falls outside of specification parameters. Do not continue producing material that does not meet specifications.

1. **Aggregate Gradation, Density, and Asphalt Binder Content.** If two consecutive lots have a pay factor less than 1.00 in accordance with Subsection 401.5.3, Determination of Pay Factors, make changes and adjustments to produce the specified material.

2 For the following properties, take the indicated actions if a single quality acceptance test in accordance with Subsection 401.4.7, Quality Acceptance Testing, exceeds specification limits:

2. **Mix Volumetrics.** Immediately resample and retest. If the resample exceeds specification limits, begin valid corrective action(s) immediately. After corrective action, immediately resample and retest. Suspend production if two corrective actions fail to result in the production of specification material. Obtain the engineer's approval of further proposed actions before resuming production

The department considers the following as valid corrective actions:

2.1. A change in the percentage of aggregate addition from any one storage bin by at least 5 percent;

2.2. A change in the target asphalt binder content by at least 0.2 percent;

2.3. A change in the minus No. 200 [75 µm] material in the mix by at least 1 percent; or

2.4. Other actions approved by the engineer.

Notify the engineer immediately when test results are outside mix design limits for percent air voids; dust/effective asphalt binder; film thickness in accordance with Table 401.4.13-2, Marshall and Superpave Plant Mix Properties; VMA in accordance with Table 401.4.13-3, Percent Voids in Mineral Aggregate; or the gradation is outside of the narrow bands established by the JMF. Corrective action may require a new mix design in accordance with Subsection 401.4.13.3, Mix Design, a new JMF in accordance with Subsection 401.4.13.2, Job Mix Formula, or both.

Request that the engineer evaluate the mix verification voidless unit weight tests for density control in accordance with the *Materials Testing Manual* when there are at least four test results available and the current voidless unit weight is in question. If approved by the engineer, the department will adjust the voidless unit weight using all available test results. For increases, adjustments will become effective for material produced subsequent to the receipt of the results. For decreases, the adjustment will be applied retroactively back to the beginning of production of that paving mixture.

3. **Liquid Limit and Plastic Index.** Reprocess until the material is within limits.

4. **Moisture Content of Virgin Aggregate/Hydrated Lime.** Adjust moisture immediately.

5. **Moisture Content of Plant Mix.** Adjust mix production immediately.

6. **Coarse and Fine Aggregate Angularity.** Adjust mix production immediately.

401.4.12 Testing Requirements

401.4.12.1 Performance Graded Asphalt Binder

1 Subsection 804.1.3, Testing, applies to the supplier of the PGAB.

401.4.12.2 Plant Mix

1 Table 401.4.12-1, Testing Requirements, and Table 401.4.12-2, In-Place Density Test Requirements, show the department's testing requirements for quality control, quality acceptance, verification, and density. For plant mix placed as temporary surfacing in accordance with Subsection 401.4.20.3, Temporary Surfacing, use the tables' requirements for level-of-control 5 and in-place-density II.

2 Quality control, quality acceptance and verification tests may be performed by a qualified technician, but a certified technician is required to review and sign all test results.

Table 401.4.12-1
Testing Requirements

TEST PROCEDURE	LEVEL OF CONTROL			
	2	**3**	**4**	**5**
Quality Control—Virgin Aggregate Production				
Gradation; Liquid Limit (LL); Plasticity Index (PI); Coarse Aggregate Angularity (Fractured Faces); Fine Aggregate Angularity; Flat & Elongated (2)	1/1000 ton [1/1000 t] min.	1/1000 ton [1/1000 t] min.	1/1000 ton [1/1000 t] min. (3 test min.)	1/1000 ton [1/1000 t] min. (3 test min.) If using existing stockpiles, 2/stockpile
LA Abrasion (Contractor-Furnished Sources Only) (3)	1/10,000 ton [1/10 000 t] min.	1/10,000 ton [1/10 000 t] min.	Once each construction season	Once each construction season
Soundness (MgSO4) (Contractor-Furnished Sources Only) (3) (4)	1/20,000 ton [1/20 000 t] min.	1/20,000 ton [1/20 000 t] min.	Once each construction season	No tests required
Sand Equivalent (Contractor-Furnished Source Only) (3)	1/5000 ton [1/5000 t] min.	1/5000 ton [1/5000 t] min.	Once each construction season	No tests required

Table 401.4.12-1
Testing Requirements, *continued*

TEST PROCEDURE	LEVEL OF CONTROL			
	2	3	4	5
Quality Acceptance—Mix Production(5)				
Mix Volumetrics	2 locations on first day & 1 location each 5000 ton [5000 t] thereafter	2 locations on first day & 1 location each day thereafter until no further corrective actions are required	No tests required	No tests required
Virgin Aggregate Gradation	1 lot/5000 ton [1 lot/5000 t]	1 lot/5000 ton [1 lot/5000 t]	1 lot/5000 ton [1 lot/5000 t] (6)	No tests required
Asphalt Binder Content	1/day	1/day	1/day	No tests required
Virgin Aggregate—LL; PI; Coarse Aggregate Angularity (Fractured Faces); Fine Aggregate Angularity; Flat & Elongated (7)	1/1000 ton [1/1000 t] min.	1/1000 ton [1/1000 t] min.	No tests required	No tests required
Moisture Content of Virgin Aggregate/ Hydrated Lime; Moisture Content of Mix	1/day min.	1/day min.	No tests required	No tests required
Verification—Mix Production				
Mix Volumetrics	Split sample required but no test frequency specifically required	Split sample required but no test frequency specifically required	No tests required	No tests required
Virgin Aggregate Gradation	1/lot	1/lot	No tests required	No tests required
Asphalt Binder Content	No tests required	No tests required	No tests required	No tests required
Virgin Aggregate—LL, PI, Coarse and Fine Aggregate Angularity; Moisture Content of Virgin Aggregate/ Hydrated Lime; Moisture Content of Mix; Flat and Elongated	1/mix design (8)	1/mix design (8)	No tests required	No tests required

(1) Testing frequencies shown are minimum quantities. Example:

1 min/1000 ton [1 min/1000 t]

(2) If the first three tests for coarse aggregate angularity, fine aggregate angularity, and flat and elongated are within specification, and there are no changes in the crushing process, test at a frequency of 1/10,000 ton [1/10 000 t].

(3) Test frequency refers to the total combined aggregate weight produced. The total combined aggregate weight includes the total weight of coarse aggregate, fine aggregate, and filler, if applicable, combined at the anticipated rates. Testing that applies only to material passing the No. 4 [4.75 mm] sieve (sand equivalent) will be performed on the combination of fines and filler combined at the anticipated rates and tested at the frequency determined by the total combined aggregate weight.

(4) Soundness (MgS04) will be tested on the coarse and fine aggregate separately. The specification for soundness applies to the coarse aggregate only.

(5) Quality acceptance tests may be used for quality control purposes.

(6) The department will perform acceptance testing.

(7) If, during aggregate production, the test results for LL, PI, coarse aggregate angularity, fine aggregate angularity, and flat and elongated were within specification, the department will not require retesting.

(8) LL, PI, and coarse and fine aggregate angularity only.

Table 401.4.12-2
In-Place Density Test Requirements

Requirement	In-Place Density Designation				
	I	II	III	IV	V
In-Place Density (1)	1 lot/1500 ton [1 lot /1500 t] of produced material.	All in place mix compacted to ≥ 92.0% of voidless unit weight.	≥ 5 passes (2) of a pneumatic tire and ≥ 5 passes (2) of a steel wheel roller in accordance with Subsection 210.3.6, Roller, and until a nuclear density gauge indicates the mix no longer increases in compaction.	5 passes (2) of a pneumatic tire and 5 passes (2) of a steel wheel roller in accordance with Subsection 210.3.6, Roller.	≥ 5 passes (2) of a steel wheel roller in vibratory mode in accordance with Subsection 210.3.6, Roller.
Test Strip	Required	Not required	Not required	Not required	Not required
Quality Acceptance Testing	1 lot/1500 ton [1 lot/1500/t]	1 test/200 ton [1 test/200 t]	No tests required	No tests required	No test required
Verification Testing	1/lot	No tests required	No tests required	No tests required	No test required

(1) Compact temporary surfaces in accordance with In-Place Density Designation II, unless otherwise noted in the contract.

(2) The department defines one pass with a roller as a forward or backward movement over the full length of the area to be compacted.

401.4.13 Composition of Plant Mix

401.4.13.1 General

1 Develop the construction mix design. Obtain the design from a qualified laboratory in accordance with Section 114, Laboratory, Personnel, and Correlation. Contact the Materials Program if questions on procedures or specifications occur during the mix design process.

2 The department will provide available information on material properties for specified department-furnished sources. The provision of such information does not imply that contractor-produced material will meet design criteria. When such information is not available, evaluate the materials and mix design properties.

3 At least 14 calendar days before the start of paving, give the engineer a job mix formula, mix design, and documentation of AASHTO accreditation for required testing procedures. For each aggregate fraction, and RAP when specified, submit samples of the produced material collected at the same time as those collected when sampling for the mix design. When RAP is specified, submit samples collected by a production milling machine. Include in the submitted data for the mix design, the mixture properties specified in Subsection 401.4.13.3, Mix Design. Do not start paving until the engineer approves the mix design.

401.4.13.2 Job Mix Formula

1 Supply the JMF and have it approved by the engineer. For each plant mix type, establish in the JMF a single value for:

1. Percentage of virgin aggregate passing each required sieve size;
2. Target RAP percentage, when used;
3. Target asphalt binder content;
4. Percentage of asphalt binder added;
5. Lab mix and lab compaction temperature; and
6. Field mixing temperature.

2 Ensure that the JMF and allowable tolerances are within the broad band specified.

3 For level of control 4 and 5 mixes, do not reintroduce a greater percentage of baghouse fines than the difference between the wide band upper limit percent on the No. 200 [75 µm] sieve and the total percent passing the No. 200 [75 µm] sieve (defined as the sum of the JMF's No. 200 [75 µm] percent value and the percent lime). If reintroducing baghouse fines for a level of control 2 and 3 mixes, perform mix volumetric testing in accordance with Subsection 401.4.7, Quality Acceptance Testing, for level of control 2.

4 When a recycled plant mix is specified, use RAP for at least 10 percent of the total aggregate. The amount of RAP may be increased or decreased up to 10 percent (by weight [mass] of total aggregate) from the amount specified. Adjustment of the percent of RAP may result in an adjustment of the virgin aggregate gradation.

5 Do not furnish mix with virgin aggregate fractions that exceed the wide band limits or the tolerance ranges from the target JMF in accordance with Table 401.4.13-1, Virgin Aggregate Tolerance.

Table 401.4.13-1
Virgin Aggregate Tolerance

Virgin Aggregate Fractions (sieve size)	Range (%)
Passing No. 4 [4.75 mm] and larger	-5 to +5
Passing No. 8 [2.36 mm]	-4 to +4
Passing No. 30 [600 µm]	-3 to +3
Passing No. 200 [75 µm]	-2.0 to +2.0

6 For recycled mixes, ensure that combined RAP and virgin aggregate gradations are within the specified wide band.

7 Do not change the JMF without the engineer's written approval. The engineer will approve a change of the JMF gradation limits without requiring a new mix design if the gradation on each control sieve of the original design remains within the new limits. The new limits become effective at the time of approval and are not retroactive except if the JMF is adjusted during the second lot, the adjustment will apply to the first lot. Issue a new JMF when changing the asphalt binder content, when performing a new mix design, or when significantly changing the mineral aggregate split to maintain proper air voids, VMA, or both.

401.4.13.3 Mix Design

401.4.13.3.1 General

1 Design Superpave and Marshall mixes in accordance with the *Materials Testing Manual*. Test to determine each of the properties specified in Table 401.4.13-2, Marshall and Superpave Plant Mix Properties, and Table 401.4.13-3, Percent Voids in Mineral Aggregate. For the specified class of pavement, compose the plant mix of virgin aggregate, RAP (when specified), asphalt binder, and hydrated lime, and meet the requirements of the tables for the class of pavement specified.

Table 401.4.13-2
Marshall and Superpave Plant Mix Properties[1]

Property	Class					
	I-M	II-M	III-M	I-S	II-S	III-S
Number of Marshall Blows	75	75	50			
Marshall Stability (lbs [N]) minimum	2500 [11 000]	2500 [11 000]	2000 [9000]			
Marshall Flow (0.01 in [0.25 mm])	8–16 [8–16]	8–16 [8–16]	8–16 [8–16]			
Number of Superpave Gyrations				100	75	50
% Voids in Laboratory Mix	5.0–6.0	4.0–5.0	4.0–5.0	4.0–5.0	4.0–5.0	4.0–5.0
% Voids in Production Mix	4.0–6.0	3.0–5.0	2.5–5.0	3.0–5.0	3.0–5.0	2.5–5.0
Dust/Effective Asphalt Binder	0.8–1.4	0.8–1.4	0.8–1.4	0.8–1.4	0.8–1.4	0.8–1.4
Minimum % Asphalt Binder	4.5	4.5	4.5	4.5	4.5	4.5
Minimum Tensile Strength Retained %	75	75	75	75	75	75
Film Thickness µm[2]	6–12	6–12	6–12	6–12	6–12	6–12
Voids Filled with Asphalt Binder (VFA)				65–75	65–78	65–78
Aggregate/Lime Moisture Content, % Minimum	4.0	4.0	4.0	4.0	4.0	4.0
Mixture Moisture Content, % Maximum	0.5	0.5	0.5	0.5	0.5	0.5

(1) The requirements are for properties obtained from laboratory-batched and mixed samples of the plant mix, except for air voids and VMA which are for laboratory batched and production mix requirements.

(2) This test is not required when the plant mix contains RAP.

Table 401.4.13-3
Percent Voids in Mineral Aggregate

Class	Voids in Mineral Aggregate (%) Maximum Nominal Size			
	1 in [25 mm]	¾ in [19 mm]	½ in [12.5 mm]	⅜ in [9.50 mm]
Laboratory Mix				
I-M, II-M, I-S, II-S	12.0–15.0	13.0–16.0	14.0–17.0	14.0–17.0
III-M, III-S	11.0–14.0	12.0–15.0	13.0–16.0	13.0–16.0
Production Mix				
I-M, II-M, I-S, II-S	11.0–15.0	12.0–16.0	13.0–17.0	13.0–17.0
III-M, III-S	10.0–14.0	11.0–15.0	12.0–16.0	12.0–16.0

2 If submitting a request to reference a mix design, in accordance with Subsection 401.4.13.3.2, Mix Design Referencing Criteria, give supporting test data to and obtain approval from the engineer before use.

3 The engineer will evaluate the need for and may require a new mix design if, relative to the approved mix design, there are changes in the grade of asphalt binder or changes in aggregate splits, the JMF, or material sources.

401.4.13.3.2 Mix Design Referencing Criteria

1. **Level of Control 2.** The department requires a full mix design; do not reference.

2. **Level of Control 3 and 4.** The mix design may be referenced if:

   2.1. Using the same virgin aggregate source as the reference mix design and the JMF is within 3 percent for No. 8 [2.36 mm] and larger sieves and 2 percent for sieves smaller than the No. 8 [2.36 mm] of the reference design;

2.2. The percentage and source of RAP is the same as the reference design and the engineer receives data on extraction and gradation properties for at least two samples that are representative of the source or stockpile;

2.3. Using departmental procedures, a voidless unit weight is determined and it is within 2 lb/ft³ [32 kg/m³] of the reference design (use the reference design voidless unit weight for density control);

2.4. The reference mix design was completed during the same construction season; and

2.5. Placing less than 5000 ton [5000 t] of plant mix.

3. **Level of Control 5.** The mix design may be referenced if:

3.1. Using for sieves smaller than the No. 8 [2.36 mm];

3.2. The percentage and source of RAP is the same as the reference design and the engineer receives data on extraction and gradation properties for at least two samples that are representative of the source or stockpile;

3.3. The reference design was completed within the past two years;

3.4. Along with the reference request, the engineer receives two gradation analyses per stockpile of coarse and fine aggregate material and their specific gravities and absorptions; and

3.5. Placing less than 5000 ton [5000 t] of plant mix.

401.4.13.4 Adjustment of Baghouse Fines

1 If the amount of baghouse fines being reintroduced changes by more than ± 0.5 percent during production of level of control 2 and 3 mixes, verify that the plant mix meets the mix design volumetric control limits. With the engineer, choose at least two randomly selected sampling locations and perform testing in accordance with Subsection 401.4.7, Quality Acceptance Testing, for mix volumetrics properties. If the samples with baghouse fines meet the mix design control limits, fines may be reintroduced.

401.4.14 Cold Milling Plant Mix Pavement

1 Remove the existing pavement specified as the source of the RAP in accordance with Subsection 202.4.5(2), Milling Plant Mix and Profile Milling Plant Mix. Weigh and stockpile the removed material in the designated plant site area.

401.4.15 Leveling of Existing Surface

1 If specified, use a leveler in accordance with Subsection 401.3.7, Paving Leveler, to level pavement before placing the first layer of plant mix. Spot fill depressions and swales separately to meet the profile gradeline. When specified, seal longitudinal and transverse joints and random cracks, and remove excess sealant before placing the leveling course.

2 Clean the surface of vegetation, loose materials, dirt, mud, and other extraneous material before placing the leveling course. Place layers of a compacted thickness no greater than 3 in [75 mm]; compact the plant mix using rollers as specified in Subsection 210.3.6, Rollers, operated at 4 mph [6.4 km/h]. Meet the requirements for in-place density IV in accordance with Table 401.4.12-2, In-Place Density Test Requirements. Operate the steel wheel roller in vibratory mode unless otherwise approved by the engineer.

401.4.16 Mixing

401.4.16.1 General

1 At least one week before delivery of binder, give the engineer the recommended mixing and compaction temperatures.

2 If the correlation testing for aggregate gradation has not been completed, test a split aggregate sample in accordance with Subsection 114.3.3.2, Aggregate Gradation, prior to beginning production.

3 Dry the aggregate lime mixture and heat to the required temperature. Mix the materials until the aggregate is completely and uniformly coated and the asphalt binder is uniformly distributed throughout the aggregate. Produce the plant mix within the temperatures specified in Subsection 401.4.16.2, Asphalt Binder.

4 When using the batch plant process, introduce the asphalt binder and aggregate into the mixer within the specified temperature range and within 25 ºF [15 ºC] of each other.

5 Set time intervals for batch plants in the presence of the engineer. Keep the case covering the timing device locked until changing the timing periods.

6 Determine the mixing temperature at the point of discharge from the mixer, and give the engineer a continuous record of the temperatures each day.

401.4.16.2 Asphalt Binder

401.4.16.2.1 General

1 Heat the asphalt binder to the specified temperature without local overheating, and provide a continuous supply to the mixer at a uniform temperature.

2 Store and handle all PGAB to prevent contamination or mixing with other asphalt materials of different grades, types, or sources. If PGAB is contaminated or mixed with other asphalt materials during storage:

1. Stop using PGAB from the storage tank;
2. Notify engineer; and
3. Test the PGAB in accordance with Subsection 401.4.6, Quality Control Testing.

401.4.16.2.2 Modified Asphalt Binders

1 For modified binders, obtain from the supplier recommended mixing and compaction temperatures for its use.

401.4.16.2.3 Unmodified Asphalt Binders

1 For unmodified binders, base the mixing and compaction temperature ranges for the plant mix on the viscosity-temperature curve provided by the supplier. Use temperature ranges for mixing and compaction that correspond to those required to produce binder rotational viscosities of 0.17 ± 0.02 Pa•s and 0.28 ± 0.03 Pa•s, respectively.

401.4.17 Hauling

1 Provide weigh tickets in accordance with Subsection 109.1.4.2, Documentation.

2 If using a truck bed release agent, ensure that it does not adversely affect the plant mix. The engineer may reject plant mix hauled in truck beds that have been sprayed with a solvent or petroleum based release agent.

3 Do not dump material on the ground and reload into trucks or directly into the paver.

401.4.18 Test Strip

401.4.18.1 General

1 If required by Table 401.4.12-2, In-Place Density Test Requirements, construct a test strip to evaluate the mix design and rollers, and to determine the rolling pattern. Construct the strip as follows:

1. The first 500 ton [500 t] of plant mix pavement placed at the specified depth constitute the test strip. Produce the material at the normal plant rate. Do not place additional pavement of the type in the test strip until the engineer accepts the strip; as necessary, construct additional test strips, for no additional pay for the item "Test Strip," until specifications are met. Upon acceptance, the test strip will remain in place and become part of the pavement.

2. Determine the type and number of rollers needed to provide enough compaction to obtain the specified density. Begin compaction immediately after placing the plant mix; compact continuously and uniformly over the entire test strip.

3. From the last 300 ton [300 t] of placed and compacted plant mix, the engineer will randomly select sample locations for density tests, and will apply test procedures and statistical evaluation, in accordance with Subsection 114.3.3., Correlation.

4. In accordance with Subsection 401.4.7.4(2.1), Virgin Aggregate Gradation, the engineer will include the test strip in the first lot. In accordance with Subsection 401.4.7.4(2.2), In-Place Density, the test strip is one lot.

5. If significant changes occur in the mix, the JMF, or placing operations, construct a new test strip for no additional pay for the item "Test Strip."

6. The engineer will determine acceptability of the test strip within 24 hours of an acceptable correlation in accordance with Subsection 401.4.18.2, Acceptance of Test Strip Materials.

7. After the engineer has accepted the test strip, place and compact the remaining plant mix using the methods and procedures established from the test strip.

401.4.18.2 Acceptance of Test Strip Materials

1 The engineer will use the contractor's quality acceptance tests for acceptance of the test strip if the engineer's and contractor's tests correlate.

2 The engineer will determine the pay factor for the seven density samples from the test strip in accordance with Subsection 401.5.3.3 (2), In-Place Density. The engineer will accept the test strip if the pay factor is 1.00 or greater. For pay factors less than 1.00 and greater than or equal to 0.50, the pavement may be left in place, as approved by the engineer, at the reduced price determined by the pay factor and construct a new test strip for no additional pay for the item "Test Strip." For pay factors less than 0.50, remove the test strip from the roadway and dispose of it at no additional cost to the department.

3 The engineer will analyze aggregate gradation to determine a pay factor in accordance with Subsection 401.5.3.3(1), Virgin Aggregate Gradation.

4 The engineer may reject the test strip if the asphalt binder content varies more than 1.0 percent from the target established in the JMF.

401.4.19 Spreading and Finishing

1 Clean the surface of vegetation, loose materials, dirt, mud, and other extraneous material before placing plant mix.

2 For any one lift, do not exceed a compacted thickness of 2 in [50 mm] or twice the maximum aggregate size, whichever is greater.

3 Handle and place the plant mix to minimize segregation. Produce finished pavement with a uniform and dense appearance. Remove and replace segregated areas at no additional cost to the department.

4 When pavement is placed adjacent to curb and gutter, construct the top of the final lift of surfacing flush with the top of the front edge of the gutter or as

directed by the engineer. If paving over a slotted drain, cover the openings to prevent foreign material from entering the slot, and ensure the slot does not extend above the paving.

5 Use plant mix pavers to distribute the plant mix to the established grade and transverse slope over the entire width or a partial width. Use a screed to produce the specified finished surface without tearing, shoving, segregating, or gouging the plant mix. Except on tapers, narrow median areas, shoulders, and similar areas of irregular shape, limited length, or restrictive width, control the paver screed by the automatic screed control. The engineer will set references for line and grade control (if required) at reasonable intervals.

6 Provide, place, and maintain materials, devices, and equipment required to provide specified independent line, grade control references, and other controls needed for proper execution of the work.

7 Control the placement of the first layer of pavement material by the independent control reference. Subsequent layers may be controlled by the mobile reference or a joint shoe if satisfactory results are obtained.

8 Position the longitudinal construction joint in the top lift of plant mix pavement on the lane line(s) unless a plant mix wearing course is specified, in which case offset the joint 6 in [150 mm] from the lane line(s). Offset the longitudinal construction joint in subsequent layers of plant mix 6 in [150 mm] and stagger so that no two coincide. Place longitudinal construction joints within 6 in [150 mm] of the specified lane line(s).

9 Form transverse joints by cutting back on the previous run of plant mix to expose the full depth of the course.

10 Before placing additional plant mix, apply tack coat material in accordance with Section 407, Tack Coat, to join contact surfaces.

11 In areas where irregularities or obstacles make the use of mechanical spreading and finishing equipment impractical, place the material to produce a uniform surface finish and the required compacted thickness without tearing, shoving, gouging, or segregating.

12 When constructing pavements thicker than 1 in [25 mm] under traffic, do not leave a longitudinal exposed vertical drop-off between adjacent travel lanes at day's end. A continuous, integral taper with a slope no greater than 1V:3H may be constructed the entire length of the face of the exposed longitudinal joint between adjacent travel lanes. Do not construct more than one day's paving run

with a taper before completing the plant mix pavement course on the adjacent travel lane. Taper transverse joint drop-offs with a slope of at least 1V:6H.

13 In case of failure of the control system, operate the paver by mechanical control only until the material produced prior to the failure is placed.

14 If paving is suspended because of bad weather, equipment breakdown, or other reason and a longitudinal vertical drop-off greater than 1 in [25 mm] exists between adjacent travel lanes, place temporary traffic controls in accordance with Section 703, Temporary Traffic Control. If the suspension is expected to last longer than 48 hours, construct a temporary taper with stable material and a slope of 1V:3H along the drop-off. At no additional cost to the department, remove the taper before placing plant mix pavement on the adjacent travel lane.

15 Provide and maintain temporary traffic control required because of negligence, breakdown of equipment, or convenience at no additional cost to the department.

16 Do not open the new pavement to traffic before the plant mix has cooled to 125 ºF [50 ºC] or less.

401.4.20 Compaction

401.4.20.1 General

1 Roll plant mix immediately after placement and until thoroughly and uniformly compacted. Continue rolling until density is reached and while the mix is workable. Ensure that compactive effort does not result in distress to the pavement. Provide rollers of sufficient number, weight, and types to obtain the required compaction without displacement, cracking, or shoving; operate with the drive wheels or drums nearest the paver. Do not use equipment that results in excessive crushing of the aggregate, and do not operate or park rollers in a manner that adversely affects the surface of the pavement.

2 When placing plant mix against previously placed material, begin rolling at the joint, then follow the pattern established from the test strip. On super-elevated curves, begin rolling at the low side and progress to the high side using overlapping longitudinal passes parallel to the centerline.

3 Along forms, curbs, headers, walls, and other areas not accessible to the rollers, compact plant mix with hot hand or mechanical tampers. In depressed areas, a trench roller or cleated compression strips may be used under the roller to transmit compression.

401.4.20.2 Approaches

1 Compact approaches in accordance with the requirements of Table 401.4.12-2, In-Place Density Testing Requirements, for in-place density V. Use in-place density II requirements for approaches specified as “major.”

401.4.20.3 Temporary Surfacing

1 If placement of plant mix pavement has not been finished by October 15 or work on the project is suspended for any reason, provide and place temporary plant mix pavement on uncompleted portions and designated approaches before suspending work. Use temporary material with a mix design equivalent to the mainline paving mix or from a commercial source, if approved by the engineer. Place material at least 4 in [100 mm] thick or the design thickness, whichever is less, and at the specified width. Compact temporary surfaces in accordance with the requirements of Table 401.4.12-2, In-Place Density Testing Requirements, for in-place density II. The department will assess liquidated damages in accordance with Table 108.8-1, Schedule of Liquidated Damages, for each working day after it has been determined that the project will be suspended, until the roadway is open to unrestricted traffic. Maintain the temporary surfacing, except for snow removal, until the engineer allows removal. Provide, place, maintain, remove, and dispose of temporary surfacing at no additional cost to the department, including associated traffic control costs.

401.4.21 Surface Tolerances

1 The engineer will test the final surface using a 10-foot [3 m] straightedge at selected locations. Do not allow variation of the surface from the straightedge between any two contacts with the surface greater than $^3/_{16}$ in [5 mm] in both transverse and longitudinal directions.

2 Repair defective work before placing chip seal or plant mix wearing course by milling, diamond grinding, or full-depth removal and replacement of the plant mix pavement.

3 Core areas that require corrective action before repairing the surface deviation. If the newly placed pavement thickness is inadequate to allow grinding and maintain the design thickness within ½ in [12.5 mm] of the thickness designated in the contract, or if the surface deviation is a dip, remove the defective area of pavement and replace it. To repair dips after removal of the appropriate depth of surfacing, place a tack coat and at least 1½ in [37.5 mm] of hot plant mix.

4 Provide power-operated milling equipment with a 30-foot [10 m] mobile reference (ski). Ensure the milling machine has a drum with a triple-scroll micro-mill pattern and is operated at a slow forward speed to ensure the scroll pattern is not over-run. Ensure milling and grinding equipment have a positive means of controlling cross slope elevations.

5 Run the milling or grinding as a continuous operation to produce the best overall pattern. Ensure grinding equipment is capable of establishing a profile grade by referencing from either the existing pavement or from the independent grade control. Ensure the vertical difference between adjacent peaks and valleys of the milled or ground surface does not exceed ⅛ in [3 mm]. Conduct milling and diamond grinding parallel to the travel lanes.

6 Do not mill or grind where it will adversely affect roadway drainage. Continue the repair areas through the shoulders with the same method as the adjacent travel lane repair. Do not leave ridges. Feather grind edges if required.

7 Complete corrective work before placing the fog seal, chip seal, or plant mix wearing course and before suspension of work for winter shut-down. Corrective action on defects that develop during the winter will not be required. If corrective work is not completed before winter shut-down, correct all defects when work resumes.

8 Apply a fog seal and a blotter to surfaces that have been milled or ground, with the exception of surfaces that will receive a fog seal, chip seal, or plant mix wearing course before winter shut-down. Place the fog seal and blotter in accordance with Section 409, Chip and Fog Seals.

9 Perform the corrective work on travel lanes and adjacent shoulders, and provide the necessary traffic control at no additional cost to the department.

401.4.22 Disposal of Baghouse Fines

1 Dispose of baghouse fines properly. If using the plant site for disposal, scarify the soil to a depth of 6 in [150 mm]. Spread the fines thinly over the area and disc thoroughly into the soil. Water may be added to reduce dust. When reclaiming the site, place topsoil or overburden over the disposal area. Ensure that the size of the area within the plant site used for disposal is in accordance with Table 401.4.22-1, Baghouse Fines Disposal Area.

Table 401.4.22-1
Baghouse Fines Disposal Area

Fines Produced (ton [t])	Disposal Area (acre [hectare])
< 34,000	0.5 [0.2]
34,001 to 70,000	1.0 [0.4]
70,001 to 100,000	1.5 [0.6]
100,001 to 135,000	2.0 [0.8]
> 135,000	3.0 [1.2]

401.4.23 Reclaiming Scrubber Ponds

1 Before placing topsoil, and using the methods described in Subsection 401.4.22, Disposal of Baghouse Fines, spread residue from the pond over the plant site area in layers from 2 in to 3 in [50 mm to 75 mm] deep; scarify and disc immediately. A dewatering pad may be constructed by extending the pond liner so that soils can be placed next to the pond to allow water to drain back into the pond. After mixing residue with subsoil, spray scrubber pond water finely over the reclaimed site. Then, till the site to mix subsoil and water. Spread topsoil or overburden over the area where scrubber pond residue and water have been disposed. Dispose of scrubber pond liners in an approved landfill.

401.4.24 Acceptance

1 The engineer may isolate and reject obviously defective material without regard to testing procedures. Otherwise, the engineer will accept or reject materials as follows:

1. **PGAB** in accordance with Subsection 804.1, Performance Graded Asphalt Binder, Subsection 113.2, Acceptance of Asphalt Materials, and Subsection 401.5.3.2, Performance Graded Asphalt Binder.

   If contaminated or mixed PGAB in a storage tank fails specification as described in Subsection 401.4.6.2, Performance Graded Asphalt Binder, the engineer will reject all PGAB from the storage tank.

The engineer will reject lots represented by invalid samples in accordance with Subsection 401.4.7.2, Performance Graded Asphalt Binder.

2. **Plant Mix**

2.1. **Aggregate Gradation.** Levels of control 2, 3, and 4 mixes in accordance with Subsection 113.1, Acceptance of Aggregate, and level of control 5 mixes based on the tests taken during production.

2.2. **In-Place Density I.** In accordance with Subsection 401.5.3.3 (2), In-Place Density, and in-place density II, III, IV, and V in accordance with Table 401.4.12-2, In-Place Density Test Requirements.

2.3. **Asphalt Binder Content.** For levels of control 2, 3, and 4 mixes, in accordance with Subsection 401.5.3.3 (3), Asphalt Binder Content.

2.4. **Moisture Content of Virgin Aggregate/Hydrated Lime.** Based on each individual test and the quantity of water added.

2.5. Based on each individual test for:

2.5.1. **Liquid Limit and Plastic Index**;

2.5.2. **Moisture Content of Plant Mix**;

2.5.3. **Coarse and Fine Aggregate Angularity**; and

2.5.4. **Mix Volumetrics**.

401.5 MEASUREMENT and PAYMENT

401.5.1 General

1 The engineer will measure:

1. Asphalt Binder (PG __ - __) by the short ton [metric ton] in accordance with Subsection 109.1.3(8), Asphalt Materials. Asphalt binder incorporated in level of control 5 mix will not be measured directly for payment. No payment will be made for the asphalt binder in excess of the approved contractor mix design value plus 0.25 percent. When

the department allows a change from an available material source in accordance with Subsection 106.3.2.2, Available Material Sources, no payment will be made for the asphalt binder in excess of the mix design shown in the contract plus 0.25 percent, or the approved contractor mix design plus 0.25 percent, whichever is less.

2. Hot Plant Mix, Hot Plant Mix Approaches, Hot Plant Mix Leveling, Hot Plant Mix (Superpave), Hot Plant Mix Approaches (Superpave), Hot Plant Mix Leveling (Superpave), Hot Plant Mix (Recycle), and Hot Plant Mix Leveling (Recycle) by the short ton [metric ton]. The cumulative weight [mass] of all batches of plant mix incorporated will be used for payment. The use of batch scales will be allowed.

3. Test Strip by the each.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Asphalt Binder (PG ___ - ___)	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]
Hot Plant Mix	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Hot Plant Mix Approaches	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Hot Plant Mix Approaches (Superpave)	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Hot Plant Mix Leveling	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Hot Plant Mix Leveling (Superpave)	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Hot Plant Mix (Recycle)	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Hot Plant Mix Leveling (Recycle)	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Hot Plant Mix (Superpave)	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Test Strip	EA [Ea]	EA [Ea]	EA [Ea]

401.5.2 Referenced Sections For Direct Payment

1 When specified, the engineer will measure and pay for:

1. Milling Plant Mix in accordance with Section 202, Removal.
2. Hydrated Lime in accordance with Section 413, Hydrated Lime.
3. Contractor Testing to perform the sampling, quality control and quality acceptance testing, and mix design requirements in accordance with Subsection 106.12, Contractor Testing.
4. Haul in accordance with Section 204, Haul.

401.5.3 Determination of Pay Factors

401.5.3.1 General

1 If warranted, a bonus will be paid when the engineer's verification test results are used for acceptance for the first lot that the results of the contractor's quality acceptance tests and the engineer's verification tests differ. A bonus will not be paid on subsequent lots when verification tests differ from the contractor's quality acceptance tests if correlation has not been completed and accepted.

401.5.3.2 Performance Graded Asphalt Binder

1 PGAB placed on the project which does not meet the contract requirements for the designated grade may be accepted and the price adjusted in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

2 For each lot, the engineer will compute a pay factor for each applicable property and will use the lowest resulting pay factor for the entire lot. The applicable properties and corresponding pay factors in accordance with Table 401.5.3-1, PGAB Pay Factors, form the basis for acceptance.

Table 401.5.3-1
PGAB Pay Factors

Dynamic Shear (G*/Sinδ), original PGAB, High grade temp., kPa	Dynamic Shear (G*/Sinδ), RTFO residue, High grade temp., kPa	Creep Stiffness (S), PAV residue, Low grade temp. +10 °C, MPa	Creep Slope (m-value), PAV residue, Low grade Low grade temp. +10 °C unitless	Elastic Recovery, RTFO residue, 77 °F, %	Pay Factor
≥ 0.90	≥ 1.98	≤ 311	≥ 0.294	≥ 55	1.00
0.89	1.97 - 1.95	312 - 315	0.293 - 0.291	54	0.95
0.88 - 0.87	1.94 - 1.91	316 - 320	0.290 - 0.288	53	0.90
0.86	1.90 - 1.88	321 - 324	0.287 - 0.285	52	0.85
0.85 - 0.84	1.87 - 1.85	325 - 329	0.284 - 0.282	51	0.80
0.83	1.84 - 1.82	330 - 333	0.281 - 0.280	50	0.75
0.82 - 0.81	1.81 - 1.78	334 - 337	0.279 - 0.277	49	0.70
0.80	1.77 - 1.75	338 - 342	0.276 - 0.274	48	0.65
0.79 - 0.78	1.74 - 1.72	343 - 346	0.273 - 0.271	47	0.60
0.77	1.71 - 1.68	347 - 351	0.270 - 0.268	46	0.55
0.76 - 0.75	1.67 - 1.65	352 - 355	0.267 - 0.265	45	0.50
< 0.75	< 1.65	> 355	< 0.265	< 45	REJECT

[3] If elastic recovery is applicable and test result equals zero, pay factor for elastic recovery equals 0.50.

[4] For non-specification PGAB with pay factor less than 1.00, the engineer will split the original lot into separate lots, each sample representing a single lot.

401.5.3.3 Plant Mix

1 The engineer will determine a pay factor for aggregate gradation and asphalt binder content for level of control 2, 3 and 4 mixes, and a pay factor for in-place density for in-place density I pavements as follows:

1. **Virgin Aggregate Gradation.** The engineer will compute the quality level analysis in accordance with procedures in Subsection 113.1, Acceptance of Aggregate. A pay factor will be calculated for each lot.

2. **In-Place Density.** For each core density determined by the contractor's quality acceptance tests in accordance with Subsection 401.4.7, Quality Acceptance Testing, the engineer will determine the percentage density in accordance with the *Materials Testing Manual* and round to the nearest 0.01 percent. Determine the average and sample standard deviation of the lot or test strip using the following formulas:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} = \textit{Average Density}$$

$$s = \sqrt{\left(\frac{1}{n-1}\right) \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

Where:

$\mathbf{x_i}$	=	the percentage density of individual cores
n	=	the number of core densities
$\bar{x}$	=	the average percentage density
s	=	the sample standard deviation of the percentage density
Σ	=	summation

Calculate the quality index as follows:

$$Q_I = \frac{(\bar{x} - 92.00)}{s}$$

Where: Q_I = the quality index, rounded to the nearest 0.01

If the average density exceeds 96.00 percent, the pay factor will be the lesser of 1.00 and the pay factor determined from Table 401.5.3-2, In-Place Density Pay Factors. If the quality index equals or exceeds 0.01 and the percent density is less than or equal to 96.00 percent, determine the pay factor from Table 401.5.3-2, In-Place Density Pay Factors.

Table 401.5.3-2
In-Place Density Pay Factors

Quality Index		Pay Factor	Quality Index		Pay Factor	Quality Index		Pay Factor
From	To		From	To		From	To	
	≤0.00	Reject	0.50	0.53	0.67	1.08	1.11	0.85
0.01	0.01	0.50	0.54	0.56	0.68	1.12	1.14	0.86
0.02	0.04	0.51	0.57	0.59	0.69	1.15	1.18	0.87
0.05	0.07	0.52	0.60	0.62	0.70	1.19	1.21	0.88
0.08	0.10	0.53	0.63	0.65	0.71	1.22	1.25	0.89
0.11	0.13	0.54	0.66	0.69	0.72	1.26	1.28	0.90
0.14	0.16	0.55	0.70	0.72	0.73	1.29	1.31	0.91
0.17	0.19	0.56	0.73	0.75	0.74	1.32	1.34	0.92
0.20	0.22	0.57	0.76	0.78	0.75	1.35	1.37	0.93
0.23	0.25	0.58	0.79	0.82	0.76	1.38	1.40	0.94
0.26	0.28	0.59	0.83	0.85	0.77	1.41	1.43	0.95
0.29	0.31	0.60	0.86	0.88	0.78	1.44	1.46	0.96
0.32	0.34	0.61	0.89	0.91	0.79	1.47	1.49	0.97
0.35	0.37	0.62	0.92	0.95	0.80	1.50	1.52	0.98
0.38	0.40	0.63	0.96	0.98	0.81	1.53	1.55	0.99
0.41	0.43	0.64	0.99	1.01	0.82	1.56	3.57	1.00
0.44	0.46	0.65	1.02	1.04	0.83		≥3.58	1.10
0.47	0.49	0.66	1.05	1.07	0.84			

3. **Asphalt Binder Content** will be determined by the engineer for each lot and by determining asphalt binder used as a percentage of plant mix produced. The binder's weight [mass] will be determined from delivery invoices and the quantity of material remaining in the storage

tank at the end of a day's production. The calculation to determine content will include all material used during the day's production of plant mix, including asphalt binder and plant mix not incorporated into the project. A pay factor will be determined in accordance with Table 401.5.3-3, Asphalt Binder Content Pay Factors.

Table 401.5.3-3
Asphalt Binder Content Pay Factors

Variance of Asphalt Binder Content from Design Content (%)	Pay Factor
0.00–0.10	1.05
0.11–0.25	1.00
0.26–0.30	0.95
0.31–0.35	0.90
0.36–0.40	0.85
0.41–0.45	0.80
0.46–0.50	0.75
≥ 0.51	Reject

2 The engineer will use a pay factor of 1.0 for lots of less than 1000 short tons [metric tons]. The pay factor for an accepted test strip will be 1.0.

401.5.4 Pay Adjustments

1 The engineer will calculate pay adjustments for aggregate gradation, in-place density, and asphalt binder content as follows:

Aggregate Gradation: $PA_A = 0.67 \times PMP \times (PF_A - 1) \times (LS_A - AP_Q)$

$PA_A = 0.67 \times PMP_{AP} \times (PF_A - 1) \times (LS_A - ML_Q)$

Aggregate Gradation for Recycle:	PA_A	=	$0.67 \times RPMP \times (RPF - 1) \times (LS_A - AP_Q)$
	PA_A	=	$0.67 \times PMP_{AP} \times (RPF - 1) \times (LS_A - ML_Q)$
In-Place Density:	PA_D	=	$1.33 \times PMP \times (PF_D - 1) \times LS_D$
Asphalt Binder Content:	PA_{AC}	=	$0.67 \times PMP \times (PF_{AC} - 1) \times (LS_{AC} - AP_Q)$
	PA_{AC}	=	$0.67 \times PMP_{AP} \times (PF_{AC} - 1) \times (LS_{AC} - ML_Q)$

Where:

PA_A	=	Pay Adjustment for Aggregate Gradation (dollars)
PA_D	=	Pay Adjustment for In-Place Density ($$)
PA_{AC}	=	Pay Adjustment for Asphalt Binder Content ($$)
PMP	=	Unit Contract Price for the respective Plant Mix Pavement pay item($$)
PMP_{AP}	=	Unit Contract Price for the respective Plant Mix Pavement Approaches pay item ($$)
$RPMP$	=	Recycled Hot Plant Mix Pavement Unit Contract Price ($$)
PF_A	=	Aggregate Gradation Pay Factor for evaluated lot
RPF	=	Virgin Aggregate Gradation Pay Factor for evaluated lot
PF_D	=	In-Place Density Pay Factor for evaluated lot
PF_{AC}	=	Asphalt Binder Content Pay Factor for evaluated lot
LS_A	=	Lot Size for Aggregate Gradation evaluated lot (short ton [metric ton])
LS_D	=	Lot Size for In-Place Density evaluated lot (short ton [metric ton])
LS_{AC}	=	Lot Size for Asphalt Binder Content evaluated lot (short ton [metric ton])
AP_Q	=	Quantity of Plant Mix Pavement from the lot placed as approach pavement (short ton [metric ton])
ML_Q	=	Quantity of Plant Mix Pavement from the lot placed as mainline pavement (short ton [metric ton])

2 For the Hot Plant Mix Leveling, Hot Plant Mix Leveling (Superpave), and Hot Plant Mix Leveling (Recycle) pay items, the engineer will make pay adjustments for aggregate gradation and asphalt binder content but not for in-place density.

SECTION 402
Vacant

SECTION 403
Plant Mix Pavement Crack Sealing

403.1 DESCRIPTION

1 This section describes the requirements for sealing cracks in plant mix pavement.

403.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Aggregate for Blotter	803
Backer Rod	807.7
Hot-Poured Elastic Sealant	807.2

2 Other materials may be used as blotter material, including portland cement, fly ash, sawdust, blotter paper, or biodegradable, non-toxic, non-hazardous compounds designed to form a temporary protective barrier over the sealant to prevent tracking.

403.3 EQUIPMENT

403.3.1 Removing Existing Sealant

1 Provide a plow, ripping tooth, wire brush, saw, or other equipment to remove existing sealant from cracks. Use carbide-tipped blades or better.

403.3.2 Routing

1 Provide mechanical, power-driven routing equipment that produces a reservoir with vertical sides and a flat bottom to the required dimensions. Do not use star bit type routers or equipment designed to plow the cracks to size. Use carbide-tipped blades or better.

403.3.3 Cleaning/Drying

1 Provide an air compressor that produces clean, oil-free, compressed air with an output of at least 125 ft^3/min [3.5 m^3/min]; equip with a ¾-inch [19 mm] diameter or smaller nozzle. Do not use backpack blowers. Provide compressed air heat

lances that produce clean, oil-free, compressed air at least 750 ºF [400 ºC] at a velocity of at least 650 ft/s [200 m/s]. Do not use direct flame driers.

403.3.4 Sealing

1 Provide a melting machine with a melting capacity of at least 100 gal/h [400 L/h] while continuously maintaining the recommended sealant application temperature. Equip to continuously agitate and mix the sealant during application.

2 Apply sealant with a pressure-type applicator equipped with a wand with the outlet tip attached to a fixed-size nozzle or an inside diameter cup of 2 in ± 0.25 in [50 mm ± 6 mm] or an approved equal.

3 Provide a compressed air heater if required by conditions.

4 Provide a U-shaped squeegee for smoothing the sealant.

403.4 CONSTRUCTION

403.4.1 General

1 Seal cracks between the dates specified. Provide the engineer access to equipment and storage area at all times. Dispose of cartons as sealant is installed as approved by the engineer. Do not use equipment that damages pavement, including spalling and overcutting. Remove and replace improperly installed sealant at no additional cost to the department. For the construction type specified, use the operations in Table 403.4.1-1, Requirements for Crack Sealing.

Table 403.4.1-1
Requirements for Crack Sealing

TYPE	REQUIRED CONSTRUCTION OPERATIONS				
	Removing Existing Sealant	Routing Crack	Cleaning and Drying Crack	Sealant Configuration	
				Flush	Recessed
I		X	X	X	
II			X	X	
III		X	X		X
IV			X		X
V	X	X	X	X	
VI	X		X	X	
VII	X	X	X		X
VIII	X		X		X

403.4.2 Removing Existing Sealant

1 When specified, remove existing sealant from cracks without damaging the pavement.

403.4.3 Routing

1 Rout no more than can be sealed each day, and in accordance with Table 403.4.3-1, Routing Dimensions.

Table 403.4.3-1
Routing Dimensions

<table>
<tr><th rowspan="2">Crack Width</th><th colspan="2">Sealant</th></tr>
<tr><th>AASHTO M 324
Type 1
WY Modified</th><th>AASHTO M 324
Type IV
WY Modified</th></tr>
<tr><td>< ⅛ in [3 mm]</td><td colspan="2">does not need routing or sealing</td></tr>
<tr><td>⅛ in to less than ½ in [3 mm to less than 12 mm]</td><td>rout to
½ in wide × ¾ in deep
[12 mm wide × 19 mm deep]</td><td rowspan="2">rout to
¾ in wide × ¾ in deep
[19 mm wide × 19 mm deep]</td></tr>
<tr><td>½ in to ¾ in
[12 mm to 19 mm]</td><td>does not need routing</td></tr>
<tr><td>> ¾ in [19 mm]</td><td colspan="2">does not need routing</td></tr>
</table>

403.4.4 Cleaning/Drying

1 Use compressed air to clean cracks and reservoirs of dust, dirt, and other deleterious materials. Prepare cracks by using compressed air heat lances, but do not overheat the pavement. Before applying sealant, clean and dry cracks exposed to precipitation. The engineer will inspect prepared cracks before sealing.

2 Before reopening the roadway to traffic, remove debris using a power broom or other approved means. Remove swept material from curb and gutter areas.

403.4.5 Lot Sizes, Sampling, and Testing

403.4.5.1 Quantity Equal to or Less Than 45,000 lb [20 000 kg] or Incidental

1 Submit written certification 30 calendar days before sealing. Ensure certification from sealant manufacturer/supplier specifically states compliance with appropriate AASHTO specification, either M 324 Type 1 WY Modified or M 324 Type IV WY Modified. Include quality control data from sealant manufacturer/supplier for the production run of crack sealant. The department defines a “production run” as the weight [mass] of sealant produced during one cycle from startup to shutdown of the manufacturer’s equipment. For quality control data, use format

and units described in Table 807.2-1, Hot-Poured Elastic Sealant Specification Limits. Report results for the bond test as the sum of successful extensions for all three specimen blocks for the required number of complete cycles specified in Table 807.2-1, Hot-Poured Elastic Sealant Specification Limits.

403.4.5.2 Quantity Greater Than 45,000 lb [20 000 kg]

1 One test series is one sample tested for each applicable property for the type of sealant as shown in Table 807.2-1, Hot-Poured Elastic Sealant Specification Limits. The engineer will test all samples. Partial lots of less than three samples will be combined with previous lot for analysis. Analysis will not exceed five samples per lot.

2 The department defines a lot as the quantity represented by three test series or no more than 90,000 lb [40 000 kg]; a sublot is the quantity represented by one test series or no more than 30,000 lb [13 000 kg]. If the exact quantity in a lot varies due to changes in production or construction schedules, three to five samples may represent a lot.

3 As directed, take samples of crack sealant in the presence of the engineer; do so directly from the applicator nozzle during sealing and once the melting equipment has stabilized for temperature and agitation/mixing. Provide two boxes that have a silicone release coating on the inside surfaces, each filled with 5 lb [2.3 kg] of sealant. Document the sample with the contractor's name, sealant manufacturer's name and address, lot and sublot number, total sublot quantity, type of sealant, department project number, and project location. From each sample, the engineer will keep one box of sealant as a referee sample.

403.4.6 Sealing

403.4.6.1 General

1 Before starting, give the engineer two copies of the sealant manufacturer's recommendations for preparation, handling, mixing, and application.

2 Seal cracks only in dry weather. Ensure that pavement inside the crack is at least 40 ºF [5 ºC] unless the manufacturer requires a higher temperature; if necessary, heat the pavement. Keep the sealant at the manufacturer recommended application temperature. Do not begin installing sealant until the equipment has stabilized for temperature and agitation/mixing.

3 Seal cracks or portions of cracks greater than ⅛ in [3 mm] wide, unless otherwise approved by the engineer. Apply sealant from the bottom up. When using the cup attachment, hold it firmly against the roadway surface during application. When using squeegees, smooth sealant tightly against the pavement. Center the squeegeed band on the crack so that the width on either side of the crack is no more than 1 in [25 mm].

4 Seal cracks so that the finished, cured surface is to the configuration specified:

1. **Flush Configuration.** Flush with the pavement and is not recessed into the crack by shrinkage.

2. **Recessed Configuration.** Recess below the pavement ¼ in [6 mm]. Do not use squeegees or wands with a 2 in [50 mm] inside diameter cup.

5 If sealant flows out the end of the crack, plug or dike the end as approved by the engineer. Remove spilled sealant, and reseal properly. Remove excess sealant from roadway while it is still liquid. If sealant pulls out or tracking occurs, apply blotter material to minimize damage. Replace sealant damaged by tracking at no additional cost to the department.

6 Do not mix sealant from different manufacturers in the sealing machine. Purge the machine (empty the kettle, hoses, etc.) of sealant before switching sealants. Follow manufacturer recommendations for mixing sealant from different production runs.

403.4.6.2 Backer Rod

1 Install backer rod only when

1. AASHTO M 324 Type IV WY Modified sealant is specified;

2. Final width of crack or reservoir exceeds ⅜ in [10 mm]; and

3. Full depth of crack, including routed reservoir if applicable, exceeds 1½ in [38 mm].

2 Install backer rod with the top edge recessed ¾ in [19 mm] below the pavement. Install AASHTO M 324 Type IV WY Modified sealant.

403.4.7 Crack Seal Acceptance

1 The engineer will accept crack sealant material as follows:

1. **Quantity Equal to or Less Than 45,000 lb [20 000 kg] or Incidental to Other Pay Items.** Based on the written certification of production sealant in accordance with Subsection 403.4.5, Lot Sizes, Sampling and Testing.

2. **Quantity Greater Than 45,000 lb [20 000 kg].** Based on random samples and a quality analysis to determine a pay factor for each lot when tested in accordance with Subsection 403.4.5, Lot Sizes, Sampling, and Testing. If the pay factor for a lot is less than 0.50, the engineer will evaluate the material for acceptance in accordance with Subsection 113.2, Acceptance of Asphalt Material, paragraph 2.

403.5 MEASUREMENT and PAYMENT

403.5.1 General

1 The engineer will measure Crack Seal (Plant Mix) by the pound [kilogram] of sealant.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Crack Seal (Plant Mix)	LB [kg]	lb [kg]	LB [kg]

403.5.2 Determination of Pay Factor and Pay Adjustment

403.5.2.1 General

1 For projects with a quantity greater than 45,000 lb [20 000 kg], the engineer will determine a pay factor for each property and the lowest pay factor of all the properties will be the pay factor for the lot.

2 The engineer will evaluate the sealant using the compliance limits in accordance with Table 403.5.2-1 Hot-Poured Elastic Sealant Compliance Limits, to establish the pay factor.

Table 403.5.2-1
Hot-Poured Elastic Sealant Compliance Limits[(1)]

PROPERTY	COMPLIANCE LIMITS			
	AASHTO M 324 Type 1 WY Modified		AASHTO M 324 Type IV WY Modified	
	Lower	Upper	Lower	Upper
Cone Penetration	—	97	83	162
Flow	—	6	—	4
Bond	5	—	—	—
Bond, 200% Extension	—	—	3	—
Relative Density	—	1.200	—	1.120
Softening Point, ºF [ºC]	—	—	165.0 [74.0]	—

(1) For appropriate test procedures and measurement units, see Table 807.2-1, Hot-Poured Elastic Sealant Specification Limits.

3 If the average relative density is greater than the compliance limit, the engineer will calculate the pay factor as follows, rounding to the nearest 0.01:

$$\text{Pay Factor} = (PF_{\text{Quality Analysis}}) - [\text{the GREATER of } 0.01 \text{ or } \frac{\bar{x} - CL_U}{CL_U}]$$

Where: $\mathbf{PF}_{\textbf{Quality Analysis}}$ = pay factor as determined from quality analysis with an obtainable pay factor no greater than 1.00

$\bar{x}$ = average relative density

$\mathbf{CL_U}$ = upper compliance limit for relative density

4 For lots with a pay factor less than 1.00, the engineer will keep corresponding referee samples for 1 year from the issue date of report. Referee samples will not be kept for lots having a pay factor of 1.00 or greater.

403.5.2.2 Quality Level Analysis (Except Bond Test)

1 The engineer will compute quality level analysis for each lot, except for the bond test, as follows:

Note: For Relative Density, only the arithmetic mean will be computed.

1. Determine the arithmetic mean $\bar{x}$ rounded to the nearest 0.1 (0.01 for Softening Point, 0.001 for Relative Density).

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Where:

$\bar{x}$	=	arithmetic mean
$\sum$	=	summation
$\mathbf{x_i}$	=	individual test value from each test series
n	=	total number of test values

2. Compute the sample standard deviation **s** rounded to the nearest 0.01 (0.001 for Softening Point).

$$\mathbf{s} = \sqrt{\left(\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n - 1}\right)}$$

Where:

s	=	sample standard deviation
$\bar{x}$	=	arithmetic mean
$\sum$	=	summation
$\mathbf{x_i}$	=	individual test value from each test series
n	=	total number of test values

3. Compute the upper quality index Q_U rounded to the nearest 0.01.

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

Where:
$\bar{x}$ = arithmetic mean
$\mathbf{Q_U}$ = upper quality index
$\mathbf{CL_U}$ = upper compliance limit or maximum
s = sample standard deviation

4. Compute the lower quality index Q_L rounded to the nearest 0.01.

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

Where:
$\bar{x}$ = arithmetic mean
$\mathbf{Q_L}$ = lower quality index
$\mathbf{CL_L}$ = lower compliance limit or minimum
s = sample standard deviation

5. Determine P_U (theoretical percentage below the upper compliance limit corresponding to a given Q_U) from Table 113.1-1, Quality Level Analysis by the Standard Deviation Method. If a CL_U is not specified, then $P_U = 100$.

6. Determine P_L (theoretical percentage above the lower compliance limit corresponding to a given Q_L) from Table 113.1-1, Quality Level Analysis by the Standard Deviation Method. If a CL_L is not specified, then $P_L = 100$.

7. Determine the Quality Level (the total theoretical percentage within the compliance limits), rounded to the nearest whole number.

Quality Level = $(P_U + P_L) - 100$

Where: **P_U** = theoretical percentage below the upper compliance limit corresponding to a given Q_U

P_L = theoretical percentage above the lower compliance limit corresponding to a given Q_L

8. Determine the pay factor from Table 403.5.2-2, Pay Factor, corresponding to the quality level and number of sublot samples.

403.5.2.3 Quality Level Analysis (Bond Test)

1 For the bond test, the engineer will compute quality level analysis for each lot as follows:

1. Calculate the quality level, which is equal to the percentage of completed bond cycles for all sample blocks, rounded to the nearest whole number.

$$\textit{Quality Level} = \left[\frac{\sum_{\text{block 1}}^{\text{block n}} \text{Completed Bond Cycles}}{(n \times CL_L)} \right] \times 100$$

Where: $\sum$ = summation of completed cycles for test blocks 1 through n (includes all test series)

n = total number of test blocks in the lot or (number of sublots in lot) × (3 blocks per sublot)

CL_L = lower compliance limit or minimum

2. Determine the pay factor corresponding to the quality level and number of sublot samples using Table 403.5.2-2, Pay Factor.

Table 403.5.2-2
Pay Factor

Pay Factor	MINIMUM REQUIRED QUALITY LEVEL		
	Sample Size = number of sublots		
	n = 3	n = 4	n = 5
1.03	97	98	99
1.02	90	93	96
1.01	84	89	93
1.00	68	74	78
0.97	66	73	78
0.94	64	72	77
0.90	61	71	77
0.87	59	68	74
0.85	58	67	73
0.83	57	66	71
0.80	54	64	69
0.78	53	62	67
0.76	52	61	66
0.73	50	59	64
0.70	48	57	61
0.69	47	56	60
0.67	46	55	59
0.64	44	52	56
0.63	43	51	55
0.61	41	49	53
0.59	40	47	51
0.57	38	45	49
0.55	36	43	47
0.52	34	40	43
0.50	32	38	41

2 The engineer will compute payment adjustment for each lot separately using the following equation:

$$PA = (PF\text{-}1.00) \times (\text{CONTRACT UNIT PRICE}) \times (\text{ACTUAL QUANTITY})$$

Where: **PA** = pay adjustment

PF = pay factor from Table 403.5.2-2, Pay Factor

SECTION 404
Plant Mix Wearing Course

404.1 DESCRIPTION

1 This section describes the requirements for the construction of a plant mix wearing course on a prepared surface.

404.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Aggregate for Wearing Course	803
Asphalt Binder	804.1
Emulsified Asphalt	804.3
Hydrated Lime	820
Water	814

2 Provide asphalt binder as specified and in accordance with Subsections 401.2.1, Performance Graded Asphalt Binder, and Subsection 401.4.6.2, Performance Graded Asphalt Binder.

3 Use Emulsions SS-1, CSS-1, SS-1h, or CSS-1h.

404.3 EQUIPMENT

404.3.1 Seal Coat

1 Provide an asphalt distributor for heating and applying emulsified asphalt that meets the requirements of Subsection 407.3, Equipment. Provide power-operated rotary brooms for cleaning the roadway.

404.3.2 Plant Mix Wearing Course

1 Provide equipment in accordance with Subsection 401.3, Equipment.

404.4 CONSTRUCTION

404.4.1 General

1 Follow the construction requirements in Section 401, Plant Mix Pavements and Recycled Plant Mix Pavements, except as modified.

2 Place plant mix wearing course between June 1 and September 15. The engineer may give written approval to extend these dates. Schedule a prepaving conference before placement to discuss materials, equipment, and procedures.

404.4.2 Quality Requirements

1 Construct wearing course using quality control and quality acceptance procedures in accordance with the following subsections, as applicable based on testing requirements in Table 404.4.2-1, Testing Requirements.

Laboratory and Personnel	114
Correlation	114
Resolution	114
Quality Control Testing	401.4.6
Quality Acceptance Testing	401.4.7
Verification	401.4.8
Independent Assurance	401.4.9
Documentation and Reporting	401.4.10.1(1) except that no testing or results are required for items 1.2, 1.4, and 401.4.10.2
Corrective Action Plan	401.4.11

2 The department does not require recorrelation before placement if correlation testing for aggregate tests has already been performed with placement of plant mix pavement and the contractor's and department's personnel and equipment have remained unchanged.

3 Perform quality acceptance testing in accordance with Table 404.4.2-1, Testing Requirements.

404.4.2.1 Testing Requirements

1 Before placement, test a split aggregate sample in accordance with Subsection 114.3.3.2, Aggregate Gradation.

2 Test for quality control, quality acceptance, and verification in accordance with Table 404.4.2-1, Testing Requirements.

Table 404.4.2-1
Testing Requirements

Test Procedure	Test Frequency (1)
Quality Control–Virgin Aggregate Production	
Gradation; Liquid Limit (LL); Plasticity Index (PI); Coarse Aggregate Angularity (Fractured Faces); Fine Aggregate Angularity; Flat & Elongated (2)	1/1000 ton [1/1000 t] minimum
LA Abrasion (Contractor-Furnished Sources only)	1/10,000 ton [1/10 000 t] minimum
Soundness (MgS04) (3), (4) (Contractor-Furnished Source only)	1/20,000 ton [1/20 000 t] minimum
Sand Equivalent (3) (Contractor-Furnished Source only)	1/5000 ton [1/5000 t] minimum
Quality Acceptance–Mix Production (5)	
Virgin Aggregate Gradation	1 lot/5000 ton [1 lot/5000 t]
Asphalt Binder Content	1/day
Virgin Aggregate-LL; PI; Coarse Aggregate Angularity (Fractured Faces); Fine Aggregate Angularity, Flat & Elongated (6)	1/1000 ton [1/1000 t] minimum
Moisture Content of Virgin Aggregate/Hydrated Lime	1/1000 ton [1/1000 t] minimum
Moisture Content of Mix	1/day
Verification–Mix Production	
Virgin Aggregate Gradation	1/lot
Asphalt Binder Content	No tests required
Virgin Aggregate-LL; PI; Coarse Aggregate Angularity (Fractured Faces); Moisture Content of Virgin Aggregate/Hydrated Lime; Moisture Content of Mix; Flat & Elongated	No tests required
Aggregate/Hydrated Lime; Moisture Content of Mix; Flat & Elongated	

(1) Testing frequencies shown are minimum quantities. Example: 1 min/1000 ton [1 min/1000 t].

(2) If the first three tests for LL, PI, and coarse aggregate angularity, fine aggregate angularity, and flat and elongated are within specification, and there are no changes in the crushing process, test at a frequency of 1/10,000 ton [1/10 000 t].

(3) Not required if these tests were performed and found acceptable during production of the plant mix pavement.

(4) Soundness (MgSO4) will be tested on coarse and fine aggregate separately. The specification for soundness will apply to the coarse aggregate only.

(5) Quality acceptance tests may be used for quality control purposes.

(6) Not required if the results for these tests performed during aggregate production were within specification.

404.4.3 Job Mix Formula (JMF)

1 At least 14 calendar days before starting the placement of plant mix wearing course, submit a JMF with samples of produced material for each aggregate fraction to the engineer for approval. Ensure that the JMF and allowable tolerances are within the broadband specified in Subsection 803.6, Aggregate for Plant Mix Wearing Course. Use the JMF to establish a single percentage of aggregate passing each required sieve size and a single mixing temperature. The Materials Program will specify the percentage of asphalt binder to be added. Furnish mix with aggregate fractions within the wide band limits and the tolerance ranges above and below the target job mix formula as shown in Table 404.4.3-1, Aggregate Tolerances.

Table 404.4.3-1
Aggregate Tolerances

Sieve Size	Range
Passing No. 4 [4.75 mm] sieve	- 5 % to + 5 %
Passing No. 8 [2.36 mm] sieve	- 5 % to + 5 %
Passing No. 200 [75 µm] sieve	- 2.0 % to + 2.0 %
Mixing Temperature	± 20 F degrees [± 7 C degrees]

2 Do not change the JMF without the engineer's written approval.

404.4.4 Mix Design

1 The Materials Program will perform laboratory testing to establish the optimum asphalt content for the wearing course based on the contractor's JMF.

404.4.5 Seal Coat

1 Place seal coat when the application surface is dry and the air and pavement surface temperature are at least 50 ºF [10 ºC].

2 Submit emulsified asphalt samples and certification documents in accordance with Subsection 407.4.2, Sampling Procedures.

3 The application rate specified for emulsified asphalt is for specification material before additional dilution for field application. Emulsified asphalt used for seal coat may be diluted in the field at a ratio of 1 part emulsified asphalt to 1 part water (1:1). Before mixing, heat the dilution water and the emulsion to at least 110 ºF [45 ºC]; dilute by introducing the water into the emulsified asphalt.

4 Apply the seal coat so that there is uniform, complete coverage, and within the temperature range specified in Table 407.4.3-1, Emulsion Application Temperatures for Tack Coat.

5 Do not apply more seal coat to the surface area than can be covered by that day's production of plant mix wearing course.

404.4.6 Compaction

1 Compact the plant mix wearing course with three passes of a steel wheel roller in static mode. The department defines one pass with a roller as a forward or backward movement over the full length of the area to be compacted.

404.4.7 Surface Tolerances

1 Test the surface using a 10-foot [3 m] straightedge at selected locations. Do not allow variation of the surface from the straightedge between any two contacts with the surface greater than $^{3}/_{16}$ in [5 mm]. Remove and replace defective work with new material.

404.4.8 Acceptance

1 The engineer may isolate and reject obviously defective material without regard to testing procedures; otherwise, the engineer will accept or reject materials as follows:

1. **Emulsified Asphalt** in accordance with Subsection 113.2, Acceptance of Asphalt Materials.
2. **PGAB** in accordance with Subsection 804.1, Performance Graded Asphalt Binder, and Subsection 113.2, Acceptance of Asphalt Materials.
3. **Aggregate Gradation** in accordance with Subsection 113.1, Acceptance of Aggregate.
4. **Asphalt Binder Content** in accordance with Subsection 401.5.3.3 (3), Asphalt Binder Content.
5. **Moisture Content of Virgin Aggregate/Hydrated Lime** based on each individual test and the quantity of water added.
6. Based on each individual test for:

   6.1. **Liquid Limit and Plastic Index**;

   6.2. **Moisture Content of Plant Mix**; and

   6.3. **Coarse and Fine Aggregate Angularity**.

404.5 MEASUREMENT and PAYMENT

404.5.1 General

1 The engineer will measure:

1. Plant Mix Wearing Course by the short ton [metric ton], including the weight [mass] of the aggregate, performance graded asphalt binder, and hydrated lime. The cumulative weight [mass] of batches of plant mix wearing course incorporated in the work will be used for payment.

2. Seal Coat by the short ton [metric ton] of specification product in accordance with Subsection 109.1.3, Measurement Methods. The weight [mass] of Seal Coat will include the weight [mass] of water specified for mixture at the refinery as part of the designated type of emulsified asphalt.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Plant Mix Wearing Course	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Seal Coat	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]

404.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Asphalt Binder (PG __ - __) in accordance with Section 401, Plant Mix Pavements and Recycled Plant Mix Pavements.

2. Hydrated Lime in accordance with Section 413, Hydrated Lime.

3. Contractor Testing in accordance with Subsection 106.12, Contractor Testing, to perform the sampling and quality control and quality acceptance testing requirements.

4. Haul in accordance with Section 204, Haul.

404.5.3 Determination of Pay Factors

1 The engineer will determine pay factors as follows:

1. **PGAB** in accordance with Subsection 401.5.3.2, Performance Graded Asphalt Binder.

2. **Virgin Aggregate Gradation** for each lot in accordance with Subsection 113.1, Acceptance of Aggregate.

3. **Asphalt Binder Content** in accordance with Subsection 401.5.3.3(3), Asphalt Binder Content.

404.5.4 Price Adjustment

404.5.4.1 Emulsified Asphalt

1 If the samples for a truckload are not received by the Materials Program within seven calendar days of sampling, in accordance with Subsection 407.4, Construction, the engineer will reduce the payment by as much as 25 percent for that load.

2 The engineer may reduce the payment for emulsified asphalt that does not meet specifications but is accepted in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

404.5.4.2 Plant Mix Wearing Course

1 The engineer will calculate pay adjustments for aggregate gradation and asphalt binder content using the following formulas:

Aggregate Gradation: $PA_A = 0.67 \times PMWC \times (PF_A - 1) \times LS_A$

Asphalt Binder Content: $PA_{AC} = 0.67 \times PMWC \times (PF_{AC} - 1) \times LS_{AC}$

Where:

PA_A	=	Pay Adjustment for Aggregate Gradation (dollars)
PMWC	=	Plant Mix Wearing Course Contract Unit Price (dollars)
PF_A	=	Aggregate Gradation Pay Factor for evaluated lot
LS_A	=	Lot Size for Aggregate Gradation evaluated lot (short ton [metric ton])
PA_{AC}	=	Pay Adjustment for Asphalt Binder Content (dollars)
PF_{AC}	=	Asphalt Binder Pay Factor for evaluated lot
LS_{AC}	=	Lot Size for Asphalt Binder Content evaluated lot (short ton [metric ton])

SECTION 405
Vacant

SECTION 406
Plant Mix Pavement (Commercial Mix)

406.1 DESCRIPTION

1 This section describes the requirements for providing, hauling, and placing one or more courses of commercial plant mix on a prepared foundation.

406.2 MATERIALS

1 Provide plant mix pavement composed of a mixture of aggregate and asphalt binder from a commercial source. Obtain the engineer's approval before adding natural fillers or commercial additives.

406.3 EQUIPMENT

1 Provide equipment in accordance with Subsection 401.3, Equipment.

406.4 CONSTRUCTION

1 Observe weather and temperature restrictions in accordance with Subsection 401.4.2, Weather and Seasonal Limitations.

2 At least 14 calendar days before use, submit the name of the proposed commercial source and a proposed mix design for the plant mix pavement to the engineer for approval. The mix design may be referenced to an approved design used within the past two years.

3 Spread and finish the mix in accordance with Subsection 401.4.19, Spreading and Finishing.

4 Compact the mix to ensure an in-place density that equals or exceeds 92.0 percent of maximum density.

5 Ensure surface tolerances are in accordance with Subsection 401.4.21, Surface Tolerances.

406.5 MEASUREMENT and PAYMENT

406.5.1 General

1 The engineer will measure Plant Mix (Commercial) by the short ton [metric ton].

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Plant Mix (Commercial)	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]

SECTION 407
Tack Coat

407.1 DESCRIPTION

1 This section describes preparing and coating an existing bituminous or concrete surface with emulsified asphalt.

407.2 MATERIALS

1 Use emulsions SS-1, CSS-1, SS-1h, or CSS-1h. Provide materials in accordance with the following:

Materials	**Subsection**
Emulsified Asphalt	804.3
Water	814

407.3 EQUIPMENT

1 Equip tank trucks delivering emulsified asphalt to the project and on-site storage tanks with a sampling valve similar in design to those shown in AASHTO T 40. Mount the valve on the truck or tank's discharge line. Consult the *Materials Testing Manual* for drawings of suggested mountings.

2 Provide an asphalt distributor that is equipped, maintained, and operated to apply bituminous material uniformly at variable widths. Equip with a tachometer, pressure gauges, accurate volume measuring devices or a calibrated tank, a thermometer for measuring temperatures of tank contents, a power unit for the pump, full circulation spray bars capable of being adjusted laterally and vertically, and a positive cut-off for the spray bars.

407.4 CONSTRUCTION

407.4.1 Surface Preparation

1 Clean the surface of extraneous material including vegetation, dirt, mud, and loose material. Clean edges of existing pavements that will border new pavement to allow adhesion of tack coat. Obtain the engineer's approval before applying the tack coat.

407.4.2 Sampling Procedures

1 Notify the supplier that emulsified asphalt samples are required for each conveyance at the time of loading. The department requires the supplier to collect 1-quart [1 L] samples in wide-mouth high-density polyethylene (HDPE) plastic containers (3⅝-inch [90 mm] outside diameter with 3-inch [75 mm] inside diameter opening by 6½ in [162 mm] total height including screw on lid) in accordance with ASTM D2911, ship them directly to the Materials Program in Cheyenne, ensure arrival no later than seven calendar days after sampling, and accompany each sample with a clearly identified copy of a certificate of compliance that shows the following:

1. Invoice number or bill of lading number;
2. Project number;
3. Tonnage;
4. Date;
5. Type and grade;
6. Producer; and
7. Type of modifier.

2 Ensure that the supplier of the emulsified asphalt submits each sample with quality control test results for the applicable tests specified in Subsection 804.3, Emulsified Asphalt, and that the test results submitted are for a production sample taken from the same production run and sales tank.

3 Give the certification documents (including the invoice, certificate of compliance, weigh ticket, quality control tests results, etc.) to the engineer at the time of each tank delivery.

407.4.3 Application

1 Apply tack coat in accordance with Subsection 401.4.2, Weather and Seasonal Limitations, and at the rate specified or approved. The specified application rate is for specification material before additional dilution for field application.

2 Emulsified asphalt used for tack coat may be diluted in the field at a ratio of 1 part emulsified asphalt to 1 part water (1:1). Before mixing, heat the dilution water and emulsified asphalt to a minimum temperature specified by the supplier. Dilute by introducing the water into the emulsified asphalt.

3 Apply the tack coat at a uniform temperature in accordance with Table 407.4.3-1, Emulsion Application Temperatures for Tack Coat.

Table 407.4.3-1
Emulsion Application Temperatures for Tack Coat

Emulsified Asphalt	Temperature
Non-polymer modified emulsions	70 to 160 °F [20 to 70 °C]

4 Maintain pressure so that the application rate varies no more than 0.02 gal/yd² [0.10 L/m²]. Apply the emulsified asphalt so that there is uniform, complete coverage at the rate specified. Correct deficiencies and areas not covered.

5 Before placing tack coat, place a section in the presence of the engineer to verify the application rates and the uniformity and completeness of coverage; make available the distributor manufacturer's instructions for calibrating an accurate spray pattern.

6 Limit application to the area that can be covered by that day's production equal in width to a single paving ribbon of plant mix pavement.

7 When traffic is present in construction areas, apply tack coat on one half of the application surface at a time. Do not allow traffic on the tack coat until it has cured sufficiently to prevent picking up or tracking.

407.4.4 Acceptance

1 The engineer will accept emulsified asphalt in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

407.5 MEASUREMENT and PAYMENT

407.5.1 General

1 The engineer will measure Tack Coat by the short ton [metric ton] in accordance with Subsection 109.1.3, Measurement Methods, and will include the weight [mass] of water specified for mixture at the refinery as part of the designated type of emulsified asphalt. Water added at the refinery or processing plant to dilute the emulsified asphalt will not be measured for payment. Quantities in excess of those specified or approved will not be measured directly for payment.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Tack Coat	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]

407.5.2 Price Adjustment

1 If the samples for a truckload are not received by the Materials Program within seven calendar days of sampling, in accordance with Subsection 407.4, Construction, the engineer will reduce the payment by as much as 25 percent for that load.

2 The engineer may reduce the payment for emulsified asphalt that does not meet specifications but is accepted in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

SECTION 408
Prime Coat

408.1 DESCRIPTION

1 This section describes the requirements for preparing and coating an existing surface with prime coat and, if required, blotter.

408.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Aggregate for Blotter	803
Liquid Asphalt	804.2

2 Provide liquid asphalt type MC-70.

3 Provide blotter material from a specified department-furnished or contractor-furnished source.

408.3 EQUIPMENT

1 Provide tank trucks, asphalt distributor, and on-site storage tanks in accordance with Subsection 407.3, Equipment.

2 Provide mechanical spreading equipment for applying the blotter material; do not use hand tools unless approved by the engineer.

408.4 CONSTRUCTION

408.4.1 General

1 Ensure an application surface shaped to the required grade and section, free of ruts, corrugations, segregated material, and other irregularities and uniformly compacted. Reprocess or reshape damaged areas caused by delays in applying the prime coat. Obtain the engineer's approval of the surface before applying prime coat.

2 Provide samples and certification documents for the liquid asphalt in accordance with *Materials Testing Manual*, Section 501.0, Liquid Asphalt Sampling.

3 Apply prime coat when the application surface is damp and both the air and surface temperatures are above 50 ºF [10 ºC].

4 Apply the liquid asphalt in accordance with Table 408.4.1-1, Application Temperatures for Liquid Asphalt.

Table 408.4.1-1
Application Temperatures for Liquid Asphalt

Liquid Asphalt Type and Grade	Temperature (°F [°C])
MC-30	50 to 120 [10 to 48]
MC-70	80 to 150 [27 to 65]

5 Apply the prime coat so that there is uniform, complete coverage at the rate specified or approved. Correct deficiencies and areas not covered.

6 When traffic is present in construction areas, apply prime coat on one half of the application surface at a time. Do not allow traffic on the surface until the prime coat has been sufficiently absorbed to prevent picking up or tracking. Cover unabsorbed quantities with blotter material; spread the material without operating the equipment's tires on the exposed, newly applied liquid asphalt.

408.4.2 Acceptance

1 The engineer will accept liquid asphalt in accordance with Subsection 113.2, Acceptance of Asphalt Material.

408.5 MEASUREMENT and PAYMENT

408.5.1 General

1 The engineer will measure:

1. Prime Coat by the short ton [metric ton] in accordance with Subsection 109.1.3, Measurement Methods.

2. Blotter by the short ton [metric ton] or cubic yard [cubic meter].

2 The engineer will not measure for payment quantities exceeding those specified or approved.

3 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Prime Coat	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]
Blotter	TON, CY [t, m^3]	0.05 ton, ft [0.05 t, 0.5 m]	0.05 TON, CY [0.05 t, m^3]

408.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for Haul in accordance with Section 204, Haul.

408.5.3 Payment Adjustment

1 The engineer may reduce the payment for liquid asphalt that does not meet specifications but is accepted in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

SECTION 409
Chip and Fog Seals

409.1 DESCRIPTION

1 This section describes the requirements for placing chip seal and fog seal, which the department defines as follows:

1. **Chip Seal.** An application of emulsified asphalt followed by an application of aggregate and, when specified, an emulsified asphalt overshoot.

2. **Fog Seal.** An application of emulsified asphalt and, where required, a blotter cover.

409.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Aggregate for Blotter and Chip Seal	803
Emulsified Asphalt	804.3

2 For fog seals and overshoots, use emulsions SS-1h or CSS-1h.

3 Ensure that the emulsion and aggregate are compatible for chip seals. If necessary, change the emulsion type or the aggregate source to ensure compatibility. If a polymer-modified emulsion is specified, do not change to a non-polymer-modified emulsion.

4 When the contract allows and the contractor elects to use a department-furnished source as a contractor-furnished source for the chip seal aggregate, meet the applicable requirements of Subsection 106.3.3, Contractor-Furnished.

409.3 EQUIPMENT

409.3.1 General

1 Ensure that equipment meets the following:

1. Power-operated rotary brooms and a pick-up broom for curb and gutter sections.

2. Tank trucks, asphalt distributor truck, and on-site storage tanks in accordance with Subsection 407.3, Equipment.

409.3.2 Chip Seal

1 In addition to the equipment required above, provide the following equipment for the application of a chip seal:

1. A type II light pneumatic roller, a type VI vibratory roller, or both, in accordance with Subsection 210.3.6, Roller.

2. One self-propelled aggregate spreader supported by at least four wheels fitted with pneumatic tires on two axles and equipped with positive controls so that the specified quantity of material is deposited uniformly over the width of the surface. Other types of aggregate spreaders that produce equivalent results may be used.

409.3.3 Fog Seal

1 Provide mechanical spreading equipment for the blotter material; do not distribute blotter with hand tools unless approved by the engineer.

409.4 CONSTRUCTION

409.4.1 Weather and Seasonal Limitations

1 Place chip and fog seal coats from June 15 to August 31, unless otherwise approved in writing by the engineer. Place seal only on a dry surface.

2 Place the applicable seal in accordance with the following criteria:

1. **Chip Seal**

   1.1. Air and pavement surface temperatures at least 60 ºF [15 ºC] or higher;

   1.2. No fog;

   1.3. Precipitation not expected within 4 hours; and

   1.4. Applied seal material not at risk of freezing within 24 hours.

2. **Fog Seal.** Air and pavement surface temperatures at least 50 ºF [10 ºC].

409.4.2 Sampling Procedures

1 Provide emulsified asphalt samples and certification documents in accordance with Subsection 407.4.2, Sampling Procedures. For liquid asphalt other than emulsified asphalt, provide samples and certification documents in accordance with the *Materials Testing Manual*, Section 501.0, Liquid Asphalt Sampling.

409.4.3 Emulsified Asphalt Application

1 Clean surface of extraneous material, including vegetation, dirt, mud, and loose materials before applying the emulsified asphalt.

2 Provide a daily log of the usage of emulsified asphalt using "Daily Emulsion Application Rate Record," (Form E-58). Submit the form to the engineer no later than the working day following placement.

3 Apply the emulsified asphalt so that there is uniform, complete coverage at the rate established (chip seal) or specified (fog seal). Correct deficiencies and areas not covered. Apply the emulsion in accordance with Table 409.4.3-1, Emulsion Application Temperatures for Chip and Fog Seals.

Table 409.4.3-1
Emulsion Application Temperatures for Chip and Fog Seals

Emulsions		Spray Application Temperature Range °F [°C]	
Set	**Grade**	**Unmodified**	**Polymer Modified**
Rapid, Quick	RS-1; CQS-1h	70 to 140 [20 to 60]	80 to 140 [25 to 60]
	RS-2, HFRS-2; CRS-1, -2	150 to 185 [65 to 85]	160 to 185 [70 to 85]
Medium, Slow	MS-1, HFMS-1; SS-1, -1h; CSS-1, -1h	70 to 160 [20 to 70]	80 to 160 [25 to 70]
	MS-2, -2h; HFMS-2, -2h, -2s, -2ss, -1000; CMS-2, 2h	90 to 185 [30 to 85]	100 to 185 [35 to 85]

409.4.4 Chip Seal

409.4.4.1 General

1 Provide the engineer with the results of compatibility tests performed for the aggregate and emulsified asphalt.

2 Perform the homogeneity test in the presence of the engineer in accordance with the *Materials Testing Manual*.

3 Ensure that longitudinal joints coincide with the specified locations of lane lines, edge lines, or the center of traveled ways.

4 Use of a type VI vibratory roller will only be allowed by the engineer, if the chip seal is placed during the same construction season as the plant mix pavement and the plant mix pavement has been in place less than 90 calendar days. Operate the roller in static mode. Do not use the roller if it causes the aggregate to break down.

5 If necessary, wet the aggregate to eliminate or reduce the dust coating or to improve cohesion.

6 Ensure an aggregate embedment depth of 50 to 75 percent.

409.4.4.2 Quality Requirements

1 Construct the chip seal using quality assurance procedures and perform quality control of the aggregate during production and placement. Do not continue producing material that is out of specification. Provide the following:

1. **Quality Control Charts.** Maintain and display charts at the contractor's laboratory. Ensure their accessibility to the engineer.

2. **Testing Requirements.** Perform aggregate gradations and LA Abrasion tests in accordance with the *Materials Testing Manual*. Before placement, test a split aggregate sample in accordance with Subsection 114.3.3.2, Aggregate Gradation.

   Quality control, quality acceptance and verification tests may be performed by a qualified technician, but a certified technician is required to sign all test results.

Test for quality control and quality acceptance as required by Table 409.4.4-1, Chip Seal Test Requirements.

Table 409.4.4-1
Chip Seal Test Requirements

Test Procedure	Test Frequency
Compatibility Tests	Required
Quality Control—Chip Seal Aggregate Production	
Gradation	1/90,000 yd^2 [75 000 m^2], 3 minimum
LA Abrasion (Contractor-Furnished Sources Only)	1/90,000 yd^2 [75 000 m^2]
Quality Control During Placement	
Aggregate Gradation and LA Abrasion	Not required
Quality Acceptance	
Aggregate Gradation	1 lot/450,000 yd^2 [375 000 m^2]

3. **Laboratory and Personnel Requirements.** For quality control testing, use a laboratory and personnel in accordance with Subsection 114.3, Field Testing Laboratory and Personnel Requirements.

4. **Correlation of Field Testing Laboratories and Personnel.** To avoid equipment or procedural bias in test results, correlate aggregate tests in accordance with Subsection 114.3.3, Correlation. The procedure will be repeated if the possibility of bias arises during production or if new equipment or personnel are introduced during testing.

   The department does not require recorrelation before placement if correlation testing for aggregate tests has already been performed with placement of plant mix pavement and the contractor's and department's personnel and equipment have remained unchanged.

5. **Resolution of Testing Discrepancies.** Follow procedures in accordance with Subsection 114.3.4, Resolving Field Testing Discrepancies.

6. **Out of Specification Material.** Base quality control on each individual test. If test results are outside the specifications, make appropriate adjustments, retest material, and make additional adjustments if necessary.

409.4.4.3 Quality Acceptance Testing

1 The department is responsible for quality acceptance testing and will test in accordance with the requirements in Table 409.4.4-1, Chip Seal Test Requirements. Quality acceptance test results are required prior to beginning chip sealing operations. Aggregate lots that meet or exceed a pay factor level of 0.75 are acceptable for incorporation into the project at the pay factor calculated in accordance with Subsection 409.5.2, Determination of Pay Factors.

2 Lot size is defined by the department as the number of square yards [square meters] placed, represented by five tests as shown in Table 409.4.4-1, Chip Seal Test Requirements. A sublot is the quantity represented by one test. The engineer will determine the exact lot size, which may vary due to project length, production suspension, construction schedules, material source changes, or other acceptable reasons. Except in unusual situations, the engineer will use lots consisting of five samples. When necessary due to production, project size, material source changes, or suspension, lots of from three to seven samples may be used. Partial lots with less than three samples will be included with the previous lot for analysis. Lot size will be controlled by the project size or changes in the material source and may span several days of production.

3 Obtain aggregate gradation samples in accordance with Subsection 800.2 (3), Point of Sampling, and the *Materials Testing Manual* at random locations determined by the engineer and in the presence of the engineer.

409.4.4.4 Test Section

1 Before full production, construct a test section 0.5 mi [0.8 km] long or less as approved by the engineer for each type of surface upon which the chip seal is to be placed to establish the following:

1. **Rates** of emulsion and aggregate application to ensure aggregate embedment and coverage;

2. **Time Frames** to complete each phase of the chip sealing operations to meet the requirements for opening the roadway to traffic; and

3. **Roller Pattern**, roller type, and number of passes. Use the roller pattern and type determined as effective during test section placement for the remainder of the chip seal placement. Place another test section when changing roller type and pattern.

2 Do not continue chip sealing operations until the test section has been in place for 24 hours or as approved by the engineer.

409.4.4.5 Application

1 Apply the emulsified asphalt and the chip seal aggregate as follows:

1. **Emulsified Asphalt** and, when specified, overshoot, in accordance with the supplier's recommendations and Subsection 409.4.3, Emulsified Asphalt Application.

   If the texture of the surface allows the emulsified asphalt to penetrate too rapidly, spray the roadway again at a rate specified by the engineer.

   Use a strip of building paper 3 ft [1 m] wide to form a uniform edge at the beginning of each spread. Make junctions of spreads to ensure a smooth riding surface. Do not spread the emulsified asphalt beyond the width of the chip seal aggregate application or allow cooling or setting before application of the aggregate. Avoid delays that could impair retention of the aggregate.

2. **Chip Seal Aggregate** immediately after the application of emulsified asphalt, spread and seat the cover coat aggregate. Spread the material without operating the equipment's tires on the exposed, newly applied emulsified asphalt. Immediately after spreading, cover deficient areas with additional material.

2 After the emulsion used to seal the road and bond the aggregate has cured, thoroughly broom the entire surface. Remove excess aggregate. Do not remove imbedded aggregate.

3 When specified, apply an overshoot after placing the chip seal coat. When using a rapid set emulsion for the overshoot, have it diluted by the emulsified asphalt

supplier at its facility. Overshoot the chip seal at the rate established during the test section production. Do not allow traffic on the surface until the overshoot has sufficiently cured to prevent picking up or tracking. Cover excess quantities with blotter material.

409.4.4.6 Opening to Traffic

1 Open roadways as follows:

1. **Chip Seal Without Overshoot.** Do not allow unrestricted traffic on the chip sealed surface before removing excess cover coat aggregate. If placing traffic on the chip seal before the removal of excess flyrock, pilot the traffic through the work at 30 mph [50 km/h] or less. Open the roadway to full, unrestricted traffic flow within 36 hours of the beginning of aggregate placement.

2. **Chip Seal With Overshoot.** Do not allow traffic on the chip sealed surface until the blotter is applied and the overshoot has cured.

409.4.5 Fog Seal

1 The specified application rate is for specification material before additional dilution for field application. Emulsified asphalt used for fog seal may be diluted in the field at a ratio of 1 part emulsified asphalt to 2 part water (1:2). Before mixing, heat the dilution water and emulsified asphalt to a minimum temperature specified by the supplier. Dilute by introducing the water into the emulsified asphalt. Apply at a temperature range in accordance with Table 409.4.3-1, Emulsion Application Temperatures for Chip and Fog Seals.

2 Cover areas where the emulsified asphalt would be picked up or damaged by traffic with a uniform, protective coat of blotter.

3 Sweep and remove loose blotter cover from the roadway surface no more than 24 hours after the emulsified asphalt has cured.

409.4.6 Acceptance

1 The engineer will accept:

1. **Emulsified Asphalt** in accordance with Subsection 113.2, Acceptance of Asphalt Material.

2. **Aggregate Gradation** in accordance with Subsection 113.1, Acceptance of Aggregate.

2 If a chip seal, with or without overshoot, experiences chip loss or bleeding within two weeks of placement, repair it at no additional cost to the department. Provide and maintain temporary traffic control required on the project to repair areas of failing seal coat at no additional cost to the department.

409.5 MEASUREMENT and PAYMENT

409.5.1 General

1 The engineer will measure:

1. Chip Seal and Chip Seal (Overshoot) by the square yard [square meter], based on the length placed and the lesser of the measured or specified width placed.

2. Emulsified Asphalt, Emulsified Asphalt Modified, Emulsified Asphalt (Overshoot) by the short ton [metric ton] in accordance with Subsection 109.1.3, Measurement Methods. Quantities of water to dilute the emulsified asphalt for application will not be measured and paid for as Emulsified Asphalt.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Chip Seal	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Chip Seal (Overshoot)	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Emulsified Asphalt	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]
Emulsified Asphalt Modified	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]
Emulsified Asphalt Overshoot	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]
Fog Seal	TON [t]	0.01 ton [0.01 t]	0.01TON [0.01 t]

409.5.2 Determination of Pay Factors

1 The engineer will evaluate the gradation for chip seal aggregate in accordance with Subsection 113.1, Acceptance of Aggregate, and adjust payment accordingly.

409.5.3 Price Adjustment

409.5.3.1 Emulsified Asphalt

1 If the samples for a truckload are not received by the Materials Program within seven calendar days of sampling, in accordance with Subsection 407.4, Construction, the engineer will reduce the payment by as much as 25 percent for that load.

2 The engineer may adjust the price for emulsified asphalt that does not meet specifications but is accepted in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

409.5.3.2 Chip Seal

1 The engineer may reduce payment as follows:

1. **Operations.** If the roadway is not open to unrestricted traffic flow as specified, the engineer will assess liquidated damages of $125 per hour for each hour or partial hour after 36 hours. These damages will be added to, and simultaneous with, other specified liquidated damages.

2. **Aggregate.** The payment for chip seal will be reduced based on the following equation:

$$PA_A = (PF_A - 1.00)\ (LS_A)\ (CS)$$

Where:	PA_A =	Pay Adjustment for Aggregate Gradation ($$)
	PF_A =	Aggregate Gradation Pay Factor for evaluated lot
	LS_A =	Lot Size for evaluated lot (SY [m^2])
	CS =	Contract Unit Price of the Chip Seal pay item ($$/SY [$$/m^2])

SECTION 410
Microsurfacing

410.1 DESCRIPTION

1 This section describes the requirements for applying microsurfacing material.

410.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Aggregate for Microsurfacing	803
Cement	801
Hydrated Lime	820
Polymer-Modified Emulsified Asphalt	804.3
Water	814

2 Provide polymer-modified, quick-set CQS-1HP emulsified asphalt; commercially available type I or type II portland cement or hydrated lime; and other additives as needed to accelerate or retard the breaking point and set times or improve the resulting finished surface.

410.3 EQUIPMENT

410.3.1 Emulsified Asphalt

1 Provide tank trucks and on-site storage tanks in accordance with Subsection 407.3, Equipment.

410.3.2 Microsurfacing

1 Provide a self-propelled, continuous load paver (manufactured exclusively for microsurfacing application) that is a continuous-flow mixing unit capable of accurately delivering proportionate amounts of aggregate, emulsified asphalt, cement, additives, and water to a revolving multi-blade, twin-shafted mixer, and of discharging a continuous flow of thoroughly mixed product. Equip the machine with:

1. Sufficient storage capacity for aggregate, emulsified asphalt, cement, additives, and water to maintain an adequate supply to the proportioning controls during nurse vehicle exchange;

2. Self-loading devices that provide for the loading of materials while continuously applying microsurfacing;

3. Opposite-side driving stations to optimize longitudinal alignment;

4. A water pressure system and nozzle-type spray bar to provide a fine mist immediately ahead and outside of the spreader box;

5. A fines feeder to deliver a uniform, positive, accurately metered, and predetermined amount of cement at the same time and place the aggregate is incorporated; and

6. Means to allow the operator full control of the forward and reverse speed and movement during application.

2 Ensure that the self-loading devices, opposite-side driving stations, and forward and reverse controls are of the original manufacturer's design. Do not use individual slurry trucks.

3 Provide individual volume or weight [mass] controls and a visible means of observation of the meters for proportioning each material added to the mix. Calibrate each proportioning device and properly mark for identification.

4 Equip the aggregate feed to the mixer with a revolution counter or similar device to determine the amount of aggregate used at any time.

5 Provide a positive displacement type emulsion pump and equip with a revolution counter or similar device to determine the amount of emulsion used at any time.

6 For spreading the microsurfacing mixture, provide a mechanical type spreader box attached to the paver and equip with rotating paddle shafts or spiral augers to agitate and spread the material throughout the box. Provide a leading edge seal and an adjustable trailing edge seal that acts as a final strike-off. Design and operate the unit to ensure a free flow of material to the trailing edge seal. Provide the spreader box with suitable means to shift the box. Provide rubber squeegees sized to match the width of material placed.

7 Provide a rut filling box when required in accordance with Subsection 410.4.8.2, Transverse Depressions/Cracks and Longitudinal Ruts/Cracks.

8 Provide truck platform scales in accordance with Section 109.1.4, Weighing Procedures and Equipment. The engineer may approve the use of hopper scales.

410.4 CONSTRUCTION

410.4.1 General

1 Arrange for a representative of the emulsified-asphalt supplier to meet with the engineer and the microsurfacing contractor's field personnel before placing the test section. Ensure that the representative is present on the first day of placement. Address at a minimum, production, materials, supply, and calibration of the continuous-load paver.

2 Provide weigh tickets in accordance with Subsection 109.1.4.2, Documentation, for documenting the weight [mass] of the aggregate in the transfer trucks at the time and place of loading into the mixing machine. With the approval of the engineer, invoices may be accepted in lieu of the weigh tickets.

3 Before beginning microsurfacing operations, calibrate the mixing unit in the presence of the engineer. Before loading into the hauling units, the engineer will test aggregate gradation to ensure it meets the requirements of Subsection 803.7, Aggregate for Micorsurfacing, at the stockpile.

4 Carry enough material in the spreader to ensure complete coverage but avoid overloading. Do not allow lumping, balling, or unmixed aggregate.

5 Ensure that the material is:

1. Workable and of uniform consistency upon leaving the mixer;
2. Of uniform surface texture and color after placement;
3. Sufficiently stable to prevent premature breaking in the spreader box;
4. Homogenous during and after mixing and spreading;
5. Free of excessive water or emulsion; and
6. Not subject to segregation.

6 Do not spray water directly into the spreader box while placing material.

7 Formulate the material to allow use by traffic within one hour of application without damaging the surface or vehicles. Stop application early enough each day to allow safe travel over the work before dark.

8 Stop production if two corrective actions fail to result in the production of material as specified.

410.4.2 Weather and Seasonal Limitations

1 Place microsurfacing material from June 1 to September 30. Apply when pavement temperature is at least 60 ºF [15 ºC] or higher and the air temperature is 50 ºF [10 ºC] and rising. Do not apply in fog or rain, when the finished product is at risk of freezing within 24 hours, or if weather conditions will prevent use by traffic in one hour.

410.4.3 Quality Control Plan

1 The department requires a written quality control plan. Give the engineer two copies at the preconstruction conference. Nonadherence to the plan may cause the engineer to suspend work. Include the following minimum information:

1. **Descriptive Information and Calibration Records.** For production facilities, including those for crushing, hauling, and stockpiling, provide the make, type, location, frequency of inspection, frequency and procedures for calibrating weighing and metering devices, and all certifications issued for the facility.

   For placing operations, provide the make and type of equipment, frequency of inspection and maintenance, frequency of and procedures for calibrating control devices, frequency of and procedures for verifying calibration, and all certifications issued for the equipment.

2. **Personnel and Responsibilities.** Provide an organizational chart indicating lines of authority for quality control in all aspects of microsurfacing, including crushing and stockpiling. Include the names, phone numbers, and qualifications of the people responsible for quality control.

3. **Sampling Procedures.** Indicate the proposed procedure for obtaining aggregate samples for the mix design, the method for determining sampling times and locations during production, collection procedures, and the testing and reporting of results.

4. **Mix Design Process.** Include the parameters to determine at what stage of aggregate production the laboratory mix design is performed, the qualifications of the organization performing the design, and the name, address, and phone numbers of the person responsible.

5. **Documentation and Reporting.** Document observations, records of inspection, adjustments to mixture, and test results on a daily basis. Record field observations, inspections, and measurements as they occur in a permanent duplicating field book or diary. Make copies of daily entries and records available to the engineer upon request.

6. **Corrective Action Process.** Provide rules for determining what actions are necessary when the material does not meet specifications. As a minimum, include in the process a written notification to the engineer of what will be done when a problem is identified.

7. **Test Section Construction.** Provide information on the location and construction procedures of the test section.

8. **Notification of Start-up.** The process for notifying the engineer of the intent to start each aspect of the work, including crushing, stockpiling, mix design, and placement of material.

410.4.4 Quality Acceptance

1 The department is responsible for quality acceptance testing. Aggregate gradation lot size is defined by the department as the quantity of produced aggregate, represented by five tests or a maximum of 5000 ton [5000 t]; a sublot is the quantity represented by one test. The exact tonnage may vary due to production suspension, construction schedules, or other acceptable reasons. Except in unusual situations, the engineer will use lots consisting of five samples. When necessary because of production changes or suspension, lots of from three to seven samples may be used. Partial lots with less than three samples will be included with the previous lot for analysis. Lot size will be controlled by tonnage and a lot may span several days of production.

2 Obtain aggregate gradation samples in accordance with Subsection 800.2 (3), Point of Sampling. To determine lot size, measure tonnage by belt scale or another method approved by the engineer.

410.4.5 Job Mix Formula (JMF)

1 Submit a completed mix design developed by an approved testing laboratory to the engineer for approval at least 14 calendar days before placing microsurfacing. Address in the mix design the proportions of aggregate, polymer-modified emulsified asphalt, cement, water, and other additives required to achieve maximum stability (ASTM D 1560) at a minimum emulsion content. Include with the mix design report the manufacturer, brand, type, and percentages of the aggregate, asphalt emulsion, and additives (to both mix and emulsion) and aggregate test results for sand equivalent, LA abrasion, and when required, results in accordance with Table 803.6.2-1, Polish-Resistant Aggregate Requirements. Provide a new mix design if any of these characteristics are changed.

2 With the mix design, submit to the engineer an aggregate sample and JMF in accordance with Table 410.4.5-1, Aggregate JMF Tolerance.

Table 410.4.5-1
Aggregate JMF Tolerance

Sieve Size	Job Mix Formula Tolerance (%)
Passing No. 4 [4.75 mm]	-5 to +5
Passing No. 8 [2.36 mm]	-5 to +5
Passing No. 16 [1.18 mm]	-5 to +5
Passing No. 30 [600 µm]	-5 to +5
Passing No. 50 [330 µm]	-4 to +4
Passing No. 100 [150 µm]	-3 to +3
Passing No. 200 [75 µm]	-2 to +2

3 Ensure the tests shown in Table 410.4.5-2, Testing Requirements, meet the requirements at the minimum emulsion content. Because some systems require longer times for the emulsified asphalt to adhere to the stone, a modified Marshall Stability Test (ISSA TB140) may be used to determine emulsified asphalt content.

Table 410.4.5-2
Testing Requirements

Test Procedure	Description	Specification
ISSA TB139	Wet Cohesion @ 30 minutes (set), minimum @ 60 minutes (traffic), minimum	 31 kg-in [12 kg-cm] 51 kg-in [20 kg-cm] or Near Spin
ISSA TB109	Excess Asphalt by LWT Sand Adhesion, maximum	50 g/ft² [538 g/m²]
ISSA TB114	Wet Stripping, 90% minimum	Pass
ISSA TB100	Wet Track Abrasion Loss One Hour Soak, maximum Six Day Soak, maximum	50 g/ft² [538 g/m²] 75 g/ft² [807 g/m²]
ISSA TB147	Lateral Displacement, maximum	5%
	Specific Gravity after 1,000 Cycles of 125 lb [57 kg], maximum	2.10
ISSA TB144	Classification Compatibility, minimum	11 grade points (AAA, BAA)
ISSA TB113	Mix Time @ 77 ºF [25 ºC], minimum	Controllable to 120 seconds

410.4.6 Surface Preparation

1 Immediately before applying material, thoroughly clean the roadway surface of extraneous materials, including vegetation, dirt, mud, and loose material and prewet as necessary. Application may begin when there is no standing water present and the surface is damp.

410.4.7 Test Section

1 Construct a test section of enough quantity to evaluate the mix design for initial and final set curing times, surface appearance, and final profile; obtain the engineer's approval before beginning normal placement. Include all aspects of the specified work in the test section, including transverse depression and crack filling, longitudinal rut and crack filling, strike-off pass, and finish pass. Ensure that the depth of material placed for the transverse depression and crack filling and longitudinal rut and crack filling portions of the test section are equal to the project's maximum specified depth. Construct another test section if a new mix design is required in accordance with Subsection 410.4.5, Mix Design, or if either breakdowns or stops and starts in operations exceed five per day.

410.4.8 Application

410.4.8.1 General

1 Provide a leading edge seal that allows no loss of the mixture at the contact point with the roadway surface.

2 Center the material placement over the depression, rut, crack, or lane-width. If specified, perform transverse depression and crack filling and allow time to cure completely before performing longitudinal rut and crack filling, strike-off, or finish passes.

3 Keep to a minimum the use of hand squeegees to achieve the required surface tolerance and appearance. Do not leave excess buildup, uncovered areas, or an unsightly appearance.

4 Place longitudinal joints on lane lines.

5 Provide straight lines along the shoulder edges with no run-off. Ensure straight lines at intersections. If necessary, use a suitable material to mask-off the end of streets to provide straight lines. Do not let edges vary horizontally more than ± 2 in [± 50 mm] in any 100-foot [30 m] length.

410.4.8.2 Transverse Depressions/Cracks and Longitudinal Ruts Cracks

1 Where longitudinal rut depth exceeds ⅜ in [10 mm], spread the material with a rut box to fill ruts. Fill both ruts if one rut exceeds ⅜ in [10 mm].

2 Overfill transverse depressions and cracks and longitudinal ruts and cracks to ⅛ in [3 mm] per ¼ in [6 mm] of material as a crown to provide for consolidation by traffic. For material used in transverse depression and crack filling, longitudinal rut and crack filling, and strike-off passes, reduce the asphalt emulsion content 1.0 percent from the design emulsion content. Taper the material onto the existing pavement on both edges of the rut to provide a smooth transition. Create a smooth, uniform seam wherever two passes join between the rut. Remove rough and uneven seams, and apply new material at no additional cost to the department.

3 At the end of each pass, taper the mixture and construct a transition to the existing pavement. Fill one rut only with each pass of the surfacing machine. Let traffic compact the material to fill transverse depressions and cracks and longitudinal ruts and cracks for at least five calendar days before placing additional material.

410.4.8.3 Strike-Off Pass

1 Where rut depths are less than ⅜ in [10 mm], make a full-width strike-off pass with a full width spreader box, using a metal strike-off plate. Apply only enough material to fill the surface voids and level the surface.

2 Extend material 3 in [75 mm] from lane edges and taper onto the existing pavement to form a smooth transition. At the beginning and end of each pass, taper and apply the mixture to form a transition with the adjacent microsurfacing or existing pavement.

410.4.8.4 Finishing Pass

1 When specified, make a full-width finish pass with a full-width spreader box once the individual ruts are filled or the strike-off pass is completed. Taper the material onto the existing pavement at both edges of the lane to form a smooth transition. At the beginning and end of each pass, taper the mixture and form a transition to the adjacent microsurfacing or existing pavement.

410.4.8.5 Final Surface

1 Immediately cease operations and make appropriate adjustments if surface appearance or tolerance criteria are not met.

1. **Appearance.** Do not leave visible streaks, such as those caused by dragging oversized aggregate or spreader box residue, in the finished

surface. If excessive streaking (defined as more than four drag marks greater than ½ in [12.5 mm] wide and 4 in [100 mm] long or 1 in [25 mm] wide and 3 in [75 mm] long in any 270 ft^2 [25 m^2] area) develops, stop placement until corrected. Obtain the engineer's approval before restarting.

2. **Tolerance.** Do not allow ripples equal to or greater than ¼ in [6 mm] deep, as measured by placing a 10-foot [3 m] straightedge over the surface.

   Construct transverse and longitudinal joints where microsurfacing passes meet to be uniform in appearance and level with the adjacent microsurfacing. Do not overlap longitudinal joints more than 3 in [75 mm]. Do not allow an elevation difference between joints and the adjacent surface greater than ¼ in [6 mm] deep, as measured by placing a 10-foot [3 m] straightedge over the joint.

410.4.9 Final Clean-up

1 Remove microsurfacing material and debris from areas not treated, such as gutters, intersections, and shoulders on a daily basis.

410.4.10 Acceptance

1 The engineer will reject material placed without an approved mix design. Remove by milling and replace at no additional cost to the department. Repair completed microsurface that is damaged by traffic at no additional cost to the department.

2 The engineer will accept:

1. **Emulsified Asphalt** in accordance with Subsection113.2, Acceptance of Asphalt Material.

2. **Aggregate Gradation** in accordance with Subsection 113.1, Acceptance of Aggregate.

410.5 MEASUREMENT and PAYMENT

410.5.1 General

1 The engineer will measure Microsurfacing (Aggregate) by the short ton [metric ton] in the transfer trucks at the time and place of loading into the mixing machine as documented on the weigh tickets or invoices; no deduction will be made for moisture in the aggregate.

2 The engineer will measure Microsurfacing (Emulsified Asphalt) by the short ton [metric ton] in accordance with Subsection 109.1.3, Measurement Methods.

3 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Microsurfacing (Aggregate)	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]
Microsurfacing (Emulsified Asphalt)	TON [t]	0.01 ton [0.01 t]	0.01 TON [0.01 t]

410.5.2 Pay Adjustment

410.5.2.1 Emulsified Asphalt

1 If the samples for a truckload are not received by the Materials Program within seven calendar days of sampling, in accordance with Subsection 407.4, Construction, the engineer will reduce the payment by as much as 25 percent for that load.

2 The engineer may reduce the payment for emulsified asphalt that does not meet specifications but is accepted in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

410.5.2.2 Aggregate

1 The engineer will evaluate the gradation for microsurfacing aggregate in accordance with Subsection 113.1, Acceptance of Aggregate, and adjust payment accordingly.

SECTION 411
Paving Fabric

411.1 DESCRIPTION

1 This section describes the requirements for providing and placing performance graded asphalt binder and paving fabric. This applies to fabric membranes used for full coverage of the pavement or as strips over transverse and longitudinal pavement joints.

411.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Glass Fiber Reinforced Paving Fabric	805.3
Paving Fabric	805.3
Performance Graded Asphalt Binder	804.1

2 Use a qualified source of PGAB, in accordance with Subsection 804.1, Performance Graded Asphalt Binder and Subsection 401.2.1, Performance Graded Asphalt Binder.

411.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Asphalt Distributor	407.3
Tank Trucks	401.3.4.1
Storage Tanks	401.3.8

2 Provide an asphalt distributor that has a single-nozzle hand spray with a positive shut-off valve.

3 Provide mechanical or manual lay-down equipment to lay the fabric smoothly and a pneumatic roller if required.

4 Provide stiff bristle brooms or squeegees to smooth the fabric, scissors or blades to cut the fabric, and brushes to apply PGAB at fabric overlaps.

411.4 CONSTRUCTION

411.4.1 General

1 Store fabric rolls so that they are protected from the weather. If stored outdoors, store the rolls elevated above the ground and protected with a waterproof covering.

Install fabric when pavement and air temperatures are 50 ºF [10 ºC] and rising and the surface is dry.

2 Do not use more than one paving fabric product.

3 Do not expose fabric to traffic except for emergency and construction traffic. Leave no more than 10 ft [3 m] of the paving fabric installation exposed to traffic at the end of the day's work. At no additional cost to the department, provide specified temporary traffic control, including flagging, to route traffic through the construction area where fabric is in place and not covered with a lift of plant mix pavement.

411.4.2 Application of PGAB

1 Before applying the PGAB and fabric, clean the roadway surface of extraneous material, including vegetation, dirt, mud, and loose material.

2 Apply the PGAB to the prepared surface so that there is uniform, complete coverage, at the rate and width specified. Use a distributor spray bar and keep hand spraying to a minimum. For PGAB, the minimum application temperature is 290 ºF [140 ºC] and the maximum temperature in the distributor is 325 ºF [160 ºC].

3 Apply in widths equal to that of the fabric width plus 6 in [150 mm]. Do not apply PGAB any farther in advance of fabric placement than the distance that can be maintained free of traffic. Clean PGAB spills from the road surface.

411.4.3 Fabric Placement

1 Ensure the presence of a representative of the fabric manufacturer during initial placement of the fabric.

2 Before the PGAB cools and loses tackiness, place the fabric into the PGAB with minimum wrinkling. Cut and lay flat wrinkles or folds greater than 1 in [25 mm]. Use brooming to maximize fabric contact with the pavement surface. Use a pneumatic roller when the air temperature is lower than 60 ºF [15 ºC] or the wind speed is greater than 20 mph [30 km/h].

3 Sufficiently overlap fabric joints to ensure full closure but not more than 6 in [150 mm]. Lap transverse joints in the direction of paving to prevent edge pickup by the paver. If necessary, apply PGAB to fabric overlaps a second time to ensure proper bonding of the double fabric layer.

4 Ensure that paving equipment and hauling units do not wrinkle, fold, or displace the fabric. Replace damaged fabric at no additional cost to the department.

5 Keep the plant mix overlay at a temperature in accordance with the fabric manufacturer's recommendations. If the PGAB bleeds through the fabric and causes construction problems before placement of the overlay, blot the areas by spreading washed sand or hot-mix.

411.4.3.1 Additional Requirements for Glass Fiber Reinforced Paving Fabric

1 Fill cracks greater than ¼ in [6 mm] in width or holes greater than ½ in [13 mm] in diameter in the existing pavement with bituminous filler material that contains no solvents. Obtain approval from the engineer regarding the bituminous filler material and the proposed composite material placement method before work begins.

2 Apply the asphalt binder at a rate of 0.23 to 0.28 gal/yd^2 [1.0 to 1.3 L/m^2], depending upon the roughness of the existing surface, before placing the composite material. Ensure the temperature of the asphalt binder during application is within the asphalt supplier's recommended mixing temperature range for the performance grade being used. Follow the composite material manufacturer's representative's temperature recommendations if they are different from the asphalt supplier's. Ensure the width of the asphalt binder application is 6 in [150 mm] greater than the width of the composite material to be placed. Coordinate the application of the asphalt binder and the placement of the composite material to ensure complete bonding of the composite material to the substrate surface.

3 Ensure the composite material exceeds the size of the cracked area by at least 6 in [150 mm] in all directions. Place the composite material with the grid side up. Place the composite material using continuous pieces wherever possible. Ensure individual pieces overlap 2 in to 6 in [50 mm to 150 mm]. Ensure end joints and joints from the repair of wrinkles overlap or shingle in the direction that the pavement overlay will be placed. Apply a uniform layer of asphalt binder between overlaps. Perform brooming, rubber tire rolling, or both to maximize composite material contact with the substrate surface.

4 Correct any excess asphalt binder that bleeds through the composite material by broadcasting blotter material meeting the requirements of Subsection 803.9, Aggregate for Blotter, or place hot mix over the bleed spots, as approved by the engineer. If it rains on the composite material before the new plant mix pavement is placed, allow the composite material to dry completely before placing the pavement.

411.4.4 Acceptance

1 The engineer will accept PGAB in accordance with Subsection 804.1, Performance Graded Asphalt Binder, and Subsection 113.2, Acceptance of Asphalt Materials.

411.5 MEASUREMENT and PAYMENT

411.5.1 General

1 The engineer will measure Paving Fabric by the square yard [square meter] of surface area complete and in place with no allowance for overlaps.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Glass Fiber Reinforced Paving Fabric	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Paving Fabric	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]

411.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure, pay, and price adjust for Asphalt Binder (PG __ - __) in accordance with Section 401, Plant Mix Pavement. The measurement will not include quantities of PGAB applied in excess of the application rate.

SECTION 412
Plant Mix Surface Appurtenances

412.1 DESCRIPTION

1 This section describes the requirements for constructing curbs, spillways, median pavings, bike paths, or other minor items constructed of plant mix.

412.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Aggregate for Plant Mix	803
Emulsified Asphalt	804.3
Hydrated Lime	820
Performance Graded Asphalt Binder	804.1

2 Use a qualified source of PGAB, in accordance with Subsection 804.1, Performance Graded Asphalt Binder, and Subsection 401.2.1, Performance Graded Asphalt Binder.

3 Construct appurtenances of plant mix of the type specified. When both a ¾-inch [19 mm] maximum and a ½-inch [12.5 mm] maximum nominally-dimensioned aggregate are specified, use either.

412.3 EQUIPMENT

1 Provide equipment in accordance with the requirements of Subsection 401.3, Equipment.

412.4 CONSTRUCTION

412.4.1 General

1 Construct appurtenances only when the air temperature is 50 ºF [10 ºC] or higher and the weather is dry.

2 Construct on firm foundations shaped and compacted to coincide with the bottom surface of the appurtenance.

3 Immediately before construction, clean existing concrete or plant mix surfaces on or against which the appurtenance will be placed and lightly coat with tack coat in accordance with Section 407, Tack Coat.

4 When machine forming is not feasible, hand-place and shape the material. Where practical, supplement hand-placement by the use of outside forms or screed guides to obtain smooth, even lines and grades.

5 Compact appurtenances to form a smooth, dense, and watertight surface.

6 Correct irregular curb or curb that deviates noticeably from the established line and grade by removing and replacing defective areas with new material at no additional cost to the department.

412.4.2 Acceptance

1 The engineer will accept:

1. **PGAB** in accordance with Subsection 804.1, Performance Graded Asphalt Binder, and Subsection 113.2, Acceptance of Asphalt Materials.

2. **Emulsified Asphalt** in accordance with Subsection 113.2, Acceptance of Asphalt Materials.

412.5 MEASUREMENT and PAYMENT

412.5.1 General

1 The engineer will measure:

1. Bike Path (Plant Mix) by the short ton [metric ton] or square yard [square meter].

2. Curb (Plant Mix) and Spillway (Plant Mix) by the foot [meter] along the flow line of the top surface.

3. Median Paving (Plant Mix), Sidewalk (Plant Mix), or other minor paved surfaces not included with the roadway items by the square yard [square meter] of top surface area parallel to the paved surface.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Bike Path (Plant Mix)	TON, SY [t, m^2]	0.05 ton, ft [0.05 t, 0.5 m]	0.05 TON, SY [0.05 t, m^2]
Curb (Plant Mix)	FT [m]	0.1 ft [0.05 m]	FT [m]
Median Paving (Plant Mix)	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Sidewalk (Plant Mix)	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Spillway (Plant Mix)	FT [m]	0.1 ft [0.05 m]	FT [m]

412.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure, pay and price adjust for:

1. Asphalt Binder (PG __ - __) in accordance with Section 401, Plant Mix Pavements.
2. Hot Plant Mix in accordance with Section 401, Plant Mix Pavements, under the appropriate pay item, except for plant mix used for the pay item Bike Path (Plant Mix).
3. Tack Coat in accordance with Section 407, Tack Coat.
4. Hydrated Lime in accordance with Section 413, Hydrated Lime.
5. Haul in accordance with Section 204, Haul.

SECTION 413
Hydrated Lime

413.1 DESCRIPTION

1 This section describes the requirements for adding dry lime to a wetted aggregate.

413.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Hydrated Lime	820
Water	814

413.3 EQUIPMENT

1 Provide a mechanical mixing device that creates a uniform and homogeneous mixture with all aggregate particles coated with hydrated lime as approved by the engineer.

2 Equip the mixing plant with facilities to weigh check samples and to calibrate gate openings and metering devices. Equip with weighing or metering devices (such as a vane feeder with a calibrated revolution counter) to determine the rate of hydrated lime introduced into the aggregate while the plant is in full operation. Do not use belt scales.

3 Use a spray bar or other approved method to wet the aggregate uniformly. Equip the plant with devices that meter the water and hydrated lime into the mixer. Interlock and synchronize the metering devices and feeders to maintain a constant rate of hydrated lime and water to the aggregate.

4 To control the daily quantity of hydrated lime added to the aggregate and to facilitate calibration of the metering devices, place the bulk storage container from which hydrated lime is metered on scales or equip with load cells to enable the accurate measurement of the remaining weight [mass] in the container at the end of each day. Do not use strain gages.

5 Use a pug mill with a mixing chamber to mix the hydrated lime and water with the aggregate. Keep the materials in the chamber until obtaining a uniform and

homogeneous mixture of lime, water, and aggregate. Do not use devices that allow the materials to drop directly through the mixing paddles.

6 Locate the pug mill to allow inspection of the mixture during mixing and after discharge from the mixer. Make the belt from the pug mill to the dryer accessible for sampling. Provide a template of the belt for taking a sample to determine moisture content.

413.4 CONSTRUCTION

1 Mix the hydrated lime and water with the aggregate before they enter the dryer.

2 Prior to entering the dryer, ensure the moisture content of the mixture meets the requirements in accordance with Table 401.4.13-2, Marshall and Superpave Plant Mix Properties.

413.5 MEASUREMENT and PAYMENT

1 The engineer will measure Hydrated Lime by the short ton [metric ton].

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Hydrated Lime	TON [t]	0.05 ton [0.05 t]	0.05 TON [0.05 t]

SECTION 414
Portland Cement Concrete Pavement

414.1 DESCRIPTION

1 This section describes the requirements for construction of portland cement concrete pavement on a prepared sub-grade, base course, or other prepared surface.

414.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Admixtures	801.4
Aggregate for Concrete	803
Curing Materials	802.1
Dowel Bars and Tie Bars	811.2
Fly Ash	801.2
Joint Sealer	807
Portland Cement	801.1
Water	814.1

2 If using fly ash, incorporate only pre-approved fly ash as listed in the *Materials Testing Manual*. Do not use class C fly ash.

3 If using hot poured elastic joint sealant, ensure material meets AASHTO M 324-04, Type IV.

4 Ensure tie bars are epoxy coated with the exception of the bar ends.

5 Ensure dowel supporting units (baskets) are specifically manufactured for this purpose. Dowel bars may be arc or resistance welded to the basket assemblies at alternating ends of the bars. Welded areas on dowel bars need not be field epoxy coated. Ensure the basket assemblies are manufactured such that the dowel bars do not slip during concrete placement.

6 When specified, provide aggregate in accordance with Subsection 803.62, Polish Resistant Aggregate.

7 For dowel bars, use approved graphite lubricant or other approved release agent. Ensure the graphite lubricant contains at least 10 percent graphite and is certified by the manufacturer.

414.3 EQUIPMENT

414.3.1 Proportioning, Batching, and Mixing

1 Provide equipment meeting the following requirements:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2

2 Ensure the central mixing plant has a manufacturer's capacity plate or operating instructions to clearly show the capacity and mixing speeds and a non-resettable batch counter to show the number of batches proportioned.

414.3.1.1 Scales

1 Ensure scales conform to the requirements of Subsection 109.1.4, Weighing Procedures and Equipment.

2 When beam type scales are used, provide provisions such as a telltale dial to indicate that the required load in the weigh hopper is being approached. Provide a device on the weighing beams to indicate the critical positions clearly.

3 For level of control I, furnish a plant with bins and hoppers for each type of aggregate, cement, and fly ash. Provide separate scales for the aggregate and the cement. If cement and fly ash are weighed in the same hopper, ensure the cement is weighed first. Weigh material using an automated weighing and charging system with a printed ticket showing the following:

1. Project number;
2. Truck number;
3. Time batched;
4. Total yards batched per load;
5. Total yards batched per day;
6. Aggregate weights;

7. Aggregate moisture;

8. Cement and fly ash weight;

9. Admixtures and amount added; and

10. Water added at the plant.

414.3.2 Hauling, Placing, and Finishing Equipment

1 Transport concrete in truck mixers, truck agitators, or non-agitating dump bodies. Provide an adequate number of vehicles to ensure a steady forward progress of the paver. Provide non-agitating truck bodies with a smooth, mortar tight, metal container capable of discharging the concrete at a controlled rate without segregation. Bed vibrators are required.

2 Provide finishing machines in accordance with Subsection 513.3.3, Placing and Finishing Equipment. Do not use steel trowels, steel floats, or fresnos.

3 For texturing pavement in locations with a design speed limit less than or equal to 40 mph [60 km/h], provide carpet drag, brooming, or tining equipment. For texturing locations with a design speed limit greater than 40 mph [60 km/h], provide tining equipment.

4 When employing carpet drag, provide a dense indoor/outdoor carpet material. Ensure equipment uses an independent work bridge with automatic line and grade control to produce a straight, consistent, longitudinal texture. Provide carpet material that will create an acceptable surface texture, as directed by the engineer, and does not roll or tear the surface.

5 For a broomed finish, use a mechanical broom device that drags stiff bristles transversely across the surface.

6 For longitudinal tining, use an independent work bridge with automatic line and grade control to produce a straight and consistent texture meeting the specified straightness. Ensure a maximum of ¾ in [18 mm] spacing between tines and a tine width of $^{3}/_{32}$ in to ⅛ in [2 mm to 3 mm].

7 For transverse tining, provide a tine width of $^{3}/_{32}$ in to ⅛ in [2 mm to 3 mm] and a random spacing of tines. Provide random transverse tine spacing with a minimum spacing of ½ in [12 mm] and a maximum spacing of 1½ in [37 mm], with no more than 50 percent of the spaces exceeding 1 in [25 mm]. Use a transverse tining rack with a minimum width of 3 ft [1 m].

414.3.3 Dowel Bar Insertion

1 A mechanical dowel bar inserter (DBI) may be used with approval of the engineer. Lubricate dowels in accordance with Subsection 414.4.10.10.1, Dowel Joints. Submit details and specifications of the proposed slip-form paver with bar inserter to the engineer at least 14 calendar days before the concrete pre-paving conference. Ensure the slip-form paver is specifically manufactured with dowel bar insertion capabilities. Assist the engineer with the inspection of the equipment relating to its condition and operation to determine if it is suitable to perform the work within the required tolerances.

2 Approval of the use of the proposed inserter equipment will be based upon the information submitted and the engineer's inspection of the equipment. The conditions of approval include but are not be limited to:

1. Performing needed repair and maintenance work, if required. The engineer will then reinspect the slip-form paver;

2. Requiring a manufacturer's technical representative be present during the initial concrete placement to ensure proper equipment operation; and

3. During the test section placement, achieving satisfactory performance in meeting tolerances of final dowel position and concrete pavement smoothness as specified in the contract.

3 If the insertion performance during the test section is not satisfactory, demonstrate to the engineer that corrective actions have been taken by placing an additional test section. If the insertion performance is not satisfactory during the second test section, the equipment will be rejected for use in placing dowel bars. Either propose a different slip-form paver with DBI capabilities, or use basket assemblies. The department will not pay for delays and costs associated with the engineer's rejection of proposed equipment.

4 Provide a pachometer, for use by the engineer. Ensure the pachometer is in good working order and available during all concrete placement operations and subsequent monitoring by the engineer. The engineer and the Materials Program will review the quality and effectiveness of an individual pachometer. If the results are not satisfactory, provide a new pachometer. Provide a core drill and operator at no additional cost to the department.

414.3.4 Smoothness Evaluation and Correction

1 Provide a computerized profilograph or a class 1 inertial profiler. Ensure the class 1 inertial profiler output simulates a mechanical profilograph output using a 0.1-mile [0.016 km] long blanking band template.

2 Provide a 10-foot [3 m] straightedge designed specifically for evaluating smoothness.

3 Provide a diamond grinder for corrective action. Ensure the grinder is a power-driven, self-propelled machine with a minimum 3-foot [1 m] wide cutting head and an effective wheelbase of not less than 12 ft [3.5 m]. Ensure grinding equipment does not cause excessive raveling, aggregate fracturing, or spalling. Do not use bush hammers or other impact devices.

414.4 CONSTRUCTION

414.4.1 General

1 Before beginning any paving operations, schedule a pre-paving conference with the engineer at a mutually agreeable time to discuss the materials, equipment, and procedures.

414.4.2 Levels of Control

1 The extent of quality control and quality acceptance will be defined by the level of control, which will be shown in the contract. Testing requirements for each level of control are shown in Table 414.4.2-1, QC/QA Testing Requirements Versus Level of Control.

Table 414.4.2-1
QC/QA Testing Requirements Versus Level of Control

	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
QC TESTING (CONTRACTOR)				
Coarse Aggregate				
Gradation (3)	1 test per 2000 T [1 test per 2000 t]	1 test per 2000 T [1 test per 2000 t]	1 test per 2000 T [1 test per 2000 t]	1 test per 2000 T [1 test per 2000 t]
Moisture Content	1 test min. per day	1 test min. per day	1 test min. per day	1 test min. per day
Fractured Faces	1 test min. per 2000 T [1 test min. per 2000t]	1 test min. per 2000 T [1 test min. per 2000 t]	1 test min.	1 test min.
Fine Aggregate				
Gradation(3) /Fineness Modulus	1 test per 2000 T [1 test per 2000 t]	1 test per 2000 T [1 test per 2000 t]	1 test per 2000 T [1 test per 2000 t]	1 test per 2000 T [1 test per 2000 t]
Moisture Content	1 test min. per day	1 test min. per day	1 test min. per day	1 test min. per day
Water/Cementitious Ratio	1 test min. per day	1 test min. per day	1 test min. per day	1 test min. per day
Deleterious Substances	1 ea. Gradation test min.	1 ea. Gradation test min.	1 test min.	1 test min.
Dowel Bar Placement	1 test min. per day	1 test min. per day	1 test min. per day	1 test min. per day
Air Content/Slump	At start-up (1) and 1 min. per 2000 SY [At start-up (1) and 1 min. per 2000 m^2]	At start-up (1) and 1 min. per 1000 SY [At start-up (1) and 1 min. per 1000 m^2]	At start-up (1) and 1 min. per 1000 SY [At start-up (1) and 1 min. per 1000 m^2]	At start-up (1) and 1 min. per 1000 SY [At start-up (1) and 1 min. per 1000 m^2]
Texture Straightness	1 test min. per day	1 test min. per day	1 test min. per day	1 test min. per day

Table 414.4.2-1
QC/QA Testing Requirements Versus Level of Control, continued

	LEVEL I	LEVEL II	LEVEL III	LEVEL IV
QA TESTING (CONTRACTOR) "Gradation Lots"				
	Lot Size: 20000 SY max. [Lot Size:: 20000 m^2 max.]	Lot Size: 14000 SY max. [Lot Size:: 14000 m^2 max.]	Lot Size: 14000 SY max. [Lot Size:: 14000 m^2 max.]	Lot Size: 20000 SY max. [Lot Size:: 20000 m^2 max.]
Gradation	1 per sublot	1 per sublot	1 per sublot	1 per sublot
QA TESTING (WYDOT) "Paved Lots"				
	Lot Size: 12000 SY max., 3 Sublots (2) [Lot Size: 12000 m^2 max., 3 Sublots (2)]	Lot Size: 6000 SY max., 3 Sublots (2) [Lot Size: 6000 m^2 max., 3 Sublots (2)]	Lot Size: 6000 SY max., 3 Sublots (2) [Lot Size: 6000 m^2 max., 3 Sublots (2)]	n/a
Air Content	1 per sublot	1 per sublot	1 per sublot	1 per 3000 SY [1 per 3000 m^2]
Strength Tests	1 set per sublot	1 set per sublot	1 set per sublot	1 set per 3000 SY [1 per 3000 m^2]
Thickness	1 per sublot	1 per sublot	1 per sublot	1 per 3000 SY [1 per 3000 m^2]

(1) Conduct air and slump tests on the first load, then two times within one hour of start-up, and after any shutdown exceeding 30 minutes.

(2) 1 lot minimum in all cases. 3 sublots per lot, each comprising one-third the lot surface area.

(3) Conduct gradation quality control testing during aggregate production.

414.4.3 Weather and Seasonal Limitations

1 Provide adequate lighting when paving during dawn or dusk or at night. Do not place pavement during rainy weather. Ensure the concrete temperature is between 50 °F and 90 °F [10 °C and 30 °C] during placement. Provide uniform cooling or heating of the aggregate to maintain the mix in this temperature range.

2 Do not place concrete when the ambient temperature is below 40 °F [4 °C]. Cover and heat the pavement if the temperature drops below 35 °F [2 °C], and ensure a minimum pavement surface temperature of 50 °F [10 °C] for 72 hours and above 40 °F [4 °C] for an additional 96 hours. Ensure field-cured concrete test cylinders achieve 3500 psi [24 MPa] before removing covering and heating. Do not place pavement on frozen subbase or base. Do not place concrete when wind speeds exceed a sustained 20 mph [30 km/h], unless approved by the engineer.

414.4.4 Laboratory and Personnel Requirements

1 Ensure laboratories performing mix design obtain and maintain AASHTO accreditation in accordance with Subsection 114.2.1, Laboratory.

2 Provide field testing personnel in accordance with Subsection 114.3, Field Testing Laboratory and Personnel Requirements. Ensure that technicians testing concrete hold a current certification in concrete from the Wyoming Materials Technician Certification Program.

3 Ensure test equipment to determine compressive strength is calibrated annually by an independent agency using calibration equipment traceable to the National Institute of Standards and Technology (NIST). Provide calibration documentation to the engineer.

4 Before testing, provide to the engineer documentation for all profilograph or inertial profiler operators that shows their experience or training. Prohibit personnel with no experience or prior training in equipment operation from PI testing.

414.4.5 Correlation

1 For slump, air content, and unit weight tests, use correlation testing performed by the technicians responsible for the quality control tests and quality acceptance tests to ensure results are free from equipment or procedural bias.

2 Conduct correlation testing of aggregate gradation in accordance with Subsection 114.3.3, Correlation.

414.4.5.1 Slump, Air Content, and Unit Weight Tests

1 Before placing concrete, perform correlation of slump, unit weight, and air content tests on a batch of at least 1 yd^3 [1 m^3]. Ensure the differences do not exceed the values in Table 414.4.5.1-1, Slump, Air Content, and Unit Weight Tests.

Table 414.4.5.1-1
Slump, Air Content, and Unit Weight Tests

Test	Value
Slump (when < 4 in [100 mm])	0.5 in [12 mm]
Slump (when ≥ 4 in [100 mm])	1.0 in [25 mm]
Air Content	0.4%
Unit Weight	1 lb/ft^3 [16 kg/m^3]

2 If any one pair of the test results exceed the above limits, perform an inspection, calibration, or both on the equipment, review test procedures, and repeat the correlation. Incorporate different equipment if the correlation fails a second time, and conduct a third correlation. Continue this process until the cause for bias is identified and corrected.

3 Perform additional correlation tests if either the contractor or the department suspects equipment or testing bias. Perform new correlation tests if new equipment or personnel (department or contractor) are introduced during testing.

414.4.6 Dispute Resolution

1 Resolution of disputes will be conducted in accordance with Subsection 114.3.4, Resolving Test Discrepancies.

414.4.7 Proportioning Portland Cement Concrete Mixes

1. **All Levels of Control.** A new mix design is required if there are any changes in material source, admixtures, cement type, or fly ash source.

The fine aggregate may be adjusted up to 2 percent by weight, based on the total weight of aggregate without requiring a new mix design. Ensure the fine aggregate fraction does not exceed 44 percent of the total aggregate mass.

Original mix designs may be resubmitted for later jobs as long as the mix design is not more than 2 years old. Adjust for changes in aggregate absorptions, specific gravities, or both since the original mix design was conducted. Ensure the coarse and fine aggregate gradations of the samples submitted with the mix design are within 10 percent on all specification sieves of those shown on the mix design, and the fineness modulus of the fine aggregate is within 0.3 of that shown on the mix design.

Replacement of 20 to 25 percent of cement with class F fly ash, by mass, is allowed for concrete pavement mix designs.

2. **Levels of Control I, II, and III.** Determine the proportions of the materials, including admixtures, to be used for producing a workable mix having the required properties. Prepare a mix design in accordance with procedure no. 610.0, Contractor Concrete Mix Design Procedure, of the *Materials Testing Manual*.

   Design concrete pavement mixes using a cement content or combined cement plus fly ash content between 564 lb/yd^3 and 705 lb/yd^3 [335 kg/m^3 to 418 kg/m^3]. For mixes incorporating fly ash, ensure a minimum cement content of 470 lb/yd^3 [279 kg/m^3].

   Provide a mix within a slump range of 0.5 in to 2 in [12 mm to 50 mm] for concrete placed using a slip form paver or a maximum of 4 in [100 mm] (6 in [150 mm] if using a water reducer) for concrete placed in forms. Ensure an entrained air content of 4.5 to 7.5 percent and a water to cementitious materials ratio not to exceed 0.45:1.

   For level of control I, a substitution of 20 to 25 percent of cement with class F fly ash is required.

   Provide a concrete pavement mix that meets a design 28-day flexural strength of 650 psi [4.5 MPa], unless shown differently in the contract.

Concrete strength testing requires the use of cylinders for compressive strength. Correlate the mix design compressive strength to flexural strength using procedure No. 621.1, Correlation of Compressive Strength to Flexural Strength, of the *Materials Testing Manual*.

Submit the mix design for review to the engineer at least 30 calendar days before the start of concrete placement. Use the mix design only following approval from WYDOT's Materials Program. As part of the review process, the department may run a test batch using the proposed mix design proportions.

Document all concrete placements, and include mixture proportioning and water to cementitious materials ratio.

3. **Level of Control IV.** Request a mix design in accordance with procedure no. 612.0, WYDOT Concrete Mix Design Procedure, of the *Materials Testing Manual*. The department will complete two concrete mix designs at no cost to the contractor. Do not make changes in materials sources, suppliers, or mix proportions without the written approval of the department.

   Ensure the concrete meets the requirements of class A concrete in accordance with Subsection 513.4.4, Mix Design.

414.4.7.1 Use of Admixtures

1 As applicable, use stabilizers, slump enhancers, air enhancers, and accelerators in accordance with Section 701 of the *Materials Testing Manual*.

414.4.7.2 Alkali Silica Reactivity (ASR)

1 ASR testing is required when specified in the contract.

2 Test concrete aggregate in accordance with AASHTO T303 (ASTM C1260) Accelerated Detection of Potentially Deleterious Expansion of Mortar Bars Due to Alkali-Silica Reaction, or when fly ash is used in the mix, test in accordance with ASTM C1567 Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).

3 Conduct the AASHTO T303 (ASTM C1260) or ASTM C1567 test using a combined sample of fine aggregate and coarse aggregate in the same proportions that will be used in the concrete mix design and using the cementitious material that is to be used in final concrete mix design.

4 Ensure the test results indicate an expansion at 16 days from casting of 0.10 percent or less

5 Mitigate sources that indicate reactive through the use of a class F fly ash approved for ASR mitigation in accordance with the *Materials Testing Manual*, lithium nitrate additive, or both. Ensure the AASHTO T303 (ASTM C1260) and ASTM C1567 tests are performed within 12 months before the submittal date. The department's Materials Program maintains the option to conduct AASHTO T303 (ASTM C1260) and ASTM C1567 testing for verification.

414.4.8 Quality Control

414.4.8.1 General

1 Perform quality control testing. Ensure all concrete materials, mixtures, and constructed concrete pavements submitted for acceptance conform to the contract, and either bring into compliance or reject out-of-specification material. Ensure all concrete materials, mixtures, and constructed concrete pavements meet the requirement of the contract.

414.4.8.2 Quality Control Plan

1 Provide a Quality Control Plan for projects involving level of control I or II paving. Submit two copies of the Quality Control Plan to the engineer at least 14 calendar days before the pre-paving conference. The engineer must accept and approve the Quality Control Plan before concrete is placed.

2 The engineer will suspend operations when the Quality Control Plan is not followed.

3 Provide a Quality Control Plan that contains the following information at a minimum:

1. An organizational chart indicating lines of authority for quality control for all aspects of the concrete construction. The names, phone numbers, and qualifications of the individual(s) responsible for the contractor's

quality control program, including the quality control supervisor, and a listing of the certified technician(s) responsible for the quality control testing are to be shown.

2. Document general mix design and trial batch information, including the organization that will perform the mix design and trial batch.

3. Description of the plan for collecting quality control samples.

4. Document specific products anticipated for use as on-site admixtures in the mix design. Include names and titles of personnel who have the authority to redose trucks on site.

5. Describe installation of dowel bar, tie bar, or both, including the method of dowel placement, type of supporting units, method of anchorage, and how the location and alignment is to be verified to meet tolerances.

6. Provide a description of curing equipment, curing compounds to be used, rates, and procedures for application.

7. Describe the plan for control joint sawing and sealing, with specific timing of both the sawing and sealing.

8. Describe the timing of smoothness testing, equipment to be used, equipment settings, and equipment calibration data.

414.4.8.3 Control Chart

1 Designate a display location for the quality control chart. Record quality control tests results on the control chart immediately upon completion of the test or receipt of the test results but no later than the end of the day on which the test is completed. Record the following parameters on the quality control chart:

1. Coarse aggregate gradation;

2. Fine aggregate gradation;

3. Fine aggregate fineness modulus;

4. Slump measurements;

5. Air content measurements; and

6. Water to cementitious materials ratio.

2 Include the specification limits and each individual quality control test result. Ensure the control chart is displayed and accessible to the engineer at all times.

414.4.8.4 Smoothness Quality Control Testing

1 For levels of control I and II, test each lane of pavement as soon as possible to monitor placement. Summarize the PI of each day's production, and list defect areas. Cease paving operations if any day's PI average exceeds three times the level specified until the cause can be determined and corrected. Provide the engineer with PI traces within 24 hours after the measurements are taken.

2 For level of control III, test each lane of pavement as soon as possible to monitor placement. For continuous paved sections exceeding 200 ft [60 m], test for PI and summarize the PI and list defect areas within 1 week of paving. Cease paving operations if the PI average exceeds three times the level specified until the cause can be determined and corrected. Provide the engineer with PI traces within 24 hours after the measurements are taken. For paved lengths shorter than 200 ft [60 m], verify paving quality using a straightedge as directed by the engineer.

414.4.9 Independent Assurance

1 The department's Materials Program will conduct an independent assurance program in accordance with the WYDOT *Independent Assurance Manual*. The differences between quality control and independent assurance tests will be evaluated to determine conformance with AASHTO or ASTM multi-laboratory precision statements or cement and concrete reference laboratory proficiency sample results. If biases are shown, the department will conduct an immediate investigation.

414.4.10 Paving

414.4.10.1 General

1 For level of control I, provide a test section of between 1000 ft and 1500 ft [305 m and 460 m] in length. The test section is subject to all contract specifications. Employ paving practices as specified in this section. During placement of the

test section, the engineer and contractor must both be present to inspect paver operation. Correct any paver problems during the test section placement. Following placement of the test section, shut down paving operations for the remainder of the day and the entire following working day to conduct a quality inspection of the placement. The engineer and contractor must be present during inspection. Inspection will include review of dowel bar placement (if applicable), joint sawing, texturing quality, curing compound application, and profile index for smoothness. The profile index of the last 528 ft [150 m] of the test section must meet the acceptance criteria of the contract with no corrective action.

2 Provide an additional test section if:

1. The previous test section does not meet the acceptance criteria;
2. The paving operation is shut down for the season; or
3. The equipment is changed, modified or moved off-site.

3 Begin full-scale paving operations only after an in-specification test section is placed and approved by the engineer.

4 Use a slip-form paver for level I pavements. For small or irregular placements, the engineer must agree that a slip-form paver cannot be used and must approve the new method. Ensure the full width paving of traffic lanes, including shoulders, is placed with one pass unless otherwise shown in the contract.

5 Provide longitudinal joints for all types of paving on lane lines unless otherwise shown in the contract.

414.4.10.2 Mixing and Delivery

1 Produce concrete for slip-form pavement in a central mixing plant at or near the project site. Ensure the plant is of a size and capacity to provide a uniform flow of material at the paving machine.

2 Replace blades that exceed wear limits. Ensure the flow of water is uniform and controlled so that a portion of the water is in the mixer ahead of the cement and aggregate. Ensure that all of the water is added to the batch within the first 15 seconds of the mixing time. Introduce admixtures in accordance with the mix design. Ensure mixing time is in accordance with the plant manufacturer's recommendations but not less than 50 seconds.

3 If the concrete consistency does not meet the requirements of AASHTO M 157, additional mixing time may be required to conform with this specification. Mixing time begins when all the dry materials are in the drum and ends with the start of the discharge.

4 During the charging and mixing phases, run the mixer at operation speed. Do not exceed the manufacturer's rated capacity of the mixer.

5 Ensure non-agitated concrete is placed within 35 minutes from the time mixed and within 60 minutes of the start of mixing if truck agitators are used.

6 Truck mixers and batch plants meeting the requirements of Subsection 513.4.9, Mixing and Delivery, will be allowed for projects less than one mile in length or urban streets.

7 Provide batch weights for each load delivered. Provide copies of batch tickets to the engineer upon request.

414.4.10.3 On-Site Mix Adjustment

1 Do not make more than two on-site mix adjustments, defined as the addition of water or an on-site admixture. Do not re-dose partial loads. Adjusting the mix on-site does not increase the allowable placing time requirements. Do not use air reducing admixtures.

2 Employ additional mixing revolutions in accordance with the admixture manufacturer's recommendations. Mix for at least 30 additional revolutions at mixing speed if water is added at the site. Adjust the mix on-site while the concrete is plastic and within 45 minutes of the start of initial mixing. Do not add water or other materials to concrete that has started to set.

3 Document all re-dosing actions on the batch ticket.

414.4.10.4 Base Preparation

1 Provide base or sub-grade in accordance with Section 301, Aggregate Subbase, Base Courses, and Bed Course Material. For projects that overlay concrete or plant mix pavements, provide the required preparatory work as shown in the contract. Do not operate hauling units that cause rutting or displacement of the base or sub-grade. Repair rutted/displaced surfaces as directed by the engineer prior to concrete placement. Ensure the sub-grade or base is uniformly moist when the concrete is placed, unless waterproof sub-grade or base course cover

material is specified. Sprinkle the sub-grade or base course if the surface becomes dry. Do not allow water to form mud or to pool.

414.4.10.5 Forming and Grade Line

1 The engineer will provide grade hubs at a maximum of 50 ft [15 m] on one line for paving control, unless otherwise stated in the contract.

Set grade lines from the hubs provided.

2 Unless manual or hand placed and finished, provide steel forms with sufficient base width to support the paving machine without settling more than ⅛ in [3 mm]. Do not allow the form grade line to vary more than ⅛ in [3 mm] in grade. Use steel stakes to secure the forms at a spacing not to exceed 5 ft [2 m]. Clean and oil forms before each use. Remove forms in accordance with Subsection 513.4.5, Forms.

414.4.10.6 Slip-Form Method

1 Ensure the paver is automatically controlled from sensing devices for line and grade.

2 Ensure concrete placement that results in a uniform distribution with minimal handling and segregation. Ensure placement is continuous and provides for an even flow rate.

3 Ensure the slip-form paver operation will spread, consolidate, grade, and finish the pavement so that there is a minimal amount of hand finishing required. Do not use loaders or other equipment in front of the paver to spread the concrete. Repair damage to the subbase or base materials before placing concrete.

4 Provide internal type vibrators operating from arms spaced not more than 2 ft [0.5 m] apart across the width of the paver. Vibrate the concrete for the full width and depth. Operate vibrators between 7,000 to 12,000 impulses per minute. Provide electronic instrumentation for displaying the frequency of each vibrator to the operator. Vary the frequency with the rate of travel to result in a uniform density and air content. Suspend the paving operation when a vibrator becomes inoperable until repairs are made. Ensure vibrators automatically stop when the forward motion of the paver is stopped. Do not allow vibrators to come in contact with the reinforcing steel.

5 Ensure the previously placed pavement is at least 72 hours old or the concrete has reached 80 percent of the design strength, as determined from field cured samples, when paving adjacent to previously placed concrete. Ensure the paver is equipped with protective pads and does not damage or mar the surface.

414.4.10.7 Form Method

1 When formed paving is allowed under levels of control I, II, and III, provide a self-propelled mechanical spreader, finisher, and float. A machine may be used that combines these operations if the desired results can be achieved. Ensure the spreading machine uniformly spreads the concrete between the forms as it is placed. Verify that the concrete finishing machine is equipped with an approved screed. Ensure the spreading or finishing machine has internal vibrators that vibrate the concrete for the full width and depth. Operate vibrators at between 7,000 to 12,000 impulses per minute. Do not allow vibrators to come in contact with the reinforcing steel or forms. Ensure vibrators stop when the finishing head or motion of the machine is stopped.

2 Manual or hand placement and finishing methods will be permitted for small or irregular areas and level of control IV paving. Use hand held vibrators for internal vibration. Screed surface to meet the required cross section with an even and smooth surface.

414.4.10.8 Texturing

1 Provide a burlap drag on the surface before texturing of the surface is started.

Begin texturing as soon as the finishing operations have been completed. Provide texture type in accordance with the contract. Unless otherwise shown in the contract, provide transverse tining.

2 Texturing options are as follows:

1. **Carpet-Drag.** Where carpet-drag is used, ensure the texture is parallel to the centerline and adequately straight to ensure no deviations exceeding 1 in [25 mm] parallel to the centerline in any 50-foot [15 m] length. Ensure the surface texture is maintained and approved by the engineer on the test section. Shut down paving operations and clean the carpet-drag material at least once per 5000 yd^2 [5000 m^2]. Shut down paving operations and review texturing operations if texture depth or straightness does not meet specifications.

2. **Broomed.** Where broomed surface is employed, provide striations that are $^{1}/_{16}$ in to ⅛ in [2 mm to 3 mm] deep, parallel to the transverse joints.

3. **Tined.** Where tining is employed, provide tine grooves that are $^{3}/_{16}$ [6 mm] (± $^{1}/_{16}$ in [2 mm]) deep. Ensure tining provides the specified grooves without undue surface damage. Hand tining may be done if approved by the engineer. Ensure transverse tining is parallel to the transverse joints. Ensure longitudinal tining is parallel to the paved direction and adequately straight to ensure no deviations exceeding 1 in [25 mm] parallel to the centerline in a 50-foot [15 m] length. Ensure longitudinal tining stops at the edge of the traveled lanes. Shut down operations and determine a corrective measure in the presence of the engineer if tining straightness or dimensions are out of specification.

414.4.10.9 Curing

1 Apply a "premium white" impervious curing compound within 15 minutes after the surface texturing operations are completed. Apply the compound at the rate of 150 ft^2/gal [3.5 m^2/l]. Apply the compound with a mechanical sprayer covering the entire width and sides of the pavement. If delays occur in applying the curing compound, apply a fine mist of water or an approved evaporation retardant to the surface. Continue misting until the curing compound has been applied. Do not spray the curing compound on free standing water. Apply curing compound to the edges of the pavement upon removal of the forms. Do not apply curing compound to exposed reinforcing steel. If weather conditions do not allow uniform placement of the curing compound, immediately place wet burlap followed by plastic sheeting over the pavement, and halt paving operations until conditions improve.

414.4.10.10 Joints

1 Concrete pavement joints are designated as transverse expansion and weakened plane joints, longitudinal weakened plane joints, and construction joints. Ensure joints are placed in accordance with and are of the type shown in the contract. Unless otherwise specified, construction joints will have tie or dowel bars.

2 Secure tie bars by chairs or supports, or insert them during the paving operation to ensure placement within 1 in [25 mm] of the midpoint of the pavement

section. Insert the tie bars in drilled holes when the pavement is being placed adjacent to an existing concrete pavement as shown in the contract. Anchor with an approved epoxy resin grout.

3 Provide sawed joints of $^3/_{16}$ in [5 mm] width for all liquid applied sealants. Do not chamfer edges unless elastomeric compression joint seals are used.

4 Ensure joints are sawed in a timely manner. Remove and replace areas with uncontrolled cracking. Provide standby saws on the project site when work is in progress.

5 If using a conventional wet sawing method, saw to a depth of T/3 (where T = slab thickness) where T is greater than 10 in [250 mm] or to a depth of T/4 where T is less than or equal to 10 in [250 mm].

6 If an early-entry, dry-cutting system is used, perform the work in accordance with the manufacturer's recommendations and as approved by the engineer. Saw joints to a depth of 0.15T, unless otherwise recommended by the manufacturer. Replace saw blades in accordance with the manufacturer's recommended frequency. Replace the anti-raveling skid plate each time the saw blade is replaced. End early-entry saw cuts before free edges to avoid spalling.

7 Ensure the longitudinal joints are cut on the lane and shoulder lines unless otherwise shown in the contract.

8 Ensure transverse joints are perpendicular to centerline. Install joints at the spacing shown in the contract. Ensure construction joints are not within 6 ft [2 m] of transverse weakened plane or expansion joints. Install a construction joint if concrete placement is interrupted for more than 30 minutes.

9 Repair spalls or overcut joints.

10 Construct transverse expansion joints as shown in the contract. Ensure the preformed expansion joint filler is continuous through the pavement. Furnish preformed expansion joint filler in lengths equal to the pavement width or equal to the width of one lane. Ensure the joint filler is held in a vertical position during concrete placement operations. Use an installing bar to secure the joint filler at the proper grade and alignment during placement and finishing of the pavement. Ensure there are no gaps or holes in the joint filler that would allow concrete to penetrate.

11 Ensure expansion dowels are held in position parallel to the surface and the centerline. Secure the dowels with a device that assures a free movement of the

slabs. Coat the expansion dowels with a lubricant as required by Subsection 811.2.4, Dowel Bar Release Agent. Ensure the expansion sleeves fit the dowels tightly.

414.4.10.10.1 Dowel Joints

1 Construct joints as shown in the contract. Mark the location of all joints. Center transverse saw cuts over the doweled joints.

2 Place dowels using dowel supporting units (baskets), or use a mechanical dowel bar inserter.

3 Ensure the basket assemblies are installed so that the dowel bars do not slip during concrete placement. Ensure no portion of the dowel support assembly crosses the transverse joint. Submit shop drawings to the engineer and the Materials Program 21 calendar days before use of the proposed dowel baskets and proposed method of anchoring. The engineer will provide comments within 21 calendar days after submittal, but final acceptance of the baskets and anchoring will be based on performance during concrete placement operations. Provide a basket manufacturer representative on the project during initial placement, if requested by the engineer.

4 Within 24 hours before placing concrete, coat each dowel with a thin coating of an approved graphite lubricant or other approved release agent. Submit a 1-pint [1 l] sample of release agent and the manufacturer's product literature to the engineer at least 14 calendar days before the anticipated paving date. Apply the graphite lubricant or other approved release agent so that it will result in a thorough, thin, even covering of the entire dowel, including ends. Clean and re-coat with the approved lubricant any dowel bars that are contaminated with any foreign material or with an uneven coating before concrete placement.

5 Securely anchor and construct the dowel bar assemblies to firmly hold all the dowel bars at a depth of T/2 (concrete thickness/2), parallel to each other, and parallel to the pavement grade and alignment. Remove or cut spacer wires after the assemblies are staked in position. Ensure dowels are the only non-concrete material crossing a joint.

6 Place dowels in accordance with the following tolerances:

1. Horizontal location (spacing between dowels or the edge of the slab): ± 1 in [25 mm].

2. Vertical position (distance from the slab mid-point to the center of the dowel): ± 1 in [25 mm].

3. Skew from parallel (horizontal and vertical planes, measured from the end of the dowel to the end of the dowel): ± ⅜ in [10 mm].

4. Joint location (mid-point of dowel to actual sawn joint): ± 3 in [75 mm].

7 Suspend operations after the placement of the concrete pavement test section until the engineer has completed the dowel positioning evaluation. The engineer will provide a written report of the evaluation within 1 working day after the initial placement.

8 Core the concrete pavement placed in the test section, as directed by the engineer, as a part of the dowel placement tolerance verification. Core at least 6 bars. Provide additional cores throughout the project, as directed by the engineer, to confirm pachometer readings. If the pachometer provides unsatisfactory results, provide additional coring throughout the project to confirm dowel placement.

9 Provide a work bridge for inspection of dowel and reinforcing steel placement at all times.

10 The engineer will randomly check dowel and rebar positioning during placement operations using the pachometer, coring, or other methods as required. Joints not meeting tolerances will be rejected. Replace rejected joints by sawing the slab full depth and replacing the joint and slab as shown in the contract. No additional payment will be made by the department for replacement slabs and joints required due to joints not meeting the specified tolerances. Removed undamaged dowels may be reused if re-coated with lubricant and inspected and approved by the engineer prior to re-usage.

11 If baskets are used, 300 ft [100 m] of assembled baskets must be in-place and approved before paving. Stop paving at any time that less than 200 ft [70 m] of assemblies are in-place and approved in advance of the concrete placement operation. Approval of the initial placement of basket assemblies will not constitute acceptance of the final position of the dowel bars.

12 Suspend the paving operation if dowels are found to be installed improperly. Before the operation proceeds, demonstrate to the engineer that the problem which caused the improper dowel positioning has been corrected.

414.4.10.11 Sealing Joints

1 Ensure the joints comply to the contract dimensions before sealing. Install the joint sealant material in accordance with the manufacturer's recommendations. Furnish copies of the manufacturer's installation procedures and specifications to the engineer 15 calendar days before the joint sealing work is started. Provide a manufacturer's technical representative on the project for the initial sealing operations for silicone and elastomeric sealing materials.

2 Flush the joints after the final saw cut using wash water with sufficient pressure and volume to remove all of the cement dust and debris from the joints. Do not use water after initial flushing. Ensure the pavement and saw cuts are dry before the final cleaning is done. Coordinate the joint sawing, cleaning, and sealing operations so that other work does not contaminate or cause water to flow into the joints. Clean the joints with oil and moisture free compressed air. Ensure incompressible materials are removed from joint immediately before sealing. Seal joints within 2 hours after cleaning; otherwise, repeat cleaning immediately before sealing.

3 For any liquid applied sealant, fill the joint until the sealant is ⅛ in [3 mm] below the top surface of the pavement, and ensure it does not spill over on the surface of the pavement. If overfilled, remove all material spilled on the surface of the concrete pavement and clean the pavement surface.

4 Seal joints with self-leveling silicone sealant unless otherwise specified. Joint sealant procedures are as follows:

1. **Silicone Sealant.** Use self-leveling silicone sealant. Place ½ in [9 mm] backer rod at a minimum depth of ½ in [13 mm] before installation of sealant. Install the joint sealant when the weather is dry and the ambient temperature is above 40 °F [4 °C]. Do not seal joints until the pavement is at least 7 days old. Use a power-operated pressure system to install sealant. Provide finished sealant that does not vary by more than $^{1}/_{16}$ in [3 mm] from the dimensions shown in the contract. Do not allow traffic on the pavement until the sealant has cured for at least 24 hours.

2. **Elastomeric Compression Joint Seal.** Ensure the materials are certified by the manufacturer as to the shelf life and compliance with the specifications. Ensure the work is completed in accordance with the manufacturer's recommendation, including placement machine,

weather limitations, concrete temperature, width and depth of the saw cuts, joint intersections, and installation depth. Ensure the seal for each joint is a single piece for the full width and depth required for the joint unless otherwise approved by the engineer. When more than one piece is used in a joint, fasten the abutting ends securely and hold accurately to shape by stapling or other means approved by the engineer. Ensure the saw cut widening is done when the concrete temperature is between 40 °F and 80 °F [4 °C to 26 °C]. Provide seal at least $^{11}/_{16}$ in [17 mm] wide. Do not stretch seal during installation.

Submit a 9-foot [3 m] sample of the seal from each lot, with the lubricant, to the engineer at least 21 calendar days before the sealing work is to be started. Submit computations that show the material will be in compression over the temperature ranges for the project location.

3. **Hot Poured Elastic Joint Seal.** Backer rod is optional. If backer rod is used, install a ⅜-inch [9 mm] backer rod to a minimum depth of 1½ in [37 mm]. Do not seal joints until the pavement is at least 7 days old. Seal the joints when the weather is dry, when the ambient temperature is above 50 °F [10 °C], and in accordance with the manufacturer's recommendations. Provide finished sealant that does not vary by more than $^{1}/_{16}$ in [2 mm] from the dimensions shown in the contract.

   Ensure the equipment used to apply the sealant has a minimum melting capacity of 100 gal/hr [375 l/hr], is capable of heating the sealant mixture to at least 300 ° F [150 °C], and has a positive means of keeping the sealant mixture agitated and thoroughly mixed during sealing operations. Ensure the temperature of the sealant mixture does not exceed 390 °F [198 °C]. Additional sealant may be added to the mixing tank as long as the manufacturer's recommended minimum temperature is maintained.

5 Do not allow traffic on the pavement until the sealant has cured for at least 1 hour.

414.4.11 Smoothness

1 Before collecting data, perform equipment verification in accordance with procedure no. 515.1, Profilograph Verification, or 515.2, Inertial Profiler Verification, of the *Materials Testing Manual*. Obtain and use manufacturer's

recommended filter settings to simulate a mechanical profilograph output using a 0.1-mile [0.161 km] long blanking band template. The vertical displacement total for each wheelpath trace, in units or counts of 0.01 in [0.25 mm], outside a 0.1-inch [2.5 mm] blanking band to obtain the PI. Perform verification daily or as recommended by the manufacturer.

2 Test all paved lanes for smoothness. Calculate PI using a 0.1-inch [2.5 mm] blanking band. Conduct PI testing across mainline bridge approaches and decks, and analyze PI for all areas except the bridge deck. Exclude from PI testing all paving:

1. Falling under level of control IV;
2. Shoulders, parking lanes, medians, width transitions, acceleration or deceleration, or turning lanes less than 200 ft [60 m] in length;
3. Intersections with posted secondary direction speed < 40 mph [60 km/h] in the secondary traffic direction only;
4. Side roads;
5. Pavement on horizontal curves with centerline radius of curvature less than 1000 ft [300 m] and within 30 ft [10 m] of drainage transitions; and
6. Manholes or inlets.

3 Use a straightedge to test locations excluded from PI testing. Conduct straightedge testing in each wheel path over the entire paved surface length at 3 ft [1 m] from the lane edge or centerline unless otherwise shown in the contract. Conduct PI testing and analysis for all other locations.

4 Obtain profilograph traces in each wheel path measured at 3 ft [1 m] from the lane edge or centerline unless otherwise shown in the contract. Operate profilograph at less than 3 mph [5 km/h]. Operate light-weight inertial profiler according to manufacturer's recommendations. Ensure machine settings and filter settings meet the requirements of Subsection no. 515.1, Profilograph Verification, or 515.2, Inertial Profiler Verification, of the *Materials Testing Manual*. Include a header showing machine settings for all PI traces.

5 The department may perform independent PI testing for verification. If the verification testing results produce an average PI that differs by more than

plus or minus 10 percent over any section of at least 500 ft [150 m] in length, the department and contractor will attempt to resolve the differences. Submit a letter to the engineer outlining the agreed upon resolution within 2 working days of the meeting. Options for resolution include review of filter settings, recalibration, repeat testing, or third-party referee testing.

6 If referee testing is mutually agreed upon, the cost of the third-party testing will be paid by WYDOT if the contractor's profiler results are confirmed by the third-party testing; however, the contractor will pay for the third-party testing if WYDOT's profiler results are confirmed by the third-party testing.

414.4.12 Quality Acceptance

1 The engineer may isolate and reject obviously defective material and pavement without regard to testing procedures.

2 Quality acceptance testing and pay adjustments are based on two different types of lots: paved lots and gradation lots. See Table 414.4.2-1, QC/QA Testing Requirements Versus Level of Control, for more information.

3 Provide gradation QA testing during concrete production. Gradation lots are independent of other paved lots. For gradation lots, there will be at least one lot in all cases, with 5 to 7 sublots per lot.

4 Collect and test aggregate gradation quality acceptance samples in accordance with Table 414.4.2-1, QC/QA Testing Requirements Versus Level of Control. The engineer will determine when to collect gradation quality acceptance samples by using random numbers. Collect two samples. Test one sample for quality acceptance, and the engineer may test the other sample for verification. Collect samples from the belt or conveyor in accordance with the *Materials Testing Manual* and in presence of the engineer. If using a mechanical sampler, correlate with belt samples in accordance with the *Materials Testing Manual*. Submit results of aggregate gradation quality acceptance tests to the engineer the day after sampling.

5 The engineer or an AASHTO-accredited laboratory contracted by the department will verify aggregate gradation testing in accordance with Subsection 401.4.8, Verification.

6 The engineer will perform quality acceptance testing for air content, strength, and pavement thickness based on paved lots. Quality acceptance pay factors

apply to paved lots for levels of control I, II, and III. Test requirements and paved lot sizes are outlined in Table 414.4.2-1, QC/QA Testing Requirements Versus Level of Control. Ensure paved lots are divided into 3 sublots, with each comprising one-third of the surface area of the lot.

7 The WYDOT Materials Program, or an independent third party under contract with the department, will conduct strength tests.

8 Thickness measurements are to be made in accordance with procedure No. 609.0, Measuring Length of Drilled Concrete Cores, of the *Materials Testing Manual*, using pavement cores.

9 Concrete with strength results failing to meet at least 85 percent of the design flexural strength will be rejected.

10 Paved sections with thickness of less than the design thickness minus ¾ in [19 mm] will be rejected.

414.4.12.1 Quality Acceptance Testing for Air Content, Strength, and Thickness

414.4.12.1.1 Levels of Control I, II, and III

1 The department will perform acceptance tests on each paved lot of concrete based on independent samples. Provide the core samples for determining thickness. Any sublot with an entrained air content less than 3.3 percent will be rejected. Any paved lot with an average entrained air content of less than 4.0 percent will be rejected.

2 For strength tests, the engineer will collect one “set” of cylinders per sublot, with a “set” defined as three cylinders. The compressive strength value for the sublot will be the average of the three cylinders’ test results. This compressive strength value will then be converted to flexural strength by using the established correlation constant. Any sublot with a flexural strength less than 85 percent of design flexural strength will be rejected.

3 Take cores at the locations marked by and in the presence of the engineer. Obtain one core per sublot for thickness determination.

414.4.12.1.2 Level of Control IV

1 Quality acceptance for level of control IV paving is not based on paved lots. Test results will determine acceptance or rejection.

2 Concrete with air content results below 4.0 percent will be rejected.

414.4.12.2 Quality Acceptance Testing for Smoothness

414.4.12.2.1 PI-Based Acceptance

1 Upon paving completion, divide the project into segments, as directed by the engineer, and analyze each segment for PI. Define a segment as a continuous paved length that is 12 ft [3.6 m] wide and approximately 0.1 mi [0.16 km] long. When shorter paved lengths less than or equal to 0.05 mi [0.05 km] long occur, include these with an adjacent segment to make a continuous segment of up to 0.15 mi long. Define paved lengths greater than 0.05 mi [0.05 km] and less than 0.10 mi [2.5 km] long as separate segments.

2 Conduct quality acceptance PI testing for each segment, in the presence of the engineer, as soon as possible after completion of paving operations. Results of tests made without direct engineer supervision will not be accepted. This testing will determine acceptability of the surface, and pay factor adjustments, when applicable. Additional corrective measures may be required.

3 Provide pavement meeting PI acceptance requirements and must-grind limits shown in Table 414.4.12.2-1, Must-Grind and PI Acceptance Levels.

Table 414.4.12.2-1
Must-Grind and PI Acceptance Levels

Speed Limit (mph)	Bumps/Dips	Full Segment Grind PI[1]	Acceptance PI[2]	Bonus PI[3]
S > 55	> 0.3 inch in 25 ft [7.5 mm in 8m]	32	10 - 16	< 10
45 < S ≤ 55 & Interstate Ramps	> 0.4 inch in 25 ft [10 mm in 8m)	43	14 - 22	< 14
35 < S ≤ 45	> 0.4 inch in 25 ft [7.5 mm in 8m]	50	22 - 30	< 22
S ≤ 35	> 0.5 inch in 25 ft [12 mm in 8m)	60	26 - 36	< 26

(1) Grind all segments with PI exceeding this level in their entirety to a consistent finish.

(2) Segments with PI in this range are acceptable with no pay adjustment.

(3) Segments with PI meeting this level without corrective action are eligible for bonus.

4 Apply corrective action to remove bumps and dips and to correct out-of-specification segments. A segment is out-of-specification if either wheel path exceeds the acceptance PI. Evaluate each individual PI trace, or wheel path, within the out-of-specification segments to determine the areas where corrective actions are needed.

5 Acceptance will be determined for each segment following successful completion of any necessary corrective actions.

414.4.12.2.2 Straightedge-Based Acceptance

1 For locations tested by straightedge, ensure surface deviations do not exceed $^{3}/_{16}$ inch in 10 ft [4 mm in 3m].

414.4.12.4.3 Corrective Actions

1 Make corrections using an approved grinding device or by removing and replacing the pavement.

2 Grind the full lane width. Ensure the corrected area has uniform texture and appearance. Keep the beginning and end of the corrected area squared normal to centerline of the paved surface. Feather edges of corrected areas.

3 Diamond groove all ground locations to match adjacent concrete pavement texture, including tine spacing and straightness requirements.

414.4.13 Repair of Defective Pavement

1 Replace areas with uncontrolled cracking, corner cracks, rough areas that grinding does not correct, or other unacceptable pavement sections. Replace full panels to the existing joints.

414.5 MEASUREMENT and PAYMENT

414.5.1 General

1 The engineer will measure:

1. CONCRETE PVMT (__ in), by the square yard [square meter], based on the actual length placed and the lesser of the actual or specified width placed. The length will be the linear measurement along the centerline of each roadway.

2. Portland Cement and Fly Ash will be measured but will be considered incidental to the contract pay item CONCRETE PVMT (__ in).

3. CONTRACTOR TESTING by the Lump Sum.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Concrete Pvmt (__ in)	SY	0.1 ft	SY
Contractor Testing (1)	LS	LS	LS

(1) Payment for Contractor Testing will be made at the contract Lump Sum bid price and as follows: 25 percent of the Lump Sum bid price for Contractor Testing will be paid on the first monthly estimate; 50 percent of the Lump Sum bid price will be paid on the monthly estimate for the month in which the testing begins; and the final 25 percent will be paid upon completion of the Contractor Testing pay item. Additional compensation will not be made for additional testing required due to minor increases in quantities of contract items in this specification.Changes in quantities meeting the changed condition requirements specified in Subsection 104.2, Contract Amendment, will be sufficient justification for further adjustment.

414.5.2 Payment Adjustment

414.5.2.1 Concrete Pavement

1 Payment for Concrete Pavement will be determined as follows:

1. **Levels of Control I, II, and III.** Apply the overall pay factor PF found in Subsection 414.5.3, Determination of Pay Factors for Levels of Control I, II, and III, for each paved lot to determine the pay for that lot in accordance with the following:

$$\text{Lot Pay} = PF \times LSp \times UP$$

Where:	PCCP Pay	=	Total pay for concrete placement
	PF	=	Individual pay factor
	LSp	=	Paved Lot Size (square yard)
	UP	=	Unit Contract Price for the concrete pavement

The total project payment will then be determined by summing all lot payments.

2. **Level IV.** No pay factor adjustment applies. Payment will be based on the Unit Contract Price.

414.5.2.2 Aggregate Gradation (All Levels of Control)

1 An independent lump sum pay adjustment for aggregate gradation will be made. The total gradation pay adjustment will be made by summing all individual gradation adjustments:

$$\text{Total Gradation Adjustment} = \sum \text{PAg}$$

where PAg for each gradation lot determined as defined in Subsection 414.5.3.1, Determination of Pay Adjustment for Aggregate Gradation.

414.5.2.3 Smoothness (All Levels of Control)

1 An independent lump sum pay adjustment for smoothness bonus will be made. The total smoothness pay adjustment will be made by summing all individual segments

$$\text{Smoothness Adjustment} = \text{SEGSUM}$$

as defined in Subsection 414.5.3.2, Determination of Pay Adjustment for Smoothness.

414.5.2.4 Joint Sealant Installation Quality (All Levels of Control)

1 An independent lump sum pay adjustment for liquid joint sealing will be made. A $100 penalty will be applied to each transverse joint and any 100-foot [30 m] length of a longitudinal joint with more than 10 percent of its length overfilled. A summation of all joints falling under this penalty will comprise this pay adjustment.

414.5.3 Determination of Pay Factors for Levels of Control I, II, and III

Pay factor adjustments are based on air content, strength, and thickness. Pay
factors will be determined per paved lot for each variable then combined for
1 the final assessed pay factor for the lot, as described in the following list. The
engineer will determine pay factors on each paved lot as follows:

1. Determine the lot mean for strength and thickness, $\bar{x}$.

   The lot mean is determined as

   $$\bar{x} = (\Sigma x)/n$$

   Where: Σ = Summation
   x = Individual sublot test value
   n = Total number of test values

   Round strength mean to nearest 1 psi [0.01 MPa].

   Round thickness mean to nearest 0.1 in [2.5 mm].

2. Determine individual pay factors:

   Calculate pay factors for each variable as follows:

   2.1 **Air Content (PFa):**

   $$PFa = 1.0 - 0.1\ [(4.2 - AC_1) + (4.2 - AC_2) + (4.2 - AC_3)]$$

   Where: AC_1 = Air content for sublot #1 in percent, etc.

   If any sublot $AC_n \geq 4.2$, use $AC_n = 4.2$ in equation.

   $$\text{Max } PFa = 1.0$$

   Sublots with $AC \leq 3.3$ percent will be rejected and not included in this calculation.

   Lots with average air content of less than 4.0 percent will be rejected.

   2.2 **Strength (PFs):**

   The strength pay factor for any lot is based on the ratio of the mean flexural strength of the concrete supplied to the project and the design flexural strength.

$$PFs = 0.53 + 0.47\ (Sc/Sd)$$

Where:	Sc	=	$Cc \times (Cs)^{1/2}$
	Cc	=	Established correlation constant, per Subsection 414.4.7, Proportioning Portland Cement Concrete Mixes
	Cs	=	Mean 28 day compressive strength of delivered concrete
	Sd	=	Design flexural strength
	Max PFs	=	1.0

If the mean flexural strength of any sublot is less than 85 percent of the design flexural strength, the sublot will be rejected.

2.3 **Thickness (PFt):**

The thickness pay factor depends on the lot mean thickness and the design thickness. Thickness pay factors are determined using the following equation:

For $Tc < Td$, $PFt = 1 - 0.4\ (Td - Tc)$

For $Tc \geq Td$, $PFt = 1 + 0.08\ (Tc - Td)$

Where:	Tc	=	As constructed measured lot mean thickness, inches
	Td	=	Design thickness, shown in the contract, inches.
	Max PFt	=	1.02

If any sublot thickness is less than design thickness, Max PFt = 1.00.

Reject if $PFt < 0.8$.

For individual sublots where $Tc < Td$, the sublot will be rejected if $Tc < (Td - 0.75)$.

3. Determine overall pay factor (PF) per paved lot:

The pay factor for each paved lot will be assessed as follows:

If [(PFs + PFt)] ≥ 1 and PFa = 1 then

PF = [(PFs + PFt) - 1].

If either [(PFs + PFt) – 1] < 1 or PFa < 1 then

PF = Minimum of [(PFs + PFt) – 1] and Pfa.

414.5.3.1 Determination of Pay Factors for Aggregate Gradation

1 Aggregate for all levels of control are subject to pay factors as determined by Subsection 113.1, Acceptance of Aggregate, with a maximum allowed pay factor of 1.0.

2 The engineer will determine gradation pay factors, PFgc (pay factor for coarse aggregate gradation) and PFgf (pay factor for fine aggregate gradation), in accordance with Subsection 113.1, Acceptance of Aggregate, with a maximum value of 1.0 allowed. Pay adjustments will then be applied based on gradation lots. Gradation lots are independent of other quality acceptance paved lots. The gradation lot size will be the same for coarse and fine aggregate and is referred to as LSg. A minimum of five test results and a maximum of seven will be required to represent a lot. The total lot size cannot represent more than 20,000 SY of concrete placed. For each gradation lot, the pay adjustment will be as follows:

PAg = PAc + PAf

Where:	PAg	=	Pay adjustment for the gradation lot
	PAc	=	0.1 * UP * % C * (PFgc - 1) * LSg
	PAf	=	0.1 * UP * % F * (PFgf - 1) * LSg

and

PAc	=	Pay adjustment for coarse aggregate ($)
PAf	=	Pay adjustment for fine aggregate ($)
UP	=	Concrete pavement unit price (dollars)
% C	=	Percent coarse aggregate of total aggregate in mix design
% F	=	Percent fine aggregate of total aggregate in mix design
PFgc	=	Pay factor for coarse gradation for lot (max = 1.0)
PFgf	=	Pay factor for fines gradation for lot (max = 1.0)
LSg	=	Gradation lot size in square yards

414.5.3.2 Determination of Pay Adjustment for Smoothness

1 Pay adjustments apply only to locations accepted based on PI and are assessed per pavement segment, as defined in Subsection 414.4.12.2, Quality Acceptance Testing for Smoothness. Segments with no corrective action may be awarded a bonus based on the average PI of both wheel paths within the segment.

2 A pay potential will be applied for each segment with PI meeting the bonus PI, prior to corrective actions, in accordance with Table 414.5.3.4-1, Pay Potential Per Segment.

Table 414.5.3.4-1
Pay Potential Per Segment

Corrections in Segment	Bonus for Segment
None	$500* (Spec PI/Test PI)
Grinding Required	No Bonus

Where: Spec PI is the lower limit of the acceptance PI.

Test PI is the PI average of both wheel paths for the segment.

Test PI must meet “bonus PI” level to be eligible.

Maximum pay potential per segment = $1500.

3 The engineer will determine the sum of all segment pay potentials, referred to as SEGSUM.

4 The engineer will determine overall smoothness pay adjustment using Table 414.5.3.4-2, Overall Smoothness Pay Adjustment.

Table 414.5.3.4-2
Overall Smoothness Pay Adjustment

% ISS	Pay Adjustment
85% - 100%	1 * SEGSUM
< 85%	{1 - [(0.85 - % ISS) / 0.35]} * SEGSUM

Where: % ISS is the percentage of all segments that meet acceptance criteria prior to corrective action

Minimum Pay Adjustment = $0.00.

SECTION 415
Concrete Pavement Repair

415.1 DESCRIPTION

1 This section describes the requirements for removing and replacing existing concrete pavement slabs (full depth repair), repairing spalled locations in concrete pavement (partial depth repair), and grinding and texturing the surface of existing concrete pavement.

415.2 MATERIALS

415.2.1 Slab Replacement

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Curing Materials	802
Dowel Bars and Tie Bars	811.2
Epoxy Resin Grout	819.2
Fly Ash	801.2
Joint Materials	807
Portland Cement	801.1
Water	814

415.2.2 Spall Repair

1 Provide materials in accordance with the following:

Material	Subsection
Concrete Patching Material	810.1
Curing Materials	802.1
Joint Materials	807
Water	814

2 Provide bonding agents in accordance with the manufacturer's recommendations of the spall repair material.

415.3 EQUIPMENT

415.3.1 Slab Replacement

1 Provide equipment in accordance with Section 513, Structural Concrete, including a vibrating screed unless otherwise approved by the engineer.

2 Provide a 25-foot [7.5 m] computerized California-type profilograph or class 1 inertial profiler in accordance with Subsection 415.3.3, Grinding and Texturing, if there are repair locations that include four or more contiguous slabs to be replaced.

415.3.2 Spall Repair

1 Provide the following:

1. A concrete saw with a saw cut depth of at least 2 in [50 mm];
2. A milling head capable of stopping at a preset depth, pneumatic grinding tools, hand tools, or combination capable of removing concrete;
3. Jack hammers no larger than the nominal 30-pound [14 kg] class;
4. A sandblaster and an air compressor able to produce oil-free compressed air;
5. A mobile, continuous mixer or a small, portable, motor-driven, batch-type mixer at the placement site that accurately proportions materials for the mixture, discharges a uniform mixture, and maintains a continuous, steady flow of mixture; and
6. If necessary, a scale, accurate to the nearest pound [kilogram], and other equipment to charge the mixer with the correct proportions of materials.

415.3.3 Grinding and Texturing

1 Provide grinding equipment with diamond blades mounted on a minimum 3-foot [1 m] wide head mounted on a self-propelled machine designed for grinding and texturing concrete pavements.

2 Provide an approved and calibrated 25-foot [7.5 m] computerized California-type profilograph with a truss-type frame or an approved class 1 inertial profiler. Ensure that the computer:

1. Smooths the profile with a third order Butterworth filter with a cut-off wavelength of 24 in [600 mm];

2. Generates a profile index with a 0.1 in [2.5 mm] blanking band;

3. Allows adjustments of the bump threshold to identify corrective action locations; and

4. Does not recenter the blanking band more often than once every 0.1 mile [0.16 km].

415.4 CONSTRUCTION

415.4.1 General

1 Repair damage caused by the work to existing concrete pavement, reinforcing bars and joints outside the limits of the slab replacement, spall repair, or grinding and texturing area at no additional cost to the department.

2 Haul, dispose of, and furnish waste locations for removed concrete pavement, excavated material, and slurry from grinding operations.

415.4.2 Slab Replacement

415.4.2.1 General

1 Follow the weather limitations in Subsection 513.4.2, Weather Limitations.

2 Use the approved mix design and place concrete pavement that achieves a compressive strength of at least 3000 psi [21 Mpa] in 48 hours.

415.4.2.2 Mix Design

1 Submit the following to the engineer for approval at least 28 calendar days before the placing concrete pavement:

1. The proposed mix design meeting requirements for class A concrete and the specified early strength gain, and designating proportions of all materials;

2. Sufficient quantities of materials to trial batch a confirmation mix at the Materials Laboratory, in accordance with Subsection 513.4.4, Mix Design; and

3. A completed "Concrete Mix Design," (Form E-45) available in the *Materials Testing Manual*, documenting the project number, manufacturer, source, type, and brand for the materials.

415.4.2.3 Replacement Procedures

1 Saw-cut full-depth the existing concrete slabs and partial slabs for removal. Cut along the existing longitudinal and transverse joints to remove full-length, full-width slabs, and along an engineer-designated outline for partial slabs. For transverse joints with existing load transfer dowel bars, cut full-depth through the dowel bars. Alternatively, cut down to the top of the dowel bars only, in which case the bars may be reused in their present position if they remain undamaged and firmly embedded in the undisturbed slab.

2 In areas specified or determined by the engineer for excavation and backfill, level and consolidate existing subgrade and base material to 95 percent of maximum density in accordance with AASHTO T 99 for subgrade and AASHTO T180 for base material. Mix, place, and cure concrete in accordance with Section 513, Structural Concrete.

3 Ensure at least 7 days concrete curing time before sealant placement, unless otherwise recommended by the sealant manufacturer. Seal longitudinal and transverse joints for concrete slab replacements with silicone joint sealant, hot-poured elastic sealant, or preformed elastomeric compression sealant in accordance with Section 417, Sealing Existing Concrete Pavement Joints and Cracks. Use silicone joint sealant, if the sealant type is not specified.

415.4.2.4 Surface Tolerance

1 Do not leave deviations in the traveled way greater than 0.2 inches in 10 ft [5 mm in 3 m] when tested by a string line or straightedge.

2 If there are repair locations that include four or more contiguous new slabs, measure the surface smoothness with a 25-foot [7.5 m] computerized California-type profilograph or class 1 inertial profiler. Grind smooth deviations that exceed must-grind values in accordance with Table 415.4.2-1, Must-Grind and PI Acceptance Levels.

Table 415.4.2-1
Must-Grind and PI Acceptance Levels

Speed Limit (mph)	Must Grind Bumps	Acceptance PI
S > 55	0.3 in [8 mm] in 25 ft [7.6 m]	10 in/mi [160 mm/km]
45 < S ≤ 55	0.4 in [10 mm] in 25 ft [7.6 m]	14 in/mi [224 mm/km]
35 < S ≤ 45	0.4 in [10 mm] in 25 ft [7.6 m]	22 in/mi [352 mm/km]
S ≤ 35	0.5 in [13 mm] in 25 ft [7.6 m]	26 in/mi [416 mm/km]

415.4.2.5 Repair of New Slabs

1 Grind smooth or remove and replace new slabs that do not meet the surface tolerance specification.

2 Replace areas with uncontrolled cracks, corner cracks, rough areas not corrected by grinding, or other unacceptable pavement sections. Remove full panels to existing joints. Provide replacement panels of the same quality and dimensions specified.

415.4.3 Spall Repair

415.4.3.1 General

1 At least 14 calendar days before its expected use, give to the engineer enough patching material, including the extension aggregate, for a 0.5 ft^3 [0.01 m^3] batch. Also provide the Material Safety Data Sheet.

2 Do not place patching material if the air temperature is below 50 ºF [10 ºC] or expected to fall below 40 ºF [4 ºC] within 24 hours of placement.

3 Use the bonding material and bonding procedure for the concrete patch recommended by the patching material manufacturer. Ensure the presence of the manufacturer's technical representative for the initial placement.

4 Prepare for patching only those areas that can be completed and sufficiently cured, in accordance with the manufacturer's recommendations, to open to traffic by nightfall the same day. Do not open repaired areas to traffic before the repair material obtains a compressive strength of 4000 psi [27.6 MPa].

5 If a mobile, continuous mixer is used, calibrate the proportioning equipment for each component of the mixture in the presence of the engineer. The engineer may accept the previous calibration and require verification checks only at the settings indicated by the previous calibration. During calibration checks and normal use, operate proportioning equipment at the speed recommended by the manufacturer. When a portable batch type mixer is used, provide measuring devices and other necessary equipment.

415.4.3.2 Repair Procedures

1 The engineer will designate spall repair areas. Saw the outline of each area to a depth of at least 1 in [25 mm]. Remove unsound concrete down to sound concrete or to a depth of at least 2 in [50 mm]. Prepare square or rectangular repair areas at least 6 in [150 mm] wide and long, of uniform depth, and with vertical sides. After removing unsound concrete, clean exposed surfaces by sandblasting and air blasting.

2 Apply bonding material to exposed surfaces of the repair area in accordance with the manufacturer's recommendations, and immediately place and consolidate patching material. Reapply bonding material if it cures and hardens before placement of the patching material.

3 Place patching material continuously in each repair area until the entire area is finished to grade and sloped to match the adjacent pavement surface. Do not add water to the patching material surface until the material hardens. Cure in accordance with the manufacturer's recommendations.

4 If the repair area abuts or spans a working joint or crack, continue the joint or crack through the repair. This can be accomplished by inserting a temporary strip in the joint position before placing the patching material. Reestablish longitudinal and transverse joints throughout all repairs. Do not remove temporary insert material until 24 hours after patching.

5 After repairs have cured, replace joint sealant in transverse and longitudinal joints and random working joints disturbed by patching in accordance with Section 417, Sealing Existing Concrete Pavement Joints and Cracks.

6 Do not open repaired areas to traffic before examination by the engineer. Remove and replace any portion of the repair with cracks or inadequate bonding at no additional cost to the department.

415.4.3.3 Surface Tolerance

1 Do not leave deviations in the traveled way greater than 0.2 inches in 10 ft [5 mm in 3 m] when tested by a string line or straightedge by the engineer.

2 Grind smooth or remove and replace spall repair locations that do not meet the surface tolerance specification.

415.4.4 Grinding and Texturing

415.4.4.1 General

1 Submit a detailed grinding plan to the engineer for approval before starting work. Include a sequence to produce the desired surface ride qualities with the least grinding depth throughout the project.

2 Grind in the longitudinal direction. Grind the entire surface width specified until the pavement surfaces on both sides of all transverse joints and random cracks are on the same plane and meet surface tolerance requirements.

3 Use grinding equipment that does not strain or damage concrete pavement. Do not use grinding and texturing equipment that causes excessive raveling, aggregate fracturing, spalling, or disturbance of the transverse or longitudinal joints.

4 Leave neat, rectangular ground areas with a uniform surface appearance, uniformly tapered to adjoining pavement. Perform additional grinding as necessary to extend the ground area so that lateral limits of grinding are at a constant offset distance from, and parallel to, the nearest pavement edge. Feather vertical edges outside the area to be ground. Do not cause adverse drainage by grinding.

5 Grind mainline pavement to produce a skid-resistant surface consisting of grooves from $^{3}/_{32}$ in to ⅛ in [2.5 mm to 3 mm] wide, spaced from $^{5}/_{64}$ in to ⅛ in [2 mm to 3 mm] apart, and approximately $^{1}/_{16}$ in [1.5 mm] deep relative to the tops of the adjacent ridges.

6 Remove grinding slurry and residue continuously and immediately, leave pavement clean, and dispose of slurry as approved by the engineer.

415.4.4.2 Average Profile Index and Corrective Action

1 Provide a computerized profilograph or a class 1 inertial profiler. Ensure the class 1 inertial profiler output simulates a mechanical profilograph output using a 0.1-mile [0.16 km] long blanking band template.

2 Before use on the project and periodically thereafter, check the calibration of the profilograph in the presence of the engineer. Before checking the calibration, provide a document indicating the system specific measurement options for the profilograph to the engineer. To check the horizontal scale, run the profilograph over a known distance and scale the results on the profilograph trace. To check the vertical scale, put a block of known thickness under the profile wheel and scale the result on the profilograph trace. Correct the calibration as necessary before using the profilograph.

3 The engineer may spot check or retest areas with another profilograph or class 1 inertial profiler. If a discrepancy exists, determine the cause and reprofile the areas as requested by the engineer.

4 After grinding, test surface roughness with a profilograph. Take profile traces at a distance of 3 ft [1 m] from, and parallel to, the outside edge of the traveled way and 3 ft [1 m] from the centerline joint. In operation, move the profilograph longitudinally along the pavement surface no faster than 3 mph [5 km/h].

5 Calculate the profile index in/mi [mm/km] as the summation of the individual vertical displacements outside of a 0.1 in [2.5 mm] opaque blanking band centered on the profile trace. Convert the accumulated vertical displacement total for the length of the trace to in/mi [mm/km] to obtain a profile index.

6 For purposes of calculating the average profile index and where additional pavement grinding is required, determine the average profile index for each 0.1 mi [0.16 km] segment for each lane separately and average both parallel traces within that lane. Combine segments that are less than 0.1 mi [0.16 km] in length with an adjacent 0.1 mi [0.16 km] segment for purposes of evaluation.

7 Within 24 hours of testing, give the engineer computer-generated profilograph or class 1 inertial profiler traces and printouts of the average profile index for each 0.1 mi [0.16 km] segment evaluated, along with printouts for areas with deviations greater than 0.3 inches in 25 ft [8 mm in 7.5 m]

415.4.4.3 Surface Tolerance

1 Leave the concrete pavement surface with an average profile index of 10 in/mi [160 mm/km] or less on travel lane pavement segments; grind smooth deviations greater than 0.3 inches in 25 ft [8 mm in 7.5 m], as determined by the profilograph. Ensure the concrete pavement surface meets must-grind and profile index acceptance levels in accordance with Table 415.4.2-1, Must-Grind and PI Acceptance Levels. In the transverse slope of the pavement, do not leave deviations in the traveled way greater than 0.2 inches in 10 ft [5 mm in 3 m] when tested by a string line or straightedge placed perpendicular to the pavement centerline.

2 Regrind and texture the concrete pavement until all areas meet the surface tolerance requirements. Retest corrective action locations for surface tolerance and submit results to the engineer.

415.5 MEASUREMENT and PAYMENT

415.5.1 General

1 The engineer will measure:

1. Conc Pvmt Spall Repair by the square foot [square meter] or the cubic foot [cubic meter] measured in the plane of the existing concrete pavement surface.
2. Conc Slab Replacement by the square yard [square meter], measured parallel to the paved surface.
3. Grind/Texture Conc Pvmt by the square yard [square meter] of pavement surface ground.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Conc Slab Replacement	SY [m²]	0.1 ft [0.05 m]	SY [m²]
Conc Pvmt Spall Repair	SF, CF [m², m³]	0.1 ft, 0.1 ft [0.05 m, 0.05 m]	SF, CF [0.1 m², 0.1 m³]
Grind/Texture Conc Pvmt	SY [m²]	0.1 ft [0.05 m]	SY [m²]

415.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Crushed Base in accordance with Section 301, Aggregate Subbase, Base Courses, and Bed Course Material.

2. Sealing for working joints or cracks in accordance with Section 417, Sealing Existing Concrete Pavement Joints and Cracks.

SECTION 416
Dowel Bar Retrofit

416.1 DESCRIPTION

1 This section describes the requirements for installing epoxy-coated dowel bars into existing transverse joints in concrete pavement.

416.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Bond-Breaking Compound	810.2
Caulking Filler	810.3
Chairs	811.2.5
Dowel Bar Retrofit Concrete	810.5
Dowel Bars and Tie Bars	811.2
Dowel Bar End Caps	811.2.2
Foam Core Board	810.4

416.3 EQUIPMENT

1 Ensure that equipment meets the following:

1. A concrete saw capable of cutting at least three slots simultaneously at least 7.25 in [184 mm] deep;

2. Jack hammers no larger than the nominal 30-pound [14 kg] class;

3. A sandblaster and an air compressor able to produce oil-free compressed air;

4. A mobile, continuous mixer or a small, portable, motor-driven, batch-type mixer at the placement site that accurately proportions materials for the mixture, discharges a uniform mixture, and maintains a continuous, steady flow of mixture; and

5. If necessary, a scale, accurate to the nearest pound [kilogram] and other equipment to charge the mixer with the correct proportions of materials.

416.4 CONSTRUCTION

416.4.1 General

1 Submit a sample of each of the following items to the engineer for approval at least 14 calendar days before use:

1. End caps;
2. Chair devices;
3. Caulking filler;
4. Foam core board filler;
5. Bond breaking compound; and
6. Enough patching material, including the extension aggregate, for a 0.5 ft^3 [0.01 m^3] batch.

2 Provide saw-cut dowels, free of burrs or projections that restrict movement, with tight-fitting end caps. Repair damage to epoxy coating in the field.

3 Place dowel bar retrofit concrete in accordance with the manufacturer's recommendations. Ensure that samples acquired during production achieve a compressive strength of at least 4000 psi [27.6 MPa] in 24 hours. Conduct quality acceptance sampling of the patching material at a minimum frequency of one slump test per 100 dowels placed, and one set of three strength tests per 300 dowels placed. Any slump test exceeding 10 in [225 mm] will be cause for rejection of all material placed since the previous slump test. Test each set of three 4-inch [100 mm] cylinders for strength at between 24 and 36 hours after molding. If the average of the three test results is less than 4000 psi [28 MPa], the 300 dowels the sample represents will be rejected. This will include 25 joints before and 25 joints after the location of sampling. Test locations will be as directed by the engineer.

4 If a mobile mixer is used, provide separate bins for cement, fine aggregate, and extension aggregate. Calibrate the proportioning equipment for each component of the mixture in the presence of the engineer. During calibration checks and normal use, operate proportioning equipment at the speed recommended by the manufacturer. When a portable batch type mixer is used, provide measuring devices and other necessary equipment.

416.4.2 Test Section

1 Provide a test section consisting of complete dowel bar retrofit, to include at least 24 retrofits, at a location determined by the engineer before start of major operations. Twenty-four hours after completing the test section, take three 6-inch [150 mm] diameter full-depth cores at locations determined by the engineer to assess the installation. Take and inspect cores in the presence of the engineer. Ensure proper dowel placement and no voids around the bar circumference. Backfill core locations using the approved dowel bar retrofit concrete. Make visual observations of the backfill concrete and inspect for cracking. After obtaining the engineer's approval, begin production operations and proceed on a performance basis.

416.4.3 Installation

1 Retrofit only existing type A, weakened plane transverse joints with dowels. Cut slots in the pavement, parallel to the centerline of the roadway, to place the center of the dowel at mid-depth in the concrete slab. Simultaneously cut at least three slots per wheel path along the transverse joint or crack, or as approved. If necessary, make multiple cuts in the slot, parallel to the centerline, to properly remove material. Collect and dispose of slurry and residue at an approved location.

2 Close the lane if slots are sawn too far ahead of the operation and the "fins" formed by the saw cuts begin to break and become a traffic hazard or if traffic begins to cause corner breaks from cracks that develop between slots and the longitudinal shoulder or center line joint. Reopen the lane after the damaged areas are repaired and the retrofitting of the dowel bars is completed. Repair corner breaks or cracks caused by traffic on unfinished slots at no additional cost to the department.

3 Use a 15-pound [7 kg] jack hammer when breaking the concrete out of the slot, if the 30-pound [14 kg] hammer damages the pavement,.

4 Before installing dowel bars, sandblast and clean the slot of saw slurry and loose concrete. If the crack width of the transverse contraction joint equals or exceeds ⅛ in [3 mm], fill the joint on the bottom and the sides of the slot with silicone. Minimize the amount of silicone on the side and bottom surfaces of the slot.

5 Coat bars with a bond breaking compound, place in the approved dowel chair, and place as follows:

1. To the depth specified;

2. Parallel to the centerline;

3. At the middle of the slot;

4. With the mid-point of the dowel within 1 in [25 mm] of the centerline of the transverse joint; and

5. Parallel to the pavement surface (ensure that the bar does not deviate more than ¼ in [6 mm] from a plane parallel to the pavement surface, when measured along the length of the bar).

6 Do not allow movement of the dowel bar in the chair during placement of the grout. The engineer will reject chairs that allow movement of the bar. Ensure that dowel bar sleeves do not collapse during construction.

7 Place foam core board filler at the middle of the dowel to maintain the transverse joint or crack. Fit the board tightly around the dowel and edges of the slot. Cut or remove existing joint sealant to accommodate the board tabs (which stabilize the board during placement of patching material). Place the board so that it remains vertical and tight against all edges during placement of the patching material.

8 Fill the slot (with the installed dowel bar with caps, chairs, foam core board, and silicone in place) with an approved patching material. Thoroughly moisten all surfaces of the slot immediately before filling. Do not allow standing water in the slot. Remove excess water with compressed air. Thoroughly consolidate the dowel bar retrofit concrete in the slot and around the dowel bar with a vibrator of appropriate size and ensure there are no voids. Trowel the material toward the hardened concrete to prevent voids at the edges of the patch.

9 Cure the surface of the filled area immediately after finishing, in accordance with the patching material manufacturer's recommendations. Maintain joints by saw-cutting the surface within 24 hours of placing the grout.

10 Seal transverse contraction joints and cracks in accordance with Section 417, Sealing Existing Concrete Pavement Joints and Cracks.

11 Repair or replace damaged and nonfunctioning dowels at no additional cost to the department. During production, if cores indicate incomplete consolidation of the patching material under or around the dowel bars, stop placement and take corrective action. Obtain the engineer's approval before restarting. If

cracks develop in the dowel bar retrofit concrete or if there is any separation or debonding between the dowel bar retrofit concrete and the existing concrete, remove and replace at no additional cost to the department.

416.5 MEASUREMENT and PAYMENT

416.5.1 General

1 The engineer will measure Dowel Bar Retrofit by each dowel installed, including dowels in the test section.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Dowel Bar Retrofit	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 417
Sealing Existing Concrete Pavement Joints and Cracks

417.1 DESCRIPTION

1 This section describes the requirements for removing existing joint sealant and sawing, cleaning, and sealing existing concrete pavement joints and random concrete cracks.

417.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Backer Rod	807.7
Joint Materials	807

417.3 EQUIPMENT

1 Provide, if applicable to the work specified, the following:

1. A plow, ripping tooth, wire brush, saw, or other equipment for removing existing sealant from joints and cracks;
2. Power-driven saws with diamond blades;
3. High pressure water blaster to clean sawed joints and random cracks;
4. A power-operated pressure system for silicone joint sealing;
5. Automatic installation machine for preformed elastomeric compression sealant;
6. Air compressor in accordance with Subsection 403.3.3, Cleaning/Drying; and
7. Melting machine in accordance with Subsection 403.3.4, Sealing.

417.4 CONSTRUCTION

417.4.1 General

1 Seal joints and cracks when air and pavement temperatures are at least 40 ºF [5 ºC], unless the sealant manufacturer requires a higher temperature, and the weather and pavement are dry. Do not place silicone sealant if the engineer determines a risk of impending rain.

2 Remove all existing sealant from sealed joints.

3 Do not use equipment that causes spalling of concrete pavement surface beyond the limits of the proposed joint widths. Repair damage to the pavement (such as spalling, cracking, breaking, or overcutting) caused by the work operations at no additional cost to the department.

4 Do not allow traffic on freshly sealed joints for 24 hours, unless otherwise approved by the engineer.

417.4.2 Sawing

417.4.2.1 General

1 For joints between concrete pavement and plant mix pavement, completely remove the plant mix pavement from the concrete face during sawing. Remove raveled edges in the plant mix pavement with the saw cut.

417.4.2.2 Silicone Sealant

1 Saw transverse joints, longitudinal joints, expansion joints, and random cracks to the widths and depths specified. If the engineer determines that the existing joint can be cleaned satisfactorily without sawing, eliminate sawing and use the existing joint width.

2 For joints between concrete pavement and plant mix pavement, saw the plant mix pavement adjacent to the concrete pavement to a width of ½ in [12 mm] and a depth of ¾ in [19 mm].

417.4.2.3 Preformed Elastomeric Compression Sealant

1 Saw when the concrete temperature is from 40 ºF to 80 ºF [4 ºC to 27 ºC].

2 To accommodate the designed sealant size, ensure that the final joint width and depth are in accordance with the sealant manufacturer's recommendations.

417.4.2.4 Hot-Poured Elastic Sealant

1 Saw cracks to at least ⅛ in [3 mm] larger than the initial width and to a depth of three times the final width.

2 For joints between concrete pavement and plant mix pavement, saw the plant mix pavement adjacent to the concrete pavement to a width of ½ in [12 mm] and a depth of 1½ in [38 mm].

417.4.3 Cleaning

1 Thoroughly clean each sawed joint or random crack and the adjacent pavement surface immediately after sawing with a water wash not exceeding 3000 psi [20 685 kPa]. Remove cement dust and debris. After the initial cleaning, do not use more water to clean or prepare for sealing.

2 Immediately before placing joint sealant, sandblast and clean the sawed joints and random cracks with oil-free compressed air. Ensure that the joints and cracks are free of dirt, dust, moisture, or other foreign material that may prevent bonding of the joint sealant. The engineer will inspect and approve prepared sawed joints and random cracks before allowing joint sealing.

3 Space the final cleaning far enough behind the joint sawing to avoid contaminating cleaned joints and cracks with residual water from sawing. On uphill grades, prevent residual water from flowing into previously cleaned and sealed joints and random cracks. Reclean joints and cracks contaminated by sawing.

417.4.4 Sealing Joints and Cracks

417.4.4.1 Silicone Sealant

1 Place backer rod in the joints and random cracks as specified. Maintain the backer rods' placement during sealant application. Place the rods to maintain the specified depth of sealant for all joints and cracks. To maintain the proper

depth of sealant at transverse and longitudinal joint intersections, cut one rod and butt against the intersecting rod, or notch the rods and overlap; maintain the cut rod's placement before and during sealing.

2 Configure and place the backer rods to retain the silicone reservoir when using self-leveling silicone. If the silicone is not retained, modify the rod placement or use a non-sag product.

3 Use a masking tape bond breaker between the sealant and the joint filler on type E expansion joints.

4 When using non-sag silicone sealant, apply and tool the sealant in accordance with the manufacturer's recommendations. Ensure the presence at the site of the manufacturer's technical representative during the initial sealing.

5 Relative to the surface of the adjacent concrete pavement, place the sealant to obtain a finished sealant surface ½ in ± $^{1}/_{16}$ in [13 mm ± 2 mm] deep. Remove and replace sealant outside allowed tolerances at no additional cost to the department.

417.4.4.2 Preformed Elastomeric Compression Sealant

1 Submit sealant design computations indicating that the proposed material will be in compression over the temperature range from -40 ºF to 120 ºF [-40 ºC to 49 ºC] along with the sealant manufacturer's recommendations for joint or random crack width and depth. Perform work in accordance with the manufacturer's recommendations, including weather limitations, concrete temperature, width and depth of saw cuts, joint intersection, and installation depth.

2 At least 21 calendar days before starting sealing, submit the lubricant and a 10-foot [3 m] sample of the sealant to the engineer.

3 Use a single full-width-and-full-depth piece of material for each joint or crack, unless otherwise approved by the engineer. When using more than one piece in a joint, fasten abutting ends securely, and hold them accurately to shape by stapling or other approved methods.

4 Provide the seal at least $^{11}/_{16}$ in [17.5 mm] wide. Machine-place the seal and do not stretch during installation.

417.4.4.3 Hot-Poured Elastic Sealant

1 Seal flush with the existing pavement surface. Apply sealant to the joint or crack from the bottom up with an applicator that allows observation of the sealant flow at the applicator nozzle. Remove overflow sealant from the adjacent concrete surface. Do not use squeegees or wands with a cup.

2 When sealing cracks, use backer rod ⅛ in [3 mm] larger than the sawed crack. Place backer rod to the bottom of the sawcut. Recess the sealant below the pavement surface ¼ in [6 mm].

3 The engineer will accept hot-poured sealant in accordance with Subsection 403.4.7, Crack Seal Acceptance, except that units will be in LF (linear feet). The linear-foot units will also apply to Subsection 403.4.5, Lot Sizes, Sampling, and Testing.

417.5 MEASUREMENT and PAYMENT

417.5.1 General

1 The engineer will measure Sealing Cracks (Conc Pvmt) and Sealing Joints (Conc Pvmt) by the foot [meter] of each random crack or joint sealed.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Sealing Cracks (Conc Pvmt)	FT [m]	0.1 ft [0.05 m]	FT [m]
Sealing Joints (Conc Pvmt)	FT [m]	0.1 ft [0.05 m]	FT [m]

417.5.2 Determination of Pay Factor and Pay Adjustment

1 The engineer will determine the pay factor and pay adjustment for hot-poured elastic sealant in accordance with Subsection 403.5.2, Determination of Pay Factor and Pay Adjustment.

SECTION 418
Rumble Strips

418.1 DESCRIPTION

1 This section describes the requirements for cutting rumble strips in plant mix pavement and concrete pavement.

418.2 MATERIALS—Vacant

418.3 EQUIPMENT

1 Ensure that equipment meets the following:

1. For portland cement concrete pavement, provide a grinder with carbide-tipped grinding drum. For plant mix pavement, provide a mill with steel milling head. Ensure equipment produces a smooth cut in accordance with the corrugation pattern specified.

2. A power broom or sweeper/vacuum.

418.4 CONSTRUCTION

418.4.1 General

1 Repair or recut misaligned rumble strips. Repair or replace damaged pavement at no additional cost to the department. Before opening the adjacent lane or roadway to traffic each day, remove waste material resulting from the work.

418.4.2 Shoulder Rumble Strips

1 Align the shoulder rumble strip where specified and as verified by the engineer.

2 Demonstrate to the engineer on an initial test section of 500 ft [150 m] that the equipment and methods provide the desired rumble strip and surface inside each depression, without tearing or snagging the plant mix pavement. If the results do not meet the contract requirements, use new equipment or methods, or make necessary adjustments; repair or replace the test section as directed at no additional cost to the department.

418.4.3 Rumble Strip Sections

1 Align the group of rumble strip sections without deviation greater than 6 in [150 mm] from the longitudinal reference line. Do not install before the engineer verifies the alignment.

418.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Rumble Strips (Asphalt) or Rumble Strips (Concrete) by the mile [kilometer], longitudinally along the edge of travel way for each affected shoulder.

2. Rumble Strip Section by the each.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Rumble Strips (Asphalt)	MI [km]	0.001 mi [0.005 km]	0.01 MI [0.05 km]
Rumble Strips (Concrete)	MI [km]	0.001 mi [0.005 km]	0.01 MI [0.05 km]
Rumble Strip Section	EA [Ea]	EA [Ea]	EA [Ea]

DIVISION 500

Structures

SECTION 501
Structural Steel

501.1 DESCRIPTION

1 This section describes the requirements for structural steel.

501.2 MATERIALS

1 Provide and use materials in accordance with the following:

Material	Subsection
Automatically End-Welded Studs	815.4
Bolts and Fasteners (other than high-strength)	815.6
Bronze Bearing Plates	815.10
Elastomeric Bearing Pads	815.16
Epoxy Resin Grout	819.2
Galvanized Coating	815.14
High-Strength Anchor Bolts	815.18
High-Strength Bolts, Nuts, and Circular Washers	815.2
Nonshrink Grout	819.1
Paint	809
Preformed Fabric Pads	815.15
Sheet Metal	815.3
Steel Castings	815.12
Steel Pins and Rollers	815.11
Steel Pipe	815.5
Structural Steel	815.1
Welding Materials	815.17

2 Provide blue paint for the final field coat.

3 Use structural carbon steel.

4 Provide a feeler gauge with each lot of load indicator washers.

501.3 EQUIPMENT—Vacant

501.4 CONSTRUCTION

501.4.1 Fabrication

501.4.1.1 General

1 Use temperature-indicating crayons to determine temperatures of materials.

501.4.1.2 Fabricator Certification

1 Ensure that steel fabricators supplying structural components for bridges are certified under the American Institute of Steel Construction Quality Certification Program at the time of contract letting and that the certification remains in effect through fabrication.

501.4.1.3 Shop Drawings

1 Do not fabricate steel before the State Bridge Engineer approves shop drawings. Ensure that the fabricator gives shop drawings to the State Bridge Engineer in accordance with Subsection 105.2, Working Drawings.

2 With the advance shop drawings, submit, for approval, two copies of the Welding Electrode Certification Conformance, Procedure Qualification Record, and Welding Procedure Specification in accordance with AASHTO/AWS D1.5, Bridge Welding Code. On the drawings, reference weld symbols to “Welding Procedure Specifications.” Identify each piece by AASHTO or ASTM specification; give different assembly and erection marks to pieces of different grades of steel. Give differing piece marks to individual girders and other main members. Show details of proper washer installation on shop drawings.

501.4.1.4 Shop Inspection

1 The fabricator is responsible for quality control; ensure that the fabricator’s inspector is an AWS certified welding inspector, in accordance with AWS QC1. Ensure that the primary job of the fabricator’s inspector is quality control, independent of production. Ensure that the fabricator’s inspector reports directly to the fabricator’s top management or chief engineer and works separately from the production unit, performing no production or supervisory work for the project.

2 Before fabrication, ensure that the fabricator submits to the State Bridge Engineer a written quality control plan outlining quality control tasks the fabricator will follow to ensure that work meets specifications. Include a list of inspection and nondestructive testing personnel.

3 The department's inspector will act independently of the fabricator. Review by the department's inspector does not relieve the fabricator of responsibility for providing materials and finished members as specified. The department may reject deficient or defective materials or members at any time. Replace rejected items promptly at no additional cost to the department.

4 Notify the department's inspector in writing at least 14 calendar days before starting structural steel fabrication. Before fabrication, give the department's inspector one complete copy of the mill test reports, showing chemical and physical properties of the steel. Ensure that the reports indicate, by piece marks, the individual items fabricated for the project. Remove references to unrelated material.

5 Ensure that the fabricator helps in testing and inspection and gives the department's inspector access to fabrication and storage areas.

6 Ensure that the fabricator's inspector verifies that high-strength fasteners and elastomeric bearing pads meet contract requirements by reviewing certifications and visual inspection.

501.4.1.5 Identification of Steels During Fabrication

1 Properly identify each piece of steel used in fabrication. Use only material identifiable by heat number and mill test report.

2 Stamp flange and web plates in main girders, W-beam girders, and splice plates with the applicable heat numbers at locations visible on the finished structure. Stamp match marks and erection marks showing orientation, direction of members, or both. Use "low-stress" stamps approved by the department's inspector; stamp near ends of girders but not on the edges of plates or flanges. Use a system of assembly-marking on individual pieces that maintains the mill test report number. Do not apply marks with paint.

501.4.1.6 Orientation of Plates

1 Cut and fabricate steel plates into structural members so that the primary direction of rolling of the plate parallels the principal stress in the member.

501.4.1.7 Handling and Storing Materials

1 Place stored material above the ground on platforms, skids, or other supports. Keep material free from dirt, grease and other foreign material, properly drained, and protected from corrosion. Support long members on skids to prevent deflection damage.

2 For shipping and storage, provide softeners for lifting and tie-down chains to prevent damage to corners. When lifting with hooks, ensure sufficient jaw and throat width to prevent damage to flanges or the flange-to-web weld.

501.4.1.8 Straightening and Curving Rolled Beams and Welded Girders

501.4.1.8.1 General

1 The department will reject members made from steel heated higher than 1150 ºF [620 ºC] or cooled artificially before naturally cooling to 600 ºF [320 ºC]. Use a cooling method approved by the department's inspector. For ASTM A 709, grade 70W [ASTM A 709M, grade 485W] steel, limit application of heat to 1100 ºF [590 ºC], and perform application in accordance with procedures approved by the State Bridge Engineer.

501.4.1.8.2 Straightening Material

1 In the shop, straighten structural steel without damaging the metal and only with the department inspector's approval. The department will consider kinks and bends that cannot be straightened without damaging the member cause for rejection. Inspect the metal surface for evidence of damage after straightening.

501.4.1.8.3 Curving Rolled Beams and Welded Girders

1 If horizontally curved rolled beams or welded plate girders are specified, curve during fabrication. Fabricate rolled beams as a straight unit; induce required curvature by applying heat to the flange edges on one side. Fabricate welded girders the same way or by flame-cutting flanges to the required curvature from rectangular plates before fitting and welding to the web. The department will allow cold bending if the proposed methods are first approved by the State Bridge Engineer.

2 Perform heat-curving of beams or girders in accordance with the following:

1. Curve before painting and before or after welding of transverse intermediate stiffeners. Unless provisions are made for girder shrinkage, locate and attach connection plates and bearing stiffeners after curving. If required, curve or oxygen-cut longitudinal stiffeners separately and then weld them to the curved girder.

2. Camber girders before heat-curving. Camber rolled beams by methods approved by the department's inspector. Do not mechanically camber rolled beams without the State Bridge Engineer's approval. For plate girders, cut the web to the prescribed camber with suitable allowance for shrinkage. If necessary, correct moderate deviations from specified camber as approved by the department's inspector.

3. When curving girders with the web in a vertical position, brace or support the girder to avoid overturn. When curving with the web in a horizontal position, provide sufficient support to obtain uniform curvature. During heating, place intermediate safety catch blocks at the midlength of the girder within 2 in [50 mm] of the flanges.

4. Curve beams and girders by continuous or V-type heating. Heat those flange edges that will be on the inside of the horizontal curve after cooling. Heat both inside and outside flange surfaces when the flange thickness equals or exceeds 1¼ in [31 mm]; heat both surfaces concurrently.

    4.1. For the continuous method, heat a strip along the edge of the top and bottom flange simultaneously; ensure sufficient strip width and temperature to obtain specified curvature.

    4.2. For V-type heating, heat the top and bottom flanges at approximately the same rate and in regularly spaced truncated triangular areas having their base along the flange edge. On the inside flange surface, end the apex of the truncated triangular area just before the juncture of the web and flange. When the radius of curvature is 1000 ft [300 m] or more, extend the apex of the truncated triangular heating pattern applied to the outside flange surface to the juncture of the flange and web. When the radius of curvature is less than 1000 ft [300 m], extend the apex of the truncated triangular heating pattern of the outside flange surface past the web for a distance equal to one-eigth of the flange width or 3 in [75 mm], whichever is less. Use a truncated triangular pattern with an included angle of approximately 15 to 30 degrees and a base no greater than 10 in [250 mm]. The department's inspector may approve varying patterns.

5. Measure final horizontal curvature and vertical camber acceptance after welding and heating are complete and flanges have cooled to a uniform temperature. Check horizontal curvature with the girder in the vertical position by measuring offsets from a stringline or wire attached to both flanges or other method approved by the department's inspector. Check camber.

501.4.1.9 Finish

1 Ensure that shearing, thermal-cutting, and chipping of plates leaves edges smooth and free of discontinuities. Break, flatten, or round by grinding all edges and corners that will be exposed in the finished member.

501.4.1.10 Holes for Fasteners

1 Drill, punch, subdrill and ream, or subpunch and ream holes for fasteners. Make subpunched and subdrilled holes $^3/_{16}$ in [5 mm] smaller than the nominal fastener diameter and finished holes $^1/_{16}$ in [2 mm] larger than the nominal fastener diameter. For structural steel thicker than ¾ in [19 mm] and high-strength steel thicker than ⅝ in [16 mm], drill holes full size or subdrill and ream full size. Remove burs from inside and around the edges.

2 The department considers acceptable holes up to $^1/_{32}$ in [1 mm] larger than specified when using a drill or reamer of nominal diameter and slightly conical holes that naturally result from punching.

3 Do not thermal-cut round holes or correct mispunched or misdrilled holes by welding.

4 Do not allow thermal-cut slotted holes (whether combined with drilling or punching or not) to exceed their specified width by more than $^1/_{32}$ in [1 mm]. The department allows occasional gouges not more than $^1/_{16}$ in [2 mm] deep. Grind thermal-cut bolt hole surfaces smooth.

5 For holes in field connections and field splices of main members of trusses, arches, continuous beam spans, bents, plate girders, and rigid frames, subpunch or subdrill then ream during assembly, or drill full size through a steel template during assembly. Obtain approval of the assembly, including camber, alignment accuracy of holes, and milled joints, from the department's inspector. Holes for cross frames may be drilled full size unassembled using a steel template.

6 Ream after pieces are assembled and firmly bolted together with surfaces in close contact. If necessary, take pieces apart before bolting and remove shavings.

7 When drilling members while assembled, hold the parts securely together while drilling, and drill to finish size or subdrill and ream to finish size while all thicknesses of metal are assembled.

8 Match-mark pieces reamed or drilled together so that they may be reassembled in the same position. Give the engineer a diagram showing match-marks. Do not interchange parts reamed or drilled together.

9 Fabricate holes for floor beam and stringer field connections in accordance with the latest edition of the AASHTO *LRFD Bridge Construction Specifications*, including applicable interim revisions.

10 When specified, or approved by the State Bridge Engineer, use oversize, short-slotted, and long-slotted holes in accordance with the following:

1. With ⅝-inch [16 mm] diameter and larger high-strength bolts.
2. Oversize holes in any or all plies of friction-type connections.
3. Short-slotted holes in any or all plies of friction- or bearing-type connections. Align slots normal to the direction of loading in bearing-type connections.
4. Long-slotted holes in one of the connecting parts of a friction- or bearing-type connection at an individual faying surface. Align slots normal to the direction of loading in bearing-type connections.

11 Do not exceed the hole dimensions in Table 501.4.1-1, Maximum Hole Sizes.

Table 501.4.1-1
Maximum Hole Sizes

Bolt Diameter	Standard Diameter	Oversize Diameter	Short Slot Width × Length	Long Slot Width × Length
in [mm]				
$5/8$ [16]	$11/16$ [18]	$13/16$ [20]	$11/16 \times 7/8$ [18 × 22]	$11/16 \times 1\,9/16$ [18 × 40]
$3/4$ [19]	$13/16$ [22]	$15/16$ [24]	$13/16 \times 1$ [21 × 26]	$13/16 \times 1\,7/8$ [21 × 48]
$7/8$ [22]	$15/16$ [24]	$1\,1/16$ [28]	$15/16 \times 1\,1/8$ [24 × 30]	$15/16 \times 2\,3/16$ [24 × 55]
1 [25]	$1\,1/16$ [27]	$1\,1/4$ [31]	$1\,1/16 \times 1\,5/16$ [27 × 33]	$1\,1/16 \times 2\,1/2$ [27 × 62]
$1\,1/8$ [28]	$1\,3/16$ [30]	$1\,7/16$ [36]	$1\,3/16 \times 1\,1/2$ [30 × 38]	$1\,3/16 \times 2\,13/16$ [30 × 70]
$1\,1/4$ [31]	$1\,5/16$ [33]	$1\,9/16$ [39]	$1\,5/16 \times 1\,5/8$ [33 × 41]	$1\,5/16 \times 3\,1/8$ [33 × 78]

12 Ensure that the minimum distance from the fastener center to member edges in accordance with Table 501.4.1-2, Minimum Edge Distance for Standard Holes.

Table 501.4.1-2
Minimum Edge Distance for Standard Holes

Bolt Diameter	Sheared Edges	Rolled Edges of Plates or Shapes or Gas Cut Edges
	in [mm]	
⅝ [16]	1⅛ [28]	⅞ [22]
¾ [19]	1¼ [31]	1 [25]
⅞ [22]	1½ [38]	1⅛ [28]
1 [25]	1¾ [44]	1¼ [31]
1⅛ [28]	2 [50]	1½ [38]
1¼ [31]	2¼ [57]	1⅝ [41]
1⅜ [35]	2⅜ [60]	1¾ [44]

13 For oversized and slotted holes, ensure that there is a clear distance between the edges of the hole and the member, at least equal to the minimum required for a standard hole.

501.4.1.11 Welding and Examination of Welded Joints

501.4.1.11.1 General

1 Weld and inspect welded highway structures in accordance with AASHTO/AWS D1.5, Bridge Welding Code.

2 Ensure that welders hold the specified qualifications for applicable processes, positions, and thicknesses. For ultrasonically-tested welds, use welders experienced in this type of welding and who first pass an ultrasonic welding test.

3 The department's inspector requires notice from the fabricator 72 hours before welding inspections are required.

4 Weld structural steel by the manual shielded metal-arc, submerged-arc, or flux-cored-arc process. Do not use the gas metal-arc process. Give written welding procedure specifications to the department's inspector in accordance with AASHTO/AWS D1.5.

5 Obtain written authorization from the State Bridge Engineer to weld stiffeners to webs and flanges using automatic submerged-arc welding. Make stiffener-to-web welds on one side at a time.

6 Do not weld material to girder webs or flanges unless shown on approved shop drawings.

7 For splices in main members that will be field welded, shop-assemble in proper alignment, and check for correct fit-up dimensions. Do not repair incorrect fit-up by welding without approval from the department's inspector.

8 The department will reject members on which welds cannot be repaired or replaced in accordance with AASHTO/AWS D1.5, article 3.7, "Repairs," as determined by the department's inspector. Make repair welds at least 2 in [50 mm] long and at no additional cost to the department.

9 Perform welding on main load-carrying bridge members, including repairs, at a minimum preheat and interpass temperature of 150 ºF [65 ºC] for material thicknesses less than or equal to 2½ in [64 mm] and 225 ºF [110 ºC] for thicker material.

501.4.1.11.2 Ultrasonic Weld Testing

1 Ultrasonically test field and shop butt welds in main members in accordance with AASHTO/AWS D1.5. Document the tests in accordance with section 6.20 of AASHTO/AWS D1.5. Grind butt welds flush before ultrasonic testing. Ensure that testing personnel are qualified in accordance with the American Society of Nondestructive Testing (ASNT) SNT-TC-1A, level II. The department inspector may perform additional testing.

2 Inspect 100 percent of the following ultrasonically:

1. Flange splice welds;
2. Transverse web splice welds;
3. Longitudinal web splice welds in tension areas;
4. Full-penetration flange-to-web welds in tension areas; and
5. Longitudinal stiffener splice welds in tension areas.

3 In compression areas, inspect 10 percent of the following ultrasonically:

1. Longitudinal web splice welds;
2. Full penetration flange-to-web welds; and
3. Longitudinal stiffener splice welds.

4 If rejectable defects are found in any partially tested weld, test the entire weld.

5 Do not test radiographically.

6 Move and brace material as required for proper inspection and personnel safety.

501.4.1.11.3 Other Nondestructive Weld Testing

1 Test welds in girders using the magnetic particle or dye penetrant method as follows:

1. For fillet welds, test at least 12 inches in every 10-foot [100 mm in every 1 m] length; include the ends of the welds. If rejectable discontinuities are found in any test length, test the lesser of the weld's full length or 5 ft [1.5 m] on either side of the test length.
2. The department does not require testing welds in secondary members or the substructure.
3. Test the ends of flange butt-splice welds.
4. Test arc strikes not incorporated into the final weld after grinding.
5. Ensure that testing personnel are qualified in accordance with ASNT SNT-TC-1A, level II.

2 Perform magnetic particle testing in accordance with section 6.7.6 of AASHTO/AWS D1.5 using the yoke method. Perform dye penetrant testing in accordance with section 6.7.7 of AASHTO/AWS D1.5. Document testing in accordance with section 6.7.6.5 of AASHTO/AWS D1.5.

501.4.1.12 Thermal Cutting

1 Thermal-cut structural steel only if a smooth surface free from cracks and notches is obtained using a mechanical guide. Hand-cut only where approved by the department's inspector.

2 Cut girder flanges to ¼ in [6 mm] wider than specified. Ensure the fabricator notifies the engineer and contractor if this is done.

3 Avoid cutting inside the specified lines. Ensure that thermal-cut surfaces meet requirements of ANSI B46.1 for a surface roughness height of 1000×10^{-6} in [25 µm]. Ensure that thermal-cut surfaces of members not subject to calculated stress have a surface roughness height of no more than 2000×10^{-6} in [50 µm].

4 Fillet re-entrant cuts to a radius of at least 1 in [25 mm].

5 For surface roughness exceeding specification and notches or gouges up to $^{3}/_{16}$ in [5 mm] deep, remove by machining or grinding. Fair corrections with the surface of the cut on a minimum bevel of 1:10. Repair gouges of flame-cut edges deeper than $^{3}/_{16}$ in [5 mm] by methods approved by the department's inspector. If necessary, weld in accordance with Subsection 501.4.1.11, Welding and Examination of Welded Joints, and test ultrasonically in accordance with AASHTO/AWS D1.5. Grind completed welds smooth and flush with the adjacent surface.

6 Before painting thermal-cut surfaces, remove the layer left from resolidification by grinding.

501.4.1.13 Edge Planing

1 Plane sheared edges of plate that are thicker than ⅝ in [16 mm], and that are a, or part of a, design member to a depth of ¼ in [6 mm].

501.4.1.14 Shop Assembling Steel

1 Before assembling, bolting, or welding, clean steel contact surfaces for connections. Do not paint contact surfaces before bolting or welding.

2 When specified, shop-assemble entire structures, accurately adjusted to line and camber and with holes for field connections drilled or reamed while assembled.

3 Perform flange-to-web welds on welded plate girders before installing transverse stiffeners.

4 Assemble field-bolted joints for girders with the abutting members adjusted for alignment and camber. Drill or ream holes for field connections while assembled.

5 Ensure that the fabricator makes bolt assemblies available to the department's inspector. Before shipment, clean and relubricate or replace bolt assemblies deemed improperly lubricated, dirty, weathered, or rusted.

6 Match-mark connecting parts shop-assembled for drilling or reaming holes for field connections. Give the engineer a diagram of such marks.

501.4.1.15 Facing of Bearing Surfaces

1 Ensure that the surface finish of bearing contact surfaces is in accordance with Table 501.4.1-3, Surface Roughness Requirements.

Table 501.4.1-3
Surface Roughness Requirements

Location	Roughness Height (10^{-6} in [µm])
Plates in contact with elastomeric or preformed fabric pad	2000 [50]
Heavy plates in contact as part of bearing assemblies to be welded	1000 [25]
Milled ends of compression members, milled or ground ends of stiffeners, and fillers	500 [12]
Bridge rollers and rockers	250 [6]
Pins and pin holes	125 [3]
Sliding bearings	125 [3]

2 Ensure that bearing surfaces of bearing assemblies fit within 0.010 in [250 µm] for 75 percent of their area, with no gap elsewhere greater than $^{1}/_{32}$ in [1.0 mm].

3 For bearing and base plate surfaces and other metal bearing surfaces that will come in contact with preformed fabric pads, elastomeric pads, or portland cement grout, finish flat to within ⅛-inch tolerance in 12 in [1 mm tolerance in 100 mm] and ⅛-inch [3 mm] tolerance overall.

501.4.1.16 Abutting Joints

1 When specified, face and bring abutting joints to an even bearing. Where joints are not faced, ensure the opening does not exceed ¼ in [6 mm].

501.4.1.17 End Connection Angles

1 Locate end connection angles of floor beams and stringers flush with each other and accurately set as to position and length of member. Do not finish end connection angles. If angles are milled due to faulty shop assembly, do not reduce thickness by more than $^{1}/_{16}$ in [2 mm] or reduce the allowable bearing value below design requirements.

501.4.1.18 Elastomeric Bearing Pads

1 Supply and install elastomeric bearing pads in accordance with shop drawings.

501.4.1.19 Finished Members

1 Ensure that finished members are true to line; free from twists, bends, and open joints; and in accordance with the dimensional tolerance requirements of AASHTO/AWS D1.5, except for the specified camber of welded beams and girders, for which the department will allow variation in accordance with Table 501.4.1-4, Allowable Camber Tolerances. Apply these tolerances to the camber in the fabricated pieces before erection.

Table 501.4.1-4
Allowable Camber Tolerances

Girder Type	Camber Tolerance
Typical girder	± ⅛ in × (number of feet from the nearest end)/10 [1 mm × number of meters from nearest end], not to exceed ½ in [12 mm]
Girder with a designed concrete haunch between the slab and the top flange	± ¼ in × (number of feet from the nearest end)/10 [2 mm × number of meters from nearest end], not to exceed 1 in [25 mm]

501.4.1.20 Stiffeners

1 For bearing and other stiffeners designated as “finish to bear,” mill or grind to achieve at least 75 percent contact with the flange and no gap elsewhere greater than $^{1}/_{32}$ in [1.0 mm]. Weld other stiffeners to flanges or “fit tight,” as specified. The department defines “fit tight” stiffeners as having at least one bearing point on the flange and no clearance at any point greater than $^{1}/_{16}$ in [2 mm]. Ensure that stiffeners are perpendicular to flanges.

501.4.1.21 Bent Plates

1 Before plates are bent, round the corners or edges to a radius of $^{1}/_{16}$ in [2 mm] throughout the part of the plate to be bent.

2 For cold bending, ensure the bend line is perpendicular to the direction of rolling. Ensure a bend radius that will not crack the plate. For bends perpendicular to the direction of rolling, ensure the radius is at least the minimum radii (measured to the concave face of the metal) shown in Table 501.4.1-5, Minimum Radius for Perpendicular Bends.

Table 501.4.1-5
Minimum Radius for Perpendicular Bends

Thickness (in [mm])	Minimum Radius (t = thickness of metal to be bent)
Up to ½ [12]	2 t
Over ½ [12] to 1 [25]	2.5 t
Over 1 [25] to 1½ [38]	3 t
Over 1½ [38] to 2½ [64]	3.5 t
Over 2½ [64] to 4 [100]	4 t

3 If bend lines are parallel to the direction of final rolling, add 0.5 t to value shown in Table 501.4.1-5, Minimum Radius for Perpendicular Bends. For a shorter radius, bend plates hot; do not exceed 1150 ºF [620 ºC].

4 Hot-bend low alloy steel thicker than ½ in [12 mm] for small radii.

501.4.1.22 Stress-Relieving

1 Relieve stress in welded bearing assemblies by heat treating in accordance with section 4.4 of AASHTO/AWS D1.5. Perform finish machining after heat treating. Adequately support the weld assembly in the furnace.

2 Ensure the provision of an accurate recording pyrometer with thermocouple junctions at the hottest and coolest points on the assembly but not in the direct path of heating flames. Ensure that the recording device provides a continuous permanent record of the temperatures. Give the department's inspector two copies of the records.

501.4.1.23 Pins and Rollers

501.4.1.23.1 General

1 Use pins and rollers that are straight, smooth, free of flaws, and finished in accordance with Subsection 501.4.1.15, Facing of Bearing Surfaces.

501.4.1.23.2 Boring Pin Holes

1 Bore pin holes true to detail dimensions, smooth, straight, and at right angles to the axis of the member and parallel to each other. Always make a finishing cut. Ensure that the length outside-to-outside of holes in tension members and inside-to-inside of holes in compression members does not vary from detailed dimensions more than $^1/_{32}$ in [1 mm]. Bore holes in built-up members after shop bolting and welding.

501.4.1.23.3 Pin Clearance

1 Ensure that the pin hole diameter does not exceed that of the pin by more than $^1/_{50}$ in [500 µm] for pins 5 in [125 mm] or less in diameter or $^1/_{32}$ in [1 mm] for larger pins.

501.4.1.23.4 Pilot and Driving Nuts

1 Furnish two pilot nuts and two driving nuts for each size of pin.

501.4.1.24 Painting

501.4.1.24.1 General

1 Paint new structural steel work. Do not paint aluminum; weathering steel meeting ASTM A 709, grades 50W or 70W [ASTM A 709M, grades 345W or 485W]; galvanized; or bronze surfaces. Apply the shop coat after fabrication and after surfaces have been prepared. Apply field coats after erection is complete.

2 Ensure that paint is delivered in original, unopened containers with intact labels identifying the paint and showing the date of manufacture and batch number.

3 Paint only dry, clean surfaces. Do not paint frosted or ice-coated surfaces; when steel, paint, or air temperature is below 40 ºF [4 ºC]; in rain, wind, snow, fog, mist; or when the steel surface temperature is less than 5 ºF [3 ºC] above the dew point. If a thin film of water applied to the cleaned surface with a damp cloth evaporates within 15 minutes, the dew point requirement is satisfied.

4 Perform blast cleaning and painting in well lighted areas.

5 Mix paint thoroughly with mechanical mixers to keep the pigments in suspension and continue stirring while paint is applied. Furnish and install a water trap or separator on air-supplied equipment used in spray painting.

6 Apply paint with spray guns, rollers, or brushes. If sprayed, brush out the paint where necessary. When brushed, ensure a uniform, even coating. Work paint into joints and open spaces. On otherwise inaccessible surfaces, apply paint with sheepskin daubers.

7 Ensure that the completed coat of paint provides a uniform appearance. Protect painted surfaces while drying.

501.4.1.24.2 Shop Cleaning

1 After fabrication, blast-clean the surfaces of new structural steel to be painted, except machine finished surfaces, in accordance with the following for the selected paint system:

1. **System A.** Society for Protective Coatings SSPC-SP 6—Commercial Blast Cleaning.

2. **System B.** SSPC-SP 10—Near-White Blast Cleaning, leaving a blast profile of from 2.0 mil to 3.0 mil [50 µm to 75 µm], when tested by profilometer.

2 After fabrication, prepare unpainted weathering steel bridge girders in accordance with SSPC-SP 6—Commercial Blast Cleaning. Ensure that the final surfaces of other unpainted weathering structural steel meet or exceed the standards of SSPC-SP 2—Hand Tool Cleaning.

501.4.1.24.3 Shop Painting

1 Before applying the shop coat, stamp match and erection marks for field identification of members and weight marks in accordance with Subsection 501.4.1.5, Identification of Steels During Fabrication.

2 After acceptance of steel work by the department's inspector and before shipment, blast-clean, and before surfaces rust, apply one coat of approved shop primer. Reclean if surfaces rust or are contaminated before painting.

3 Do not paint surfaces to be embedded in concrete, except edges of top flanges; apply one coat of shop primer to them. Apply one coat of primer to machined surfaces.

4 Paint structural steel surfaces in accordance with the following for the selected paint system:

1. **System A.** Paint surfaces not in contact but inaccessible after assembly or erection with three coats of shop primer. Do not paint shop contact surfaces. Excluding slip-critical connections, give field contact surfaces one coat of primer. Ensure a minimum film thickness of 1.5 mil [40 µm] measured dry with a calibrated magnetic film thickness gage in accordance with SSPC-PA 2—Measurement of Dry Coating Thickness with Magnetic Gages.

   After painting, store the steel in an air temperature above 40 ºF [4 ºC] for no less than 24 hours, but 36 hours is preferred.

   Leave metal surfaces within 6 in [150 mm] of field welds unprimed until after field welding is complete.

2. **System B.** Apply one coat of shop primer to surfaces inaccessible after assembly or erection. Do not paint shop contact surfaces. Excluding slip-critical connections, give field contact surfaces one coat of shop primer. One coat of shop primer may be applied to slip-critical connection surfaces if the paint manufacturer ensures, in writing, that the coated surface will provide class B slip resistance as defined in the latest edition of the AASHTO *LRFD Bridge Design Specifications*, including applicable interim revisions.

5 Before surfaces rust, apply paint with airless spray equipment to a dry film thickness of from 2.0 mil to 5.0 mil [50 µm to 130 µm]. If necessary to achieve minimum dry film thickness, recoat in accordance with the manufacturer's recommendations. Brush or daub touch-up as necessary to obtain a smooth surface.

6 During application and curing, ensure that the temperature is from 40 ºF to 115 ºF [4 °C to 46 ºC], that the steel temperature is at least 5 ºF [3 ºC] above the dew point, and that the relative humidity is between 45 and 90 percent. Apply primer at lower humidities in accordance with applicable recommendations from the manufacturer.

7 Do not load members for shipment sooner than 14 calendar days after painting and until thoroughly dry. Consider paint dry when it cannot be scraped off with a thumbnail. Protect structural steel members while paint dries, and repair paint damage at no additional cost to the department.

501.4.1.25 Galvanizing

1 Galvanize steel after it is fabricated into the largest practical sections. Fabrication includes bending and welding. Before galvanizing, completely seal edges of tightly contacting surfaces by welding and blast-clean welds in accordance with SSPC-SP 5—White Metal Blast Cleaning. Galvanize components of bolted assemblies separately before assembly. Perform any straightening after galvanizing without damaging the coating.

2 Repair damaged areas of galvanizing in accordance with ASTM A 780. Perform shop repairs by metalizing or soldering with zinc-based alloys in rod or powder form.

501.4.1.26 Shipping Materials

1 Mark the weight [mass] on members weighing more than 3 ton [2.7 t]. Block projecting parts with wood or otherwise protect them from damage. Do not bend, scrape, or overstress pieces while handling and shipping. The department will reject bent or otherwise damaged pieces.

2 Ensure that material shipped to the project is accompanied by a manufacturer's certification listing each separate piece by name and piece mark along with two copies of the mill test reports and the fabricator's quality control records.

3 Ship small parts, such as bolts, nuts, washers, pins, fillers, and small connecting plates or angles in boxes, crates, kegs, or barrels. Include an itemized list and description of the contents on the outside of each package.

4 Keep the metal clean and undamaged during loading, transporting, and unloading. Ship girders upright unless otherwise approved by the State Bridge Engineer.

501.4.2 Field Work

501.4.2.1 General

1 Use temperature-indicating crayons to determine temperatures of materials.

2 Assemble structural steel as specified, following all match-marks. Handle material without damaging parts. Do not damage or distort members by hammering. Clean bearing and permanent contact surfaces before members are assembled. Provide sufficient bracing to prevent lateral buckling of girders during field erection.

3 Round corners and edges that are marred, cut, or roughened in handling or erection by grinding or other approved methods. Perform field straightening using only approved methods.

4 Tighten high-strength bolts in accordance with Subsection 501.4.2.3.4, Installation, before the superstructure concrete is placed.

501.4.2.2 Drifting of Holes

1 As necessary, drift holes to bring parts into proper alignment without enlarging the holes or otherwise distorting the metal. Ream holes that need enlarging to admit fasteners.

501.4.2.3 Connections Using High Strength Bolts

501.4.2.3.1 General

1 This subsection covers the assembly of slip-critical structural joints using high-strength bolts, nuts, and washers for structural steel joints or equivalent fasteners tightened to a high tension.

2 Use slip-critical bolted connections. Use ⅞ in [22 mm] diameter high-strength bolts with a load indicator washer, twist-off control element, or use lock-pin and collar fasteners.

501.4.2.3.2 Bolts, Nuts, and Washers

1 Determine bolt lengths in accordance with Table 501.4.2-1, Bolt Length.

Table 501.4.2-1
Bolt Length

Bolt Size (in [mm])	Add to Grip[(1)] to Determine Bolt Length (in [mm])
⅝ [16]	⅞ [22]
¾ [19]	1 [25]
⅞ [22]	1⅛ [28]
1 [25]	1¼ [31]
1⅛ [28]	1½ [38]
1¼ [31]	1⅝ [42]

(1) Grip is thickness of material to be connected exclusive of washers.

NOTES:

1. For each flat washer add $^{3}/_{16}$ in [5 mm].
2. For each bevel washer add $^{5}/_{16}$ in [8 mm].
3. For each load indicator washer add ⅛ in [3 mm].
4. For twist-off fasteners, add only the value shown; do not add additional length for the washers.
5. Adjust bolt length determined to the next longest ¼-inch [6 mm] increment.

2 Determine lengths of lock-pin fasteners in accordance with the manufacturer's recommendations.

3 Use load indicator washers that provide a method to evaluate induced bolt tension during and after tightening. Evaluate tension from measurements of the residual gap after protrusions have been flattened.

4 For fasteners with twist-off control or indicator elements, use a type with a splined end extending beyond the threaded portion of the bolt, which is then gripped by a special design wrench chuck, providing a means for turning the nut relative to the bolt until the splined end is sheared off.

501.4.2.3.3 Bolted Parts

1 Field-drill holes for bolted parts in accordance with Subsection 501.4.1.10, Holes for Fasteners.

2 Ensure that the surface slope of bolted parts in contact with the bolt head and nut does not exceed 1V:20H with respect to a plane perpendicular to the bolt axis. Ensure that bolted parts fit solidly together when assembled and are not separated by gaskets or interposed compressible material.

3 Lubricate galvanized nuts with a lubricant dyed so that a visual check for lubricant can be made during field installation. Ensure that black bolts are "oily" to the touch when installed. Clean and relubricate dry, dirty, weathered, or rusted bolts before installation. Relubricate twist-off type bolts, as necessary, in accordance with the manufacturer's recommendations.

4 Ensure that, when assembled, joint surfaces are free of dirt, loose scale, other foreign material, burrs, and other defects preventing solid seating of the parts. Ensure that contact surfaces within slip-critical type joints are free of oil, paint (including overspray), lacquer, rust inhibitor, and other foreign material. Roughen galvanized contact surfaces by hand wire brushing; do not use power wire brushing.

5 Install bolt, nut, and washer combinations from the same rotational-capacity lot.

501.4.2.3.4 Installation

501.4.2.3.4.1 Bolt Tension

1 Tighten fasteners to at least the bolt tensions shown in Table 501.4.2-2, Bolt Tension.

Table 501.4.2-2
Bolt Tension

Bolt Size (in [mm])	Minimum Bolt Tension[1] 10^3 lb [kN]
⅝ [16]	19 [94.2]
¾ [19]	28 [147]
⅞ [22]	39 [182]
1 [25]	51 [212]
1⅛ [28]	56 [275]
1¼ [31]	71 [337]

(1) Equal to the proof load (length measurement method) given in AASHTO M 164 [AASHTO M 164M].

2 Use impact wrenches that can tighten bolts in a maximum of ten seconds. Do not tighten high-strength bolts installed in or through concrete to the required tension in Table 501.4.2-2, Bolt Tension. Install with lock washers and tighten only snug-tight with lock washers flattened.

501.4.2.3.4.2 Washers

1 For slip-critical, high-strength bolted connections, provide and use washers as follows:

1. Where the outer face of the bolted parts has a slope greater than 1V:20H, with respect to a plane perpendicular to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

2. Use hardened washers under the element turned in tightening.

3. Use hardened washers where AASHTO M 164 [AASHTO M 164M] bolts are installed and tightened in an oversized or short slotted hole in an outer ply.

4. Use a plate washer or continuous bar at least $^{5}/_{16}$ in [8 mm] thick with standard holes where AASHTO M 164 [AASHTO M 164M] bolts are installed and tightened in a long slotted hole in an outer ply. This washer need not be hardened. Ensure that the washer or bar completely covers the slot after installation and is of structural grade material. Place hardened washers over the outer surface of the plate washer or bar.

5. Where required, use load indicator washers as specified in Subsection 501.4.2.3.4.6, Load Indicator Washer Installation.

501.4.2.3.4.3 Tension Calibrator

1 The engineer will provide a tension measuring device where bolts are being installed and tightened. Use it to confirm the following:

1. The ability of the complete fastener assembly, including lubrication, to be used to satisfy the requirements of Table 501.4.2-2, Bolt Tension;

2. Wrench calibration, if applicable; and

3. The bolting crew's understanding and proper use of the method to be used.

501.4.2.3.4.4 Verification Test Procedure

1 On site, demonstrate the ability to achieve required fastener tension by testing, in a tension calibrator, a representative sample of at least three fasteners of each diameter and length to be used. Test assemblies that include flat washers arranged as those in actual connections to be tensioned. The department requires that each fastener tested develops a tension at least 5 percent greater than the tension required by Table 501.4.2-2, Bolt Tension. The department does not require testing on projects using less than 100 high-strength fasteners or on fasteners too short for the calibrator.

501.4.2.3.4.5 General Installation

1 Install fasteners in all holes in the connection and bring to a snug-tight condition. The department defines snug-tight as the tightness existing when the plies of the joint are in firm contact. Snug-tighten from the center of the connection to the free edges, then retighten in a similar systematic manner, as necessary, until all fasteners are simultaneously snug-tight and all plies of the connection are in full contact.

2 After snug-tightening, tighten fasteners in the connection to achieve the minimum tension shown in Table 501.4.2-2, Bolt Tension. Progress systematically from the center of the joint to its free edges.

501.4.2.3.4.6 Load Indicator Washer Installation

1 Load indicator washers may be used to ensure proper bolt tension, as specified in Table 501.4.2-2, Bolt Tension. Place the load indicator washer on the bolt with the protrusions bearing against the underside of the bolt head; turn the nut. If the bolt head is turned, due to bolt entering and wrench clearance, place a hardened round washer on the bolt under the bolt head, and place the load indicator washer on the bolt with the protrusions against the hardened round washer.

2 If it is necessary to place the load indicator washer at the nut end, place it on the bolt with protrusions facing toward the nut. Place a hardened round washer on the bolt against the protrusions, and install the nut. Turn the nut. When beveled washers are required, they may be used in conjunction with the load indicator washer.

3 Ensure that the surface contacting the protrusions does not turn during installation. Where a load indicator washer is used with a hardened round washer, some slight movement of the round washer is acceptable.

4 For oversize or slotted holes, use hardened washers in accordance with Subsection 501.4.2.3.4.2, Washers. Do not substitute load indicating washers for required hardened washers; use them in conjunction.

5 Do not reuse load indicator washers.

6 Hold the stationary element with a hand wrench to prevent turning when tightening. Tighten the bolt until the average gap is less than 0.005 in [130 µm] as determined by a feeler gauge. If the gap around the circumference of the load indicator washer is not uniform because the wrench pulls the bolt off-center in

the hole and results in protrusions not compressing uniformly, the department will consider the criteria met when gaps are measured in accordance with Table 501.4.2-3, Load Indicator Washer Inspection Criteria.

Table 501.4.2-3
Load Indicator Washer Inspection Criteria

Number of Spaces in Washer (between protrusion)	**Minimum Number of Spaces** (gauge is refused)
4	2
5	3
6	3
7	4
8	4

7 After all bolts in a joint have been tightened, inspect the bolts to ensure that they have not slackened during tightening. If necessary, restore the tension on these bolts by tightening so that gaps are less than originally measured.

501.4.2.3.4.7 Installation of Twist-Off Fasteners

1 Under the nut, use twist-off bolt assemblies that include a hardened washer specifically designed for twist-off fasteners. On oversize or slotted holes, the department does not require a hardened washer under the bolt head if the diameter of the bolt head is at least as large as the hardened washer. Proper bolt installation tension is indicated when the bolt tip shears off.

501.4.2.3.4.8 Installation of Lock-Pin and Collar Fasteners

1 If slotted or oversize holes are specified, use hardened flat washers. Proper installation tension is indicated when the pintail separates.

501.4.2.3.4.9 Reuse of Bolts

1 Do not reuse galvanized AASHTO M 164 [AASHTO M 164M] bolts. Ungalvanized AASHTO M 164 [AASHTO M 164M] bolts may be reused once, provided no significant permanent elongation or "stretch" has occurred in the threads (as determine by assembling the nut on the bolt). The bolt may be reused if the nut runs freely the full length of the threads. Do not reuse twist-off fasteners with a sheared-off tip or lock-pin fasteners without the pintail.

501.4.2.3.5 Inspection

1 The engineer may use the following inspection procedures:

1. **Connections with Load Indicating Washers.** The engineer will use a metal feeler gauge to inspect load indicator washers and at least 10 percent of the bolts but not less than two bolts selected at random in each connection. The engineer will accept the connection as properly tightened if gaps on all the inspected bolts are in accordance with Subsection 501.4.2.3.4.6, Load Indicator Washer Installation. If any gaps checked are in excess of the specified average gap, reinspect each bolt in the connection, retighten as required, and resubmit the connection for inspection.

2. **Connections with Twist-Off Bolts.** Within 24 hours of bolt tightening, the engineer will use a manual torque wrench that indicates torque on a dial or that can be adjusted to show that the "job-inspecting torque," as defined below, has been reached.

   Tighten a representative sample of five bolts of the diameter and length, with washers, used in the work and arranged as in the work, to an initial condition of approximately 15 percent of the required fastener tension and then to the tension specified in Table 501.4.2-2, Bolt Tension, using a tension measuring device. Then apply the inspecting wrench to the tightened bolt in the calibrator. Determine the torque necessary to turn the nut or head 5 degrees (approximately 1 inch at a 12-inch radius [90 mm at 1 m]) in the tightening direction. The average of the three middle values will determine the job-inspecting torque.

   Inspect bolts represented by the sample in the preceding paragraph that have been tightened in the structure by applying, in the tightening direction, the inspecting wrench with the job-inspecting torque to 10 percent of the bolts (at least two bolts) selected at random in each connection in question. If no nut or bolt head is turned by application of the job-inspecting torque, the engineer will accept the connection as properly tightened. If any nut or bolt head is turned with the job-inspecting torque, retighten all of bolts in the connection and resubmit the connection for inspection.

3. **Lock-Pin and Collar Fasteners.** The engineer will visually inspect lock-pin and collar fasteners.

501.4.2.4 Bolted Connections Other Than High-Strength

1 For permanent connections not requiring high-strength bolts, use regular hexagon head bolts with hexagon nuts in accordance with Subsection 815.6, Bolts and Fasteners.

501.4.2.5 Field Welding

501.4.2.5.1 General

1 In the field, weld by the shielded metal-arc process using electrodes in accordance with AASHTO/AWS classification E7018 unless otherwise approved, in writing, by the State Bridge Engineer. Use welders qualified as specified in accordance with Subsection 501.4.1.11.1, Welding and Examination of Welded Joints, General.

2 At least 14 calendar days before welding or erection, give the engineer a written welding procedure specification in accordance with AASHTO/AWS D1.5, section 5 - Qualification, and generally follows the form shown in Annex IV-Sample Welding Forms for welding procedure specification. Include a sequence of welding and a method for supporting members during field welding of splices in girders or other main members. Obtain the engineer's approval before beginning welding or erection.

501.4.2.5.2 Workmanship and Technique

501.4.2.5.2.1 General

1 Make field splice welds with the members properly aligned relative to each other. Obtain the engineer's approval of the alignment before beginning welding.

2 Do not weld when the air temperature is lower than 0 ºF [-18 ºC] or when surfaces are wet or exposed to rain, snow, or high wind velocities. Do not make welds other than those specified and approved.

3 Work upward on vertical passes for all welding, including repairs.

4 Back-gouge by air carbon-arc gouging or grinding.

5 Use extension bars or run-off tabs on flange and web splice welds. Ensure that extension bars or run-off tabs for flanges have the same joint preparation and thickness as the flanges and that they fit accurately with no gaps.

501.4.2.5.2.2 Preparation of Base Metal

1 Weld surfaces and edges that are smooth, uniform, and free from discontinuities. Ensure that surfaces, including those nearby, are free from loose or thick scale, slag, rust, moisture, grease, galvanizing, and other foreign material. The department will allow mill scale that can withstand vigorous wire brushing.

501.4.2.5.2.3 Assembly

1 Bring parts to be joined by fillet welds as close together as possible. Do not allow the root opening to exceed $^{3}/_{16}$ in [5 mm]. If the root opening is greater than $^{1}/_{16}$ in [2 mm], increase the leg of the fillet weld by the amount of root opening. Do not allow the root openings of groove welds without backing to exceed $^{3}/_{16}$ in [5 mm]. For groove welds with backing, ensure a root opening of at least $^{3}/_{16}$ in [5 mm] but no more than ½ in [12 mm]. Do not allow a separation between base metal and backing bars greater than $^{1}/_{32}$ in [1 mm]. Do not use fillers.

2 Ensure that the engineer inspects and approves joint preparation before welding.

501.4.2.5.2.4 Preheat and Interpass Temperature Requirements

1 Use a preheat and interpass temperature sufficient to prevent cracking but not less than indicated in Table 501.4.2-4, Minimum Preheat and Interpass Temperature for Field Welding.

Table 501.4.2-4
Minimum Preheat and Interpass Temperature for Field Welding

Type of Welding	Material Thickness[1]		Distance[2] from Weld
	Up to 2½ in [64 mm]	Over 2½ in [64 mm]	
Main girder	200 °F [93 °C]	225 °F [110 °C]	6 in [150 mm]
Other	150 °F [65 °C]	225 °F [110 °C]	3 in [75 mm]

(1) Thickest part at point of welding.

(2) Preheat the base metal so that the surfaces on which the weld metal is being deposited are at or above the specified minimum temperature for the distance shown in all directions from the point of welding, including the side opposite to that being welded.

501.4.2.5.2.5 Tack Welding

1 The same quality requirements apply to tack weld as to final welding, except that discontinuities need not be repaired if they will be filled in by the finished weld. Make tack welds with electrodes that meet the requirements for the final weld. Perform tack welding within the joint so that all tack welds will be incorporated into the final weld. Thoroughly clean tack welds before performing the final weld.

501.4.2.5.2.6 Weld Cleaning

1 Before welding over previously deposited metal, remove slag, and brush the weld and adjacent base metal clean. Remove slag from completed welds, and clean the weld and adjacent base metal by brushing or other means.

501.4.2.5.3 Quality of Welds

1 Do not paint welded joints until after welding and cleaning and the weld has been approved by the engineer. The engineer will accept a weld by visual inspection if:

1. It has no cracks.
2. Craters are filled to the full cross-section of the weld.

3. Adjacent layers of the weld and weld metal and base metal are thoroughly fused.

4. The undercut is no deeper than 0.01 in [0.25 mm] on girders or $^{1}/_{32}$ in [0.8 mm] on other welding.

5. It has no porosity.

6. It is free of overlap.

7. The faces of fillet welds are in accordance with the profiles shown in AASHTO/AWS D1.5, Figure 3.3 (A) and (B), with none of the unacceptable profiles shown in AASHTO/AWS D1.5, Figure 3.3 (C).

8. Groove welds are made with slight or minimum face reinforcement, and in the case of butt and corner joints:

    8.1. The face reinforcement does not exceed ⅛ in [3 mm] in height and has a gradual transition to the plane of the base metal, in accordance with AASHTO/AWS D1.5, Figure 3.3 (D).

    8.2. They are free of the discontinuities shown for butt joints in AASHTO/AWS D1.5, Figure 3.3 (E).

    8.3. Butt joint surfaces required to be ground flush are finished so that the thickness of the base metal is not reduced by more than $^{1}/_{32}$ in [0.8 mm] or 5 percent of the thickness, whichever is smaller, without a reinforcement that exceeds $^{1}/_{32}$ in [0.8 mm].

2 Measure fillet welds with a fillet gauge.

501.4.2.5.4 Weld Testing

1 Test butt and fillet welds in accordance with Subsection 501.4.1.11, Welding and Examination of Welded Joints.

501.4.2.5.5 Weld Repairs

1 Remove entirely and replace or repair welds not meeting the requirements of Subsection 501.4.2.5.3, Quality of Welds, at no additional cost to the department. When repairing a weld, correct as follows:

1. Repair overlaps or excessive convexity by removing the excess metal.

2. Repair excessive concavity, undersize welds, and undercutting by adding weld metal.

3. Repair porosity, slag inclusions, and incomplete fusion by removing unacceptable portions and rewelding.

4. With approval from the engineer, repair cracks in welds or base metal by removing metal for the full length of the crack plus 2 in [50 mm] at each end and rewelding.

2 Remove weld metal by air carbon-arc gouging or grinding. Preheat repair welds in accordance with Subsection 501.4.2.5.2.4, Preheat and Interpass Temperature Requirements, and ensure a minimum length of 2 in [50 mm].

501.4.2.6 Preparation of Bearing Areas

1 Ensure that column bases, truss and girder pedestals, base plates, and masonry plates have a full and uniform bearing on the substructure concrete and are rigidly and permanently located to the correct alignments and elevations. Do not place on improperly finished, deformed, or irregular bridge seat areas of piers or abutments. Place steel pedestals, base plates, and masonry plates on preformed fabric pads.

501.4.2.7 Setting Anchor Bolts

1 Drill or form anchor bolt holes perpendicular to the plane of the bridge seat. Set the anchor bolts in epoxy resin grout unless otherwise approved by the engineer. Before setting, drop anchor bolts into dry holes to ensure a proper fit. Immediately before placing, clean holes thoroughly. Ensure that anchor bolts are free of contaminating substances. Remove oil or grease by washing with solvent.

2 Heat anchor bolts installed in temperatures below 50 ºF [10 ºC] in clean boiling water for at least five minutes. Dry with a clean cloth and immediately set in epoxy.

3 Pour the epoxy mix into the drilled hole to a depth that just overflows the hole when the bolt is inserted and pushed to the bottom. Immediately after insertion, rotate bolts two complete revolutions. Hold the bolts in their proper position during the curing period. Place and cure epoxy mix in accordance with the

manufacturer's recommendations. When checking the curing period, do not consider time while the temperature is below 35 ºF [2 ºC].

4 At no additional cost to the department, replace any bolt disturbed during curing. Remove existing epoxy from the hole and replace bolt in accordance with the above procedure.

5 Do not leave grout in slotted holes in expansion rockers, rollers, plates, or on any metal surface that will be painted. Grout anchor bolts in correct position, with expansion bearings properly adjusted, before placing the roadway slab. Remove and regrout anchor bolts not firmly anchored in hardened grout at no additional cost to the department. Based on the prevailing temperature, the engineer will give instruction for varying location of the anchor bolts in relation to slotted holes in sliding expansion shoes or plates. Ensure that the nuts on anchor bolts at the expansion ends of spans allow free movement of the span. To ensure proper location and elevation, use templates to set anchor bolts in concrete before erection of the superstructure.

501.4.2.8 Field Painting

501.4.2.8.1 General

1 Repair shipping damage to paint at no additional cost to the department. Ensure the repairs have a uniform appearance and a dry film thickness not less than the original shop coat.

501.4.2.8.2 Field Cleaning

1 After erection, remove foreign matter from unpainted areas by blast-cleaning or with hand tools. Clean areas of steel coated with shop primer using a pressure water wash.

501.4.2.8.3 Field Paint Application

1 After field erection, give all steel in the structure two full coats of paint.

2 Protect the structure against disfigurement by overspray spatters, splashes and smirches of paint, or by paint materials. Paint without damaging vehicles, persons or property, including plants and animals. Prevent dust from accumulating on freshly painted surfaces. Remove or obliterate overspray.

3 Field-paint structural steel surfaces in accordance with applicable portions of Subsection 501.4.1.24.1, General, and the following requirements for the selected paint system:

1. **System A.** Do not use this system to overcoat System B primer.

   Cover unpainted surfaces; field bolts; surfaces where paint is worn off, removed or defective; and shipping and erection marks with one coat of shop primer.

   When paint applied for touching up bolts and abraded surfaces has thoroughly dried, apply the first and second field coats. Ensure a minimum film thickness for each coat of 1.5 mil [40 µm], measured dry with a calibrated magnetic film thickness gage in accordance with SSPC-PA 2—Measurement of Dry Coating Thickness with Magnetic Gages.

   Let each coat of paint dry before applying the next coat. Consider paint dry enough for recoating when an additional coat can be applied without causing detrimental film irregularities, such as lifting, wrinkling, or loss of adhesion of the undercoat. Do not apply additional coats less than 48 hours from the application of the previous coat. Fill small cracks and cavities that have not been sealed watertight by the first field coat with a pasty mixture of first field coat paint before the second field coat is applied. Give surfaces inaccessible after field assembly two coats of second field coat paint before assembly except on surfaces that will be embedded in concrete.

2. **System B.** Do not use shop-applied primer in the field. After cleaning structural steel, coat all surfaces with one application of the field-applied intermediate coat and field primer. Mix the paint as per manufacturer's recommendations. Based on the manufacturer's recommendations, paint may be applied with an initial mist coat, allowed to dry for at least 15 minutes, and then applied again to provide a final dry film thickness of from 5.0 mil to 8.0 mil [130 µm to 200 µm], measured dry with a calibrated magnetic film thickness gage in accordance with SSPC-PA 2—Measurement of Dry Coating Thickness with Magnetic Gages. Ensure that paint is free of gas bubbles and blowouts.

Overcoat time for the field-applied intermediate coat and field primer is between four hours and one year. Before applying the top coat, ensure that the surface is cured, clean, sound, dry, and free of contamination. Mix the acrylic latex top coat per manufacturer's recommendations. Brush, roll, or spray the acrylic latex top coat to a wet film thickness of from 5.0 mil to 7.0 mil [130 µm to180 µm] or a dry film thickness of from 2.0 mil to 3.0 mil [50 µm to 75 µm] to produce a smooth surface free from runs, sags, streaks, flashes, laps, pinholes, fisheyes, or craters.

501.4.2.9 Repair of Galvanizing

1 Repair damaged areas of galvanizing in the field with zinc-rich paint and in accordance with ASTM A 780.

501.4.2.10 Falsework

1 Where falsework is supported on structural steel members, ensure that there is no rotation of the member when loads are applied. Do not weld, cut, or drill holes in structural steel to support falsework. Design and construct falsework to support loads that will be applied.

2 Remove falsework materials completely except for piling. Remove falsework piling to at least 24 in [600 mm] below the surface of the original ground, finished groundline, channel bottoms, streambed, or bottom and side slopes of excavated areas.

501.5 MEASUREMENT and PAYMENT

1 The engineer will measure Structural Steel as one complete unit or by the pound [kilogram]. Payment by the pound [kilogram] will be based on the invoice(s) for the material incorporated into the work.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Structural Steel	LS, LB [LS, kg]	LS, lb [LS, kg]	LS, 20 LB [LS, 10 kg]

SECTION 502
Precast Concrete

502.1 DESCRIPTION

1 This section describes the requirements for the design, fabrication, and construction of prestressed, precast concrete girders, precast concrete bridge members, and precast concrete box culverts.

2 The department will use the following definitions throughout this section:

1. **Fabrication.** Includes shop-cast diaphragms, placement of curb tie bars, shop-cast curbs, bearing plates, shop-placed reinforcing steel, and other inserts and sleeves, as specified.

2. **Precaster.** The contractor's precaster.

3. **Prestressed, Precast Concrete Girders.** Members designed and fabricated by the precaster to provide the span lengths, structure widths, and girder depths specified.

502.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Elastomeric Bearing Pads	815.16
Fly Ash	801.2
Portland Cement	801.1
Prestressing Steel	811.5
Reinforcing Steel	811.1
Structural Steel	815.1
Water	814.1

502.3 EQUIPMENT

1 Equip jacks used to stress tendons with a pressure gauge having an accurate dial with a diameter of at least 6 in [150 mm]. Calibrate as a unit with the cylinder extension in the position it will be in at final jacking force and in accordance with the manufacturer's recommendations.

502.4 CONSTRUCTION

502.4.1 Plant Certification

1 Ensure that plants producing permanently installed precast (not prestressed) concrete items are certified by the National Precast Concrete Association or the American Concrete Pipe Association at the time of bid opening and manufacture. Ensure that plants producing prestressed precast concrete products are certified under the Precast/Prestressed Concrete Institute Plant Certification Program, Category B4 at the time of bid opening and manufacture. Along with shop drawings, give the Bridge Program a copy of the precaster's certification, current at the time of manufacture.

2 If plants are changed, give the engineer a copy of the certification for the new plant at least seven calendar days before the delivery of precast items to the project.

502.4.2 Shop Drawings

1 Before fabrication, ensure that the precaster gives the State Bridge Engineer shop drawings of each member showing complete details of the methods, materials, mix design including slump, equipment proposed for use in precasting, and the method and details of curing, in accordance with Subsection 105.2, Working Drawings. Include a written quality control plan.

2 For prestressed members, outline the following details:

1. Method and sequence of stressing;
2. Final strand stress;
3. Individual strand stress before harping;
4. Detensioning sequence;
5. Concrete strength;
6. Complete specifications and details of the prestressing steel and anchoring devices; and
7. Other data pertaining to prestressing, including arrangement of prestressing steel in the members.

3 Do not begin fabrication without the State Bridge Engineer's approval.

502.4.3 Design

502.4.3.1 General

1 When the precaster designs structural members, submit for approval two sets of design computations and for prestressed girders, girder deflections along with the advance shop drawings to the State Bridge Engineer. Ensure that these design computations and the associated plans are prepared by or under the supervision of a professional engineer and in accordance with the latest edition of the AASHTO *LRFD Bridge Design Specifications*, including applicable interim revisions.

502.4.3.2 Prestressed, Precast Concrete Girders

1 Design prestressed, precast concrete girders for the AASHTO loading specified. Ensure the provision and use of concrete with at least the 28-day compressive strength (f'_c) specified.

2 Use a design that ensures a working stress in the prestressing steel no greater than 60 percent of the specified minimum ultimate tensile strength. Consider the working stress as the force and stress remaining in the prestressing steel after all losses; include creep and shrinkage of concrete, elastic compression of concrete, creep of steel, take up of anchorages, and other remaining losses. Estimate these losses in accordance with the latest edition of the AASHTO *LRFD Bridge Design Specifications*, including applicable interim revisions.

3 Provide bonded reinforcement in the top of the girder. Ensure a bonded reinforcement capable of resisting the total tension force in the concrete, computed on the assumption of an uncracked section. Ensure that tensile stresses in the concrete do not exceed 240 psi [1.7 MPa] before losses due to creep and shrinkage.

502.4.3.3 Precast Concrete Box Culverts

1 Design precast box culvert structures in accordance with the latest edition of the AASHTO *LRFD Bridge Design Specifications*, including applicable interim revisions, for the design live load and fill height specified; the State Bridge Engineer may approve alternate designs. Include provisions in the design for construction loads routed over the structures.

2 If the precast box culvert has cast-in-place concrete head walls and an alternate design with different thickness walls is approved, submit revised head wall details with the precaster's shop plans. Make changes in the structural concrete and reinforcing steel as a result of the alternate design at no additional cost to the department.

502.4.4 Quality Control

1 The precaster is responsible for quality control. Ensure its performance by an inspector qualified by training and experience—of which, the State Bridge Engineer will be the final judge. Ensure that the primary job of the precaster's inspector is quality control, independent of production. Ensure that the precaster's inspector reports directly to the precaster's top management or chief engineer and works separately from the production unit, performing no production or supervisory work for the project.

2 Ensure that the precaster's quality control plan outlines the steps the precaster will take to ensure that work meets specifications and that it lists the precaster's inspection personnel.

502.4.5 Inspection and Records

1 Keep records providing full information regarding the testing of materials, tensioning, concrete proportioning, placing and curing, and disposition of members.

2 Ensure that the precaster's inspection activities and records include the following:

1. Proper calibration of measuring equipment;
2. Identification, examination, and acceptance of materials such as strand, reinforcing steel, and cement and subassemblies, such as steel plates and their anchorages;
3. Tensioning observations;
4. Inspecting beds and forms before concrete placement;
5. Checking the dimensions of members; number, size, and positions of strands; reinforcing steel; other incorporated materials; opening blockouts, etc;

6. Regular inspection of batching, mixing, conveying, placing, compacting, finishing, and curing of the concrete;

7. Preparation of concrete specimens for testing and performance of tests for slump, air content, cylinder strength, etc;

8. Inspecting operations of detensioning, product removal from beds, handling and storing; and

9. General observation of plant equipment, working conditions, weather, temperature, and other items affecting products.

3 Ensure that the precaster's quality control personnel are responsible for keeping these records. Ensure that records are legible, complete, have the project identification, precaster's name, and inspector's name and signature.

502.4.6 Testing

1 Test concrete in accordance with Table 502.4.6-1, Precast Concrete Testing Requirements.

Table 502.4.6-1
Precast Concrete Testing Requirements

Test	Specification
Slump	AASHTO T 119
Air Content	AASHTO T 152
Compressive Test Specimens	AASHTO T 23
Compressive Strengths	AASHTO T 22

502.4.7 Quality Assurance

1 The department's inspector will provide independent inspection and may require a prefabrication conference with the precaster before beginning work. Before beginning work, give the department's inspector two complete copies of all mill test reports, chemical analyses, and certifications required. Ensure that the precaster notifies the department's inspector at least 14 calendar days before beginning work on precast concrete.

2 Review by the department's inspector does not relieve the precaster of the responsibility for providing materials and finished members as specified. The department may reject deficient or defective materials or members at any time. Replace rejected items promptly at no additional cost to the department.

502.4.8 Concrete

1 Ensure that the precaster uses a design mix that produces concrete with the required 28-day compressive strength (f'_c) and an air-entrainment of from 4.5 to 7.5 percent. Give the concrete mix design to the department's inspector 14 calendar days before placing concrete.

2 Measure and batch materials at a batch plant and to within ± 0.5 percent of the required individual material batch weight [mass].

3 Ensure that the precaster takes temperature, entrained air, and slump tests before placing concrete in the forms. Keep complete records of quality control tests. Give two copies to the department's inspector. Perform concrete control tests in the presence of the department's inspector.

4 For testing 28-day acceptance strengths, ensure the precaster makes, for each precast member, at least three cylinders of concrete 6 in [150 mm] diameter × 12 in [300 mm] high and cured in accordance with AASHTO T 23. Ensure that the precaster or an independent laboratory tests the cylinders and that transportation and curing (prior to and during transportation) of the cylinders is performed. Give test results to the department's inspector. Cure cylinders taken for prestressed, precast members (to determine strength for form removal or for cutting or relaxing prestressing steel) by the same method and under the same conditions as the member.

502.4.9 Reinforcing Steel

1 Ensure reinforcing steel is provided and placed in accordance with Section 514, Reinforcing Steel; ensure the precaster or an independent laboratory tests the samples. Give test results to the department's inspector.

2 Ensure that the concrete cover to the face of main reinforcing steel is at least 1½ in [38 mm] and at least 1 in [25 mm] to other reinforcing steel.

502.4.10 Prestressing Steel

1 Protect prestressing steel against physical damage, dirt, oil, or rust corrosion; visible rust or other signs of corrosion are cause for rejection.

2 Ensure the provision of a concrete cover at least 1½ in [38 mm] thick over the face of the prestressing steel, prestressing steel with a diameter less than or equal to 0.6 in [15 mm], and a center-to-center strand spacing of at least 2 in [50 mm].

3 Ensure that prestressing steel has been packaged in containers or shipping forms that protect against damage and corrosion and identify the manufacturer, type of steel, and heat number.

502.4.11 Prestressing

1 Tension prestressing steel with hydraulic jacks to at least the working stress shown in design computations. Do not cut or release prestressing steel in pretensioned members until the member has attained a compressive strength at least equal to the release value shown in design computations. Unless a load cell or other approved method is used to monitor stress in at least two strands, cast prestressed members the same day as prestressing. Keep a record of gauge pressures and elongations and give two copies to the department's inspector.

502.4.12 Structural Steel

1 Ensure the provision and incorporation into the work of structural steel in accordance with Section 501, Structural Steel. Do not paint or galvanize embedded plates. Paint other structural steel items, such as cross frames, in accordance with Subsection 501.4.1.24, Painting.

502.4.13 Bearing Devices

1 Provide and install elastomeric bearing pads in accordance with shop drawings.

502.4.14 Forms

1 Use metal forms for prestessed, precast members; use metal or wood bulkheads. Maintain metal forms in like-new condition with no open holes, dents, open joints, or misaligned butt joints. Fill open holes and joints with weld metal and grind smooth. Fill dents with weld metal and grind smooth or remove and replace with new metal welded in place and ground smooth. Make repairs so

that the surface profile of the forms does not leave bumps or depressions in the cast concrete surface. Do not make temporary repairs using such materials as duct tape, caulking, etc. Ensure that forms produce a uniform surface finish for members and that form joints are smooth and tight enough to prevent significant leakage. Use forms rigid enough to prevent distortion from concrete pressure and other loads incidental to construction, including vibration. Before placing reinforcement, treat forms with an approved form release agent that will not discolor concrete. Before placing concrete, clean the forms of debris.

502.4.15 Placing Concrete

1 Mix and place concrete in accordance with Section 513, Structural Concrete, except vibrate the concrete internally, externally, or both, as required for proper consolidation.

2 Provide holes for diaphragm dowels and venting that pass through the member, openings for connection rods, and recesses for grout in members, as specified.

3 Lifting anchors may be installed in the ends of members, provided that the portion of each anchor above the concrete is removed after the member is erected. Show lifting anchors on shop drawings, and locate them with consideration for the safe handling and lateral stability of the member.

4 Do not remove prestressed precast concrete members from forms until the design release strength has been reached.

5 Do not "dry cast."

502.4.16 Finishing Precast Concrete Surfaces

1 Do not add water to the surface of concrete to help in finishing operations.

2 Leave a rough finish to surfaces where additional concrete will be placed, a smooth surface where no additional concrete will be placed, and a transverse metal tine finish in accordance with Subsection 513.4.12.2, Finishing Bridge Decks, on deck surfaces where no additional concrete will be placed.

3 Give formed concrete surfaces an ordinary surface finish immediately after form removal. Remove and smooth fins and irregular projections. Thoroughly clean cavities produced by form ties and other holes, honeycombed spots, broken corners or edges, and other defects. Saturate with water and carefully point and true with a cement- and fine-aggregate mortar mixed as per the design mix or

with a commercial patching mixture approved by the State Bridge Engineer. Apply mortar within 30 minutes after mixing. Cure mortar patches in the same manner as the concrete.

4 For prestressed precast concrete members, patch defects with an approved two-component epoxy resin concrete compound applied in accordance with the manufacturer's recommendations. Match the finished color of the patch to the concrete.

5 Do not make concrete repairs, other than at hold-down locations for prestressed, precast concrete members, until the department's inspector has been notified of the extent of irregularities and approved the method of repair.

502.4.17 Curing Precast Concrete

1 Cure prestressed, precast concrete members by steam or alternate methods approved by the State Bridge Engineer. Cure other precast concrete members in accordance with Subsection 513.4.13, Curing Concrete, or by steam curing. Perform steam-curing as follows:

1. Cover members immediately after casting, or keep the exposed surfaces wet with fog spray or wet blankets.

2. Use enclosures that allow free circulation of steam around the member and are constructed to contain steam with minimum moisture loss. Use tarpaulins or similar flexible covers only if they are in good repair and secured to prevent steam and moisture loss.

3. Ensure that steam at the jets is low pressure and saturated and that steam jets do not impinge directly on the concrete, test cylinders, or forms. During application of steam, do not allow the temperature gradient within the enclosure to exceed 70 ºF [20 ºC] per hour. Maintain a constant curing temperature throughout the enclosure no greater than 160 ºF [71 ºC] for sufficient time to develop the required compressive strength. Cover control cylinders to prevent moisture loss and place in a location representative of the enclosure's average temperature.

4. Provide devices to obtain an accurate, continuous, and permanent record of the curing temperature; place one or more devices every 200 ft [60 m] of continuous bed length.

5. Detension members in pretension beds immediately after steam curing while the concrete and forms are still warm, or maintain the temperature in the enclosure above 60 ºF [15 ºC] until the stress is transferred to the concrete.

6. The department will consider curing complete at the end of the steam curing cycle.

502.4.18 Tolerance for Precast Concrete Members

1. **Prestressed, Precast Concrete Girders.** Use prestressed, precast concrete girders with tolerances shown in Table 502.4.18-1, Tolerances for Prestressed Precast Concrete Girders.

Table 502.4.18-1
Tolerances for Prestressed Precast Concrete Girders

Dimension	Tolerance	
	I-Girders	T-, Bulb T-, and Tri-Deck Girders
Depth: flanges, web, and fillets	±¼ in [±6 mm]	±¼ in [±6 mm]
Depth: overall	+½ in, -¼ in [+12 mm, -6 mm]	±¼ in [±6 mm]
Width: flanges	+⅜ in, -¼ in [+10 mm, -6 mm]	+⅛ in, -¼ in [+3 mm, -6 mm]
Width: web, fillets	+⅜ in, -¼ in [+10 mm, -6 mm]	+⅜ in, -¼ in [+10 mm, -6 mm]
Length of beam	±¼ in/25 ft, 1 in max. [±1 mm/m, 25 mm max.]	±¼ in/25 ft, 1 in max. [±1 mm/m, 25 mm max.]
Deviation along exposed beam ends (measure skews diagonally)	±$^{3}/_{16}$ in/ft, 1 in max. [±15 mm/m, 25 mm max.]	±⅛ in/ft, ½ in max. [±10 mm/m, 13 mm max.]
Diaphragm insert spacing	±½ in [±12 mm]	±½ in [±12 mm]
Stirrup bars: projection above top of beam	±½ in [±12 mm]	n/a
Stirrup bars: longitudinal spacing	±1 in [±25 mm]	n/a

Table continues on next page

Table 502.4.18-1
Tolerances for Prestressed Precast Concrete Girders, *continued*

Dimension	Tolerance	
	I-Girders	T-, Bulb T-, and Tri-Deck Girders
Stirrup bars: clearance at end of beam	≤2 in [≤50 mm]	n/a
Horizontal alignment: deviation from a straight line parallel to centerline of beam	⅛ in/10 ft [1 mm/m]	⅛ in/10 ft [1 mm/m]
Camber variation from design	±⅛ in/10 ft, ½ in max. up to 80 ft length [±1 mm/m, 12 mm up to 24 m length]; ±1 in max. over 80 ft length [±25 mm max. up to 24 m length]	±¼ in/10 ft, ¾ in max. [±2 mm/m, 19 mm max.]
Camber differential between adjacent beams	n/a	¼ in/10 ft [2 mm/m] ¾ in [19 mm] max.
Center of gravity of strand group	±¼ in [±6 mm]	±¼ in [±6 mm]
Position of hold-down point for depressed strands	±6 in [±150 mm]	±6 in [±150 mm]
Position of handling devices	±6 in [±150 mm]	±6 in [±150 mm]

2. **Precast Concrete Box Culverts.** Use precast concrete box culvert sections with tolerances as follows:

   2.1. Internal dimensions within ± 1.0 percent of those specified;

   2.2. Haunch dimensions within ± ¼ in [6 mm] of those specified;

   2.3. Slab and wall thicknesses not less than 5.0 percent of those specified; and

   2.4. Lengths of two opposite surfaces of the box section within ± ¾ in [19 mm] of each other, except where bevel ends are specified.

502.4.19 Precast Concrete Box Culverts

1 Before shipping precast concrete box culverts, ensure the assembly of at least three sections, chosen by the department's inspector, and that the joints fit as specified for final assembly.

2 Excavate and backfill in accordance with Section 206, Excavation and Backfill for Culverts. Before installing precast concrete box culvert sections, obtain two copies of recommended installation procedures from the precaster and give one to the engineer. Install on the prepared base in accordance with the recommendations.

3 Do not allow gaps between sections, when assembled in their final position, exceeding ½ in [12 mm] for more than 6 in [150 mm] at any one location or totaling more than 12 in [300 mm] in multiple locations. Do not allow the alignment of walls, top slabs, and bottom slabs to vary more than ½ in [12 mm] for more than 6 in [150 mm] at any one location or more than 12 in [300 mm] total in multiple locations. Measure misalignment perpendicular to slabs and walls.

502.4.20 Handling and Shipping Precast Members

1 Do not damage precast concrete members while handling, storing, or erecting. Blocking may be required to ensure safe transport. Handle, store, and erect members in an upright position and such that the points of support and directions of the support reactions with respect to the member are approximately the same as when the member is in its final position. Until concrete has attained 75 percent of the specified design strength, do not move precast members by lifting on anchors embedded in the concrete or by lifting the member itself.

2 Mark the weight [mass] on members heavier than 3 ton [2.7 t].

3 Ensure that materials shipped to the project are accompanied by a manufacturer's certification that lists each separate piece by name and piece mark and includes mill test reports and the precaster's quality control report.

4 Determine and provide the necessary temporary bracing to ensure lateral stability of prestressed, precast concrete girders during erection and placement of the diaphragms and deck. Do not remove temporary bracing until the deck is placed and the diaphragms have attained 80 percent of ultimate design strength.

502.4.21 Rejection of Precast Members

1 The department may reject precast members if, upon removal of the forms, there is cracking, honeycombing, air pockets, sand streaks, or other evidence of imperfect mixing or casting or because of failure to meet requirements of these specifications at the fabrication plant or job site.

502.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Precast Box Culverts ___ × ___ ft [mm] by the foot [meter].
2. Precast Concrete Members as one complete unit.
3. Prestressed Precast Conc Bulb-T _____ in [mm], Prestressed Precast Conc I-Girder _____ in [mm], and Prestressed Precast Conc Tri-Deck _____ in [mm] by the foot [meter] from end of girder to end of girder for each prestressed precast member supplied.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Precast Box Culverts ___ × ___ ft [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Precast Concrete Members	LS	LS	LS
Prestressed Precast Conc Bulb-T ___ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Prestressed Precast Conc I-Girder ___ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Prestressed Precast Conc Tri-Deck ___ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

SECTION 503
Bridge Railing

503.1 DESCRIPTION

1 This section describes the requirements for constructing steel bridge railing, pedestrian railing, and bridge railing modifications.

503.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Bolts and Fasteners	815.6
Bridge Railing	815.9
Epoxy Resin Grout	819.2
Galvanized Coating	815.14
High Strength Anchor Bolts	815.18

2 Use an adhesive anchorage system approved by the Bridge Program.

503.3 EQUIPMENT—Vacant

503.4 CONSTRUCTION

503.4.1 General

1 Fabricate and construct bridge railing in accordance with Section 501, Structural Steel.

503.4.2 Fabrication

1 Ensure that venting and pick-up holes in rails and sleeves are shown on the fabricator's shop drawings. Place vent holes on the underside of the rail members as installed.

2 Ensure that post base plates are flat after fabrication.

3 Shop-curve rail members for curved bridges with a radius of less than 1000 ft [300 m].

4 Grind rough edges on posts and rails smooth before galvanizing. Galvanize railing and hardware in accordance with Subsection 501.4.1.25, Galvanizing. Straight or unwelded tubes may be galvanized before fabrication, provided that cut surfaces are repaired in accordance with Subsection 501.4.1.25, Galvanizing. In addition to the requirements of AASHTO M 111, ensure that the galvanizing is free of general roughness, dross pimples, blisters, and wet storage stain.

5 Use nonmetallic spacers at least 1½ in [38 mm] thick to separate rails bundled together for storage or shipment. Ensure that metal bundling straps do not touch the rails.

503.4.3 Erection

503.4.3.1 General

1 After installing rail elements, paint the exposed rail bolt threads with two coats of zinc-rich paint in accordance with ASTM A 780.

503.4.3.2 New Construction

1 Place and properly align railing posts before placing new concrete.

503.4.3.3 Railing Modification

1 For railing modification, remove existing rail, posts, associated hardware, and portions of anchor bolts protruding beyond the concrete surface when required. Removed bridge railing becomes the contractor's property.

2 If removing and resetting bridge railing, reuse rails, posts, and splice sleeves. Toggle bolts become property of the contractor; do not reuse them. Use new U-bolts to reattach rails to the posts. Match-mark items to be reused before removal. Replace items damaged during removal and resetting at no additional cost to the department.

3 Set anchor bolts or threaded rods for railing modification in epoxy resin grout or an alternate adhesive anchorage system in accordance with Subsection 501.4.2.7, Setting Anchor Bolts. If using an alternate system, ensure that the anchor holes in the concrete are the diameter and length recommended by the adhesive manufacturer to achieve a minimum pullout capacity equaling the ultimate tensile strength of the anchor bolt or threaded rod. Preserve at least 2 in [50 mm] between the bottom of drilled holes and the underside of the concrete slab.

503.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Bridge Railing and Pedestrian Railing by the foot [meter].
2. Bridge Railing Modification, Pedestrian Rail Modification, and Reset Bridge Railing by the foot [meter] or by the complete unit.

2 The engineer will not include sleeves for attaching guardrail in the measurement for Bridge Railing or Bridge Railing Modification

3 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Bridge Railing	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Bridge Railing Modification	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, 0.5 m]
Pedestrian Railing	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Pedestrian Railing Modification	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, 0.5 m]
Reset Bridge Railing	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, 0.5 m]

SECTION 504
Bearing Piles and Sheet Piling

504.1 DESCRIPTION

1 This section describes the requirements for furnishing and driving steel bearing piles and steel sheet piling.

504.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Steel Bearing Piles	815.7
Cutwater Angles and Pile Splices	815.1
Paint	809
Sheet Piling	815.8

2 Ensure that sheet piling has a minimum section modulus (SM), (in^3/ft [cm^3/m]) as specified.

504.3 EQUIPMENT

504.3.1 Pile Driving for Bearing Piles

1 Provide hammers capable of driving piles to specified length and required bearing capacity.

2 Use fixed or swinging leads constructed to allow free movement of the hammer and rigged to hold the pile and hammer in alignment during driving. To distribute the hammer blow, fit a helmet around the pile head as needed to prevent the transfer of torsional forces during driving; maintain the proper hammer and pile alignment. Provide hammer cushions of durable manufactured materials in accordance with the hammer manufacturer's guidelines. Equip diesel hammers with a device, such as rings on the ram, that allows the engineer to visually determine hammer stroke at all times during pile driving.

3 Do not use gravity pile hammers. The engineer may approve the use of air, steam, or closed end diesel hammers.

4 Submit hammer specifications to the engineer, including the following information:

1. Make, model, and range of energy (minimum to maximum) in foot-pounds [joules] of the pile hammer;
2. Range of the pile hammer stroke in feet [meters];
3. Type, thickness in inches [millimeters], area in square inches [square millimeters], elastic modulus in kips per square inch [megapascals], and coefficient of restitution of cushioning material;
4. Weight in pounds [mass in kilograms] of the ram, striker plate, and helmet; and
5. Estimated length in feet [meters] of piling in the leads.

5 When the department requires dynamic pile testing, supply an electrical generator capable of producing 1 kW of power to operate the testing equipment.

504.3.1.1 Approval of Pile-Driving Equipment

1 The Geology Program will determine the adequacy of the pile hammer through wave equation analysis. If the hammer is deemed inadequate, provide other equipment. At least 14 calendar days before driving piles, using the "Pile Driving Hammer Configuration" (Form E-74A) give the engineer the data for each hammer to be used . The department will not allow the use of hammers for which the wave equation indicates pile stresses that exceed 90 percent of the minimum yield strength for steel piling.

504.3.2 Pile Driving for Sheet Piling

1 Use a vibratory hammer to drive sheet piling unless otherwise approved in writing by the engineer.

504.4 CONSTRUCTION

504.4.1 Determination of Length

1 Use bearing piles long enough to provide the specified bearing capacity, penetration, and extension into the cap or footing block. The length of piling

specified is an estimate only; the engineer will determine the final length following an investigation of the site.

2 For sheet piling, provide the specified area indicated on the department's "Proposal" (Form E-91), unless site conditions prevent installation to those limits.

504.4.2 Predrilled Holes

1 When specified or approved by the engineer, use predrilled holes. Extend to the elevation specified and obtain the remaining penetration with the pile driver. Do not allow the hole diameter to exceed the pile width. Place the pile in the hole and drive it to set the point firmly into bearing material, and secure full bearing. Fill the space around the pile to the ground surface with dry sand, pea gravel, flowable fill, or other material approved by the engineer. Do not use water or air jets without written approval from the engineer.

504.4.3 Pile Driving

1. **Bearing Piles.** Drive piles using the system approved and without variation, except with the engineer's written approval. The engineer will consider changes in the driving system only after the necessary information for a revised wave equation analysis is submitted. Support long piles to prevent lateral buckling during driving.

   Support pile hammers in leads while driving piles. Maintain hammers to obtain the operating length of the stroke and number of blows per minute for which the hammer is designed. Maintain cushions in good condition. The engineer will observe the hammer's initial operations to verify its adequacy. Repair or replace inadequate hammers.

   Cut the heads of steel piles squarely. Ensure that the helmet closely fits the top of the pile and extends down the sides to maintain alignment of the pile head under hard driving conditions.

   Drive piles to within ¼ in/ft [20 mm/m] of vertical or the specified batter. Drive foundation piles in footings of piers and abutments so that their tops are within 6 in [150 mm] of position in any direction.

   1.1. **Pile Bents.** Drive piles for bents so that the center of each pile's top is within 6 in [150 mm] of that specified when measured parallel to the centerline of the bent.

1.1.1. For pile bents with steel bent caps, ensure that the centerline of the tops of the piles is not out of position by more than 2 in [50 mm] measured perpendicular to the specified centerline of the bent or more than 1 in [25 mm] from a stringline stretched between the centerline of the exterior piles.

1.1.2. For pile bents with concrete bent caps, ensure that the centerline of the tops of the piles is not out of position by more than 3 in [75 mm] measured perpendicular to the specified centerline of the bent.

2. **Sheet Piling.** Install piling to the depth and lateral limits specified; do not remove. When specified, cut weep holes at the factory or in the field.

504.4.4 Bearing Value and Penetration for Bearing Piles

1 Drive pile to the length specified and at least 12 ft [4 m] into the ground when no tip elevation is specified. The department defines *ground* within an area of roadway embankment as the bottom of the roadway embankment or bottom of footing, whichever is lower. When a tip elevation is specified, drive piles to at least the specified elevation, unless otherwise allowed in writing by the engineer.

1. **End Bearing Piling.** Based on a dynamic formula, the wave equation, or both, the engineer will provide the following:

   1.1. The stroke or hammer energy;

   1.2. The blow count criteria to prevent overstressing of piling; and

   1.3. The amount of pile “set” in blows per inch [mm] to achieve refusal at a specified stroke or hammer energy for open end diesel hammers or hydraulic hammers respectively.

2. **Soil Resistance Piling.** Based on the wave equation, and including a safety factor, the engineer will provide the blow count per inch [mm] or per 12 in [300 mm] at a specified stroke or hammer energy to achieve design bearing capacity and to prevent overstressing of piling.

2.1. **Dynamic Load Tests.** If specified, the department will take dynamic load measurements. Before full production driving, drive test piling; the department will specify pile locations to be tested. Contact the engineer 14 calendar days before and again two days before installing test piles. The department will schedule a testing consultant to instrument and test piles during driving. The department's consultant will test using the pile dynamic analyzer with the Case Pile Wave Analysis Program to determine when the desired load capacity is achieved

When specified, restrike 24 hours after the test pile has been driven to ensure the desired capacity has been achieved.

Allow sufficient time for required instrumentation and testing. Delay or standby time resulting from nonadherence of the contractor to the pile testing schedule will be at no additional cost to the department.

Provide an additional 10 ft [3 m] of piling for testing. The department may change the specified length of piles driven after the tests.

504.4.5 Cutoff

1 Cut steel piles off at the elevation specified and, when required, cap them with steel plates or other devices. Cut sheet piles off at the depth specified.

504.4.6 Pile Splices

1 For bearing piles, use steel H-piles of the size and weight [mass] specified. The department will allow the length of steel pile to be built up in sections by splicing. Splice before driving, during driving, or both. Ensure that spliced piles have identical cross-sections.

2 Make steel pile splices with pile splicer sections or welded splices as follows:

1. **Pile splicer.** Bevel the outside edges of the flanges on the upper length of pile and cut a ⅞ in × 2⅛ in [22 mm × 54 mm] notch in the web for the spacer bar. Slip the splicer onto the upper pile until the bar slides into the notch, then weld the splicer to the upper pile. Set the upper

pile with the attached splicer on the driven pile. Weld the splicer and the outside edge of each flange to the driven pile.

2. **Welded splices.** Connect the two pile sections by bevel groove welding.

3 Align the connected pile sections to ensure that the axis of the pile is straight. Weld splices in accordance with Subsection 501.4.2.5, Field Welding. Do not use a pile splicer section when the splice point is above ground unless piling is embedded in concrete.

4 To reduce piling waste, use cut-offs longer than 6 ft [2 m] to extend piling, or splice them together as full-length piles and incorporate them into the structure.

504.4.7 Painting

1 Paint bearing piles that will be visible in the completed structure. Clean and paint the exposed portion of the pile and the portion extending 24 in [600 mm] below ground or low water surface, whichever is higher, in accordance with Subsection 501.4.2.8, Field Painting. For the final coat, use the same color used on structural steel.

504.4.8 Pile Points

1 Use and attach pile points as specified. Work necessary for pile points is considered incidental to the steel piling.

504.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Pile Splices required for the extension of piles due to an overrun in specified lengths per each; splices made for the contractor's convenience will not be paid for. Only one splice per pile will be paid for when an overrun in the specified length occurs.

2. Predrilled Holes, when specified, by the foot [meter].

3. Steel Piling HP ___ × ___ by the foot [meter] of driven length installed.

4. Steel Sheet Piling (SM _____) by the square foot [square meter] of installed area.

2 When the total driven quantity of piling installed is less than the total contract quantity, the department will pay the difference by the invoice price of the material and the transportation cost. Excess piling remains the property of the contractor.

3 If required by the engineer, he or she will measure piling installed in excess of the total contract quantity for payment.

4 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Pile Splices	EA [Ea]	EA [Ea]	EA [Ea]
Predrilled Holes	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Steel Piling HP ___ × ___	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Steel Sheet Piling (SM ___)	SF [m^2]	0.1 ft [0.05 m]	SF [0.1 m^2]

SECTION 505
Concrete Barrier

505.1 DESCRIPTION

1 This section describes the requirements for constructing concrete bridge barrier, bridge median barrier, median barrier, and shoulder barrier.

505.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Curing Materials	802.1
Fly Ash	801.2
Grout	819.1
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

2 Provide and install delineation as specified.

505.3 EQUIPMENT

1 Ensure that equipment meets the following requirements:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing and Finishing Equipment	513.3.3

2 Use steel forms.

505.4 CONSTRUCTION

505.4.1 General

1 Use class B concrete in accordance with Subsection 513.4.4, Mix Design.

2 Cast-in-place or slipform concrete barriers. Do not slipform bridge barrier if there is traffic on the bridge. Secure cast-in-place barrier forms for roadway barrier without damaging roadway pavement.

505.4.2 Installation

1 Vibrate and work the concrete until consolidated and free of voids without segregating the mix. For the slipform method, use concrete capable of maintaining the shape of the barrier without support. Cure in accordance with Subsection 513.4.13, Curing Concrete. Surfaces protected by forms for five calendar days or more do not require curing.

2 Immediately after removing forms, give the exposed surfaces of bridge barrier a rubbed finish in accordance with Subsection 513.4.12, Finishing Concrete Surfaces. For shoulder and median barriers, leave an ordinary finish.

3 Saw and grout shoulder and median barrier joints as specified, including casting anchor bolts in terminal ends and furnishing steel sleeves or other hardware for guardrail connections.

4 Place concrete barrier delineators, of the type specified, at 20-foot [6 m] intervals throughout the length of the barrier.

505.4.3 Dimensional Tolerances

1 Remove and replace barrier not meeting tolerance requirements at no additional cost to the department. Ensure that concrete barrier meets the following tolerances:

1. Cross-sectional dimensions within ¼ in [6 mm] of design dimensions;
2. Finished barrier true to specified line and grade ± ¼ in every 10 ft [6 mm in 3 m]; and
3. Surface variation under a 10-foot [3 m] straightedge no greater than ¼ in [6 mm].

505.5 MEASUREMENT and PAYMENT

1 The engineer will measure Bridge Barrier, Bridge Median Barrier, Median Barrier _____ in [mm], and Shoulder Barrier by the foot [meter] and without deducting for open joints required over bridge expansion joints.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Bridge Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Bridge Median Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Median Barrier ____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Shoulder Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

SECTION 506
Drilled Shaft Foundations

506.1 DESCRIPTION

1 This section describes the requirements for constructing drilled shaft foundations.

506.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Fly Ash	801.2
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

506.3 EQUIPMENT

1 Ensure that equipment meets the following requirements:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

2 Provide a power-driven rotary auger or, if required, rock drilling equipment. Provide a rig of sufficient size and capacity and equipped to produce holes of the diameter and depth specified.

506.4 CONSTRUCTION

506.4.1 Drilled Holes

1 Drill shafts to within 3 in [75 mm] of their specified locations, measured at the top of the center axis. Drill vertical shafts no more than 1.5 percent of their length from plumb. For their full length, drill battered shafts no more than 5 percent from the specified angle of inclination.

2 Drill holes deep enough to meet design requirements. The engineer may change the specified elevation of the bottom of a drilled hole depending on where satisfactory material is encountered. Do not place reinforcing steel or concrete until the final bottom elevation has been established.

3 Use removable casing, when necessary, to prevent caving or water seepage. Ensure that such casing is smooth, watertight, and made of metal strong enough to resist hydrostatic pressure, concrete pressure, and surrounding earth pressure. Ensure that the casing is clean, extends to the top of the drilled hole excavation, and has an outside diameter not less than the specified diameter of the drilled hole.

4 When the top of the drilled shaft is below ground level, use a removable oversize casing or other approved forming method from the ground surface to the shaft as required to control caving.

5 If caving conditions are encountered, stop drilling and change methods.

6 Use water for drilling mud or slurry only with approval of the engineer.

7 As approved by the engineer, dispose of excavated material not used as backfill around the completed structure.

506.4.2 Cleaning and Inspection

1 Do not place concrete before the engineer has inspected drilled holes for tolerances, satisfactory bearing material, and freedom from debris and loose material. The department will consider a hole sufficiently dry if water depth can be kept at 3 in [75 mm] or less while placing concrete.

506.4.3 Reinforcing Steel

1 Assemble the reinforcing steel cage completely and place as a unit.

2 Anchor the reinforcing cage adequately to prevent movement after installation. Use spacers to ensure proper clearance between the reinforcing steel cage and shaft face.

3 Extend the bars in the lower portion of the shaft to the bottom of the hole if the shaft is lengthened and full-depth reinforcement is specified. Lap-splice the bars to proper length in accordance with Subsection 514.4.5, Placing and Fastening, and Table 506.4.3-1, Lap Lengths for Drilled Shaft Reinforcing Steel.

Table 506.4.3-1
Lap Lengths for Drilled Shaft Reinforcing Steel

Bar Size (No.)	Length	Bar Size (No.)	Length
4 [13]	1 ft 4 in [410 mm]	8 [25]	3 ft 7 in [1100 mm]
5 [16]	1 ft 8 in [510 mm]	9 [29]	4 ft 6 in [1380 mm]
6 [19]	2 ft 0 in [610 mm]	10 [32]	5 ft 9 in [1780 mm]
7 [22]	2 ft 9 in [840 mm]	11 [36]	7 ft 0 in [2140 mm]

4 If specified as full-depth, make spiral reinforcement full-depth on extensions. Use spliced bar extensions with sufficient stability to withstand lifting, placing, and downward forces of wet concrete without slippage. If necessary to ensure stability, tack weld the lap splice extension, along with tie wire, for a distance no more than 24 in [600 mm] from the bottom of the initial reinforcement, and tack weld the spiral to the longitudinal reinforcement.

506.4.4 Concrete

1 Use class B concrete in accordance with Subsection 513.4.4, Mix Design, except with concrete slump, use it in accordance with Table 506.4.4-1, Concrete Slump Limits.

Table 506.4.4-1
Concrete Slump Limits

Casing Type	Slump	
	Minimum	Maximum
Stay-in-place	4	6
Removable	5	7

2 Place concrete as soon as possible after completing the drilled hole; place continuously in the shaft to the top elevation specified. Place in vertical dry holes, without dropping more than 25 ft [7 m]. Do not drop concrete if it strikes the reinforcing steel or the sides of the hole. In holes deeper than 25 ft [7 m], or battered holes, place concrete with an enclosed chute or pump. Where dewatering of the hole cannot maintain a static water depth of 3 in [75 mm] or less, discharge concrete below the water. If the batter exceeds 20 degrees from the vertical, or if concrete is placed underwater, immerse the placement discharge pipe at least 24 in [600 mm] into the fluid concrete.

3 Vibrate the top of the concrete in accordance with Subsection 513.4.11, Placing Concrete, for a depth equal to two shaft diameters. Do not vibrate concrete when the static water level is near or within the top portion to be vibrated.

506.4.5 Casing Removal

1 Remove the casing while concrete is workable but after all concrete has been placed, unless otherwise approved by the engineer. As necessary to facilitate the casing’s upward movement, use an initial short pull (or “jerk”), rotation, downward pressure, or tapping. Thereafter, lift vertically at a slow, uniform rate while keeping the casing aligned with the hole. Telescoping, outer and inner, or jointed casings may be pulled in stages. In all cases of removal, maintain at least 5 ft [1.5 m] of fluid concrete above the bottom of the casing.

506.5 MEASUREMENT and PAYMENT

1 The engineer will measure Drilled Shaft Foundations _____ in [mm] by the foot [meter] from the completed bottom of the shaft to the top of the shaft.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Drilled Shaft Foundation ____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

SECTION 507
Reinforced Bridge Approach Fills and Reinforced Concrete Approach Slabs

507.1 DESCRIPTION

1 This section describes the requirements for constructing reinforced bridge approach fills and reinforced concrete approach slabs.

507.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Fly Ash	801.2
Geotextile	805
Pervious Backfill Material	803
Plastic Pipe for Underdrain	808.4
Portland Cement	801.1
Reinforcing Steel	811.1
Sheet Metal	815.3
Sheet Piling	815.8
Water	814.1

2 Provide cardboard void material with an initial installed compressive strength greater than 15 psi [105 kPa] and a final compressive strength, after saturation, of less than 1 psi [5 kPa].

507.3 EQUIPMENT

1 Ensure that equipment meets the following requirements:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing and Finishing Equipment	513.3.3
Sheet Pile Driving Equipment	504.3.2

507.4 CONSTRUCTION

507.4.1 Steel Sheet Piling

1 When constructing bridge approach fills one-half at a time, with traffic on the other half of the roadway, use the specified size of steel sheet piling. Drive steel sheet piling where specified, in accordance with Section 504, Bearing Piles and Sheet Piling. Drive piling so that it extends from just below the proposed approach slab to the depth specified and from the abutment to the end of the approach backfill material. Do not damage the abutment corbel or footing. Leave the piling in place after construction.

507.4.2 Reinforced Bridge Approach Fills

1 Before placing backfill and perforated plastic pipe, line the bottom of the excavation with embankment and retaining wall reinforcement geotextile. Do not cover the top of the pipe or impede drainage with the geotextile.

2 Place perforated and nonperforated plastic pipe along the base of the abutment backwall, and slope to drain. Where steel sheet piling is required, provide a hole in the piling to facilitate pipe placement. If necessary for drainage, extend the pipe through the abutment wingwall. Wrap perforated portions of pipe with drainage and filtration geotextile; overlap longitudinal and peripheral seams from 4 in to 5 in [100 mm to 125 mm]. Place perforated pipe with the perforations down, and cap at the high end.

3 Create a void of 2 in to 4 in [50 mm to 100 mm] between reinforced approach fill and the abutment backwall and wingwalls; use a stay-in-place honeycomb cardboard, a temporary slip form, or other approved method. Do not use polystyrene slabs and a dissolving agent. Ensure that the strength reduction of stay-in-place cardboard is controllable and that the reduction is complete before construction of the approach slab. Keep cardboard materials as dry as practical during installation and placement of backfill.

4 Place backfill and geotextile in accordance with Subsection 217.4, Construction. Place an initial lift of backfill material on the geotextile lining in the bottom of the excavation. Where steel sheet piling is required, extend the geotextile up the piling face to the bottom of the next layer of geotextile. Place and compact backfill material and wrap geotextile adjacent to the void material. Place the next layer of geotextile and compact the subsequent specified thickness of backfill on top of the fabric; re-embedment folds may be required. Repeat this procedure as necessary for the height of the abutment backfill.

5 Seams perpendicular to abutment back- or wingwalls and seams parallel to abutment back- or wingwalls and more than 13 ft [4 m] away may be constructed by overlapping the geotextile at least 24 in [600 mm]. If minimum overlap cannot be reached, sew seams in accordance with Subsection 217.4, Construction. Leave seams exposed until the work has been inspected and repaired, if necessary.

6 After completing the final lift of backfill, remove the temporary slip form or saturate the stay-in-place cardboard material to create the 2-inch to 4-inch [50 mm to 100 mm] void. If a slip form is used, remove without displacing backfill or impairing the integrity of the geotextile. If cardboard is used, saturate in-place, and continuously, for at least eight hours without eroding the site.

507.4.3 Reinforced Concrete Approach Slabs

1 Use class B concrete in accordance with Subsection 513.4.4, Mix Design. Finish the foundation surface at least 24 in [600 mm] outside of slab edges to provide a firm support for forms. Moisten foundation material before placing the concrete.

2 Form, place, and cure concrete in accordance with Section 513.4, Construction. Ensure that slab surfaces meet the tolerances and finish requirements of Subsection 513.4.12.2, Finishing Bridge Decks.

3 Provide and place reinforcing steel in accordance with Section 514, Reinforcing Steel.

4 Use galvanized sheet for bond breaker above corbels or sleeper slabs.

507.5 MEASUREMENT and PAYMENT

507.5.1 General

1 The engineer will measure:

1. Bridge Approach Backfill by the cubic yard [cubic meter], based on the neat lines specified.

2. Reinforced Conc Approach Slabs by the square yard [square meter] of the out-to-out slab dimension.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Bridge Approach Backfill	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Reinforced Conc Approach Slabs	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]

507.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for the following:

1. Geotextile in accordance with Section 217, Geotextiles, based on the dimensions specified and including geotextile required for re-embedment;
2. Steel sheet piling in accordance with Section 504, Bearing Piles and Sheet Piling; and
3. Perforated and non-perforated plastic pipe in accordance with Section 605, Underdrains.

SECTION 508
Reinforced Concrete Slope Paving

508.1 DESCRIPTION

1 This section describes the requirements for constructing reinforced concrete slope paving.

508.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Admixtures	801.4
Aggregate for Concrete	803
Aggregate for Flowable Backfill	803
Curing Materials	802.1
Epoxy Resin Bonding Compound	810.6
Fly Ash	801.2
Joint Fillers and Sealers	807
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

508.3 EQUIPMENT

1 Ensure that equipment meets the following requirements:

Equipment	**Subsection**
Batch Plant	513.3.1
Mixers	513.3.2
Placing and Finishing Equipment	513.3.3

2 Machine-mix flowable backfill materials in a rotary drum or other approved mixer capable of thoroughly dispersing all ingredients throughout the material.

508.4 CONSTRUCTION

508.4.1 Slope Preparation

1. **New Construction.** Moisten material under the slope paving where necessary and compact thoroughly to the required embankment density as specified in Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control. Shape the slope to the bottom plane of the paving.

2. **Slope Paving Repair/Modification.** When specified, remove existing slope paving to the lines indicated or as approved by the engineer. Expose the existing welded wire fabric for at least 15 in [380 mm] within the removed area, and clean of old concrete. If necessary to ensure neat lines after reconstruction, saw-cut construction joints 1 in [25 mm] deep. Removed concrete becomes the property of the contractor.

   Fill voids beneath removed and adjacent slope paving with flowable backfill in accordance with Subsection 206.4, Construction; use a material consistency and placement method that will not result in voids or segregation. Place flowable backfill in maximum lifts of 24 in [600 mm], with each lift obtaining its initial set before placement of subsequent lifts. Fill voids to match the bottom plane of existing paving but without leaving a surface that would cause a new slope paving section thinner than specified. Cure at least 24 hours before placing new slope paving.

508.4.2 Placing, Finishing, and Curing Concrete

1 Use class B concrete in accordance with Subsection 513.4.4, Mix Design. Form, place, and cure in accordance with applicable portions of Section 513.4, Construction. Float-finish in accordance with Subsection 513.4.12, Finishing Concrete Surfaces.

2 When placing slope paving as a repair or modification, first clean the surfaces of the existing concrete abutting the new concrete and coat with epoxy bonding compound. Place welded wire fabric and lap with the exposed, existing wire fabric. Place new concrete while the epoxy bonding material is still tacky. If

the epoxy is no longer tacky, remove any surface contaminates and reapply. If existing joint filler was removed, place new ½ in [12 mm] joint filler with elastic joint sealer in new slope paving. Match the top surfaces of new and existing concrete.

508.5 MEASUREMENT and PAYMENT

508.5.1 General

1 The engineer will measure Reinforced Conc Slope Paving and Slope Paving Repair/Modification by the square yard [square meter] of surface area, including the outside face of cut-off walls. Measurements will be made parallel to the surface. No deduction will be made for the areas taken up by the intersection of columns or piling with the slope paving.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Reinforced Conc Slope Paving	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Slope Paving Repair/ Modification	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]

508.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for flowable backfill in accordance with Section 206, Excavation and Backfill for Culverts.

SECTION 509
Vacant

SECTION 510
Vacant

SECTION 511
Riprap and Gabion Erosion Protection

511.1 DESCRIPTION

1 This section describes the requirements for constructing bank or ditch lining or slope protection.

511.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Aggregate for Riprap	803
Filter Aggregate for Riprap	803
Geotextile	805
Wire Enclosed Riprap and Gabions	811.6

511.3 EQUIPMENT—Vacant

511.4 CONSTRUCTION

511.4.1 Preparation of Slopes

1 Shape slopes to allow for the full thickness of riprap or gabions and any bedding or filter aggregate. Slope material no steeper than its natural angle of repose. When possible, excavate the slope from undisturbed material; when not, shape and compact the underlying material to at least 90.0 percent of maximum density at optimum moisture content, in accordance with Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control.

511.4.2 Filter Aggregate

1 When specified, place a layer of filter aggregate on the slope immediately before placing riprap. Shape the layer to provide the minimum thickness specified and to match the bottom surface of the riprap.

511.4.3 Erosion Control Geotextile

1 When specified, place a layer of erosion control geotextile on the slope in accordance with Section 217.4, Construction, immediately before placing riprap or gabions.

511.4.4 Hand-Placed Stones

1 Where hand-placed stones are specified, place larger stones first and with close joints. When a footing trench is specified, place the larger rocks in the trench. Place rocks with their longitudinal axis perpendicular to the embankment face and arranged so that each rock above the foundation course has a 3-point bearing on the underlying rocks. Ensure that foundation rocks do not bear on smaller rocks used for chinking voids. Do not place rocks by dumping. Fill voids between large stones with smaller stones.

511.4.5 Machine-Placed Stones

1 Place machine-placed stones so as to minimize voids. Place larger stones in the toe course and on the outside surface of the slope protection. After completing the slope protection work, fill the footing trench with excavated material; the department does not require compaction.

511.4.6 Wire-Enclosed Riprap

1 Form wire enclosure segments to specified dimensions. Place, lace, and fill segments to provide uniform, dense erosion protection. Heavy-duty galvanized gabions may be substituted for standard wire enclosed riprap, with the engineer’s approval and at no additional cost to the department.

511.4.7 Gabions

1 Lace adjacent gabions (new-to-new and new-to-existing) along the perimeter of contact surfaces. Wire the bases of empty gabions placed on top of filled gabions tightly to the filled gabions. Stagger joints between ends of adjacent gabion baskets in a row at least 18 in [450 mm] from those in the row below.

2 Stretch the gabions in accordance with the manufacturer’s recommendations to provide proper alignment. While stretching, inspect corners for open Vs; if found, close Vs by replacing the material. Ensure that the stretching provides a resistant force to prevent bulging while installing the aggregate fill and connecting wires.

3 Place the last layer of stone in a gabion level with the top of the gabion to provide an even surface for the next course of gabions. Before placing the next course, backfill the completed course with site-excavated material in accordance with Subsection 206.4.5, Backfilling, and without displacing or damaging gabions.

511.4.8 Wire Acceptance

1 For wire products used not meeting the specification requirements for the type of wire specified, the engineer will do one of the following:

1. Reject and require removal of the out-of-specification material at no additional cost to the department;

2. Accept and leave the material in place with the contractor's cost of the wire product deducted; or

3. Accept the material at a reduced unit price in accordance with the Materials Program's *Schedule of Price Adjustment for Out-of-Specification Wire Products* in effect at the time of the contract award. Obtain a copy from the Materials Program.

511.5 MEASUREMENT and PAYMENT

511.5.1 General

1 The engineer will measure:

1. Filter Aggregate, Gabions, Hand-Placed Riprap, and Machine-Placed Riprap by the cubic yard [cubic meter] in place.

2. Wire-Encl Riprap by the square yard [square meter], parallel to the top surface.

2 If Gabions are substituted for Wire-Encl Riprap, the engineer will measure the Gabions by the square yard [square meter] as Wire-Encl Riprap.

3 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Filter Aggregate	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Gabions	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Gabions	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Hand-Placed Riprap	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Machine-Placed Riprap	CY [m^3]	0.1 ft [0.05 m]	CY [m^3]
Wire-Encl Riprap	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]

511.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for erosion control geotextile in accordance with Section 217, Geotextiles.

SECTION 512
Expansion Joints

512.1 DESCRIPTION

1 This section describes the requirements for the installation of expansion joints.

512.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Compressed Joint Material	807.6
Preformed Elastomeric Compression Joint Seal	807.5

2 Provide adhesive for installing compressed joint material and sealant for the splices as recommended by the joint material supplier. Provide lubricant adhesive for installing elastomeric compression joint seals as recommended by the joint seal supplier.

512.3 EQUIPMENT—Vacant

512.4 CONSTRUCTION

512.4.1 General

1 At least 14 calendar days before installation, give the engineer the manufacturer's written recommendations for joint installation. Do not install joint material before obtaining the engineer's approval of the prepared surface, depth, width, and alignment. Ensure the presence of a technical representative of the expansion joint material's supplier during initial installation of at least one complete joint.

2 Form the joints in the concrete to provide true, vertical sides with no projections. Remove irregularities in the joint faces that would prevent full contact of the joint material. Do not allow joint width to vary from specified dimensions by more than 12½ percent, measured perpendicular to the joint. Protect joints from damage until completion of all work on the structure.

3 After the concrete has cured and immediately before installing the joint, clean the concrete surfaces of the joint thoroughly, removing all foreign matter including grease, oil, and curing compound.

4 Ensure that the completed installation provides a watertight seal.

512.4.2 Compressed Joint Material

1 Provide compressed joint material for the specified depth and gap size. When required, coat joint contact surfaces with adhesive, in accordance with the manufacturer's recommendations. Install material at an air temperature from 45 ºF [7 ºC] to 85 ºF [30 ºC]. Uniformly recess the top of the material ¼ in [6 mm] below the top of the concrete. Ensure that splices are vertical and beveled 45 degrees horizontally. Place sealant in the splice before butting the pieces.

512.4.3 Elastomeric Compression Joint Seal

1 Install elastomeric compression joint seal in a compressed state, without stretching. Seal each joint with one continuous length of seal.

512.5 MEASUREMENT and PAYMENT

1 The engineer will measure Compressed Joint Material and Elastomeric Comp Joint Seal by the foot [meter], along the centerline of the joint, including curb and gutter sections.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Compressed Joint Material	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Elastomeric Comp Joint Seal	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

SECTION 513
Structural Concrete

513.1 DESCRIPTION

1 This section describes the requirements for furnishing and placing portland cement concrete for bridges, culverts, and other cast-in-place reinforced concrete structures.

513.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Curing Materials	802.1
Evaporation Retardant	802.2
Fly Ash	801.2
Grout	819.1
Hardware Cloth for Drains	808.4.2
Joint Fillers and Sealers	807
Portland Cement	801.1
Water	814.1

2 Provide concrete consisting of portland cement, water, fine aggregate, coarse aggregate, and approved additives proportioned and mixed as specified or approved.

3 For the wearing surfaces of bridge decks, provide type 2, white-pigmented impervious curing compound. Elsewhere, provide and use type 1, clear or translucent.

4 Fabricate stay-in-place forms that will be exposed in the finished structure, including corrugated sheets spanning supports, closures, and accessories, from hot-dipped galvanized steel in accordance with ASTM Specification A 653 Grade 50 with a minimum coating class of G165.

513.3 EQUIPMENT

513.3.1 Batch Plant

1 Use a batch plant equipped with scales, bins, and weighing hopper as follows:

1. With beam, springless-dial, or electronic scales equipped and graduated to enable the accurate determination of the weight [mass] of each material. Ensure that poises can be secured in any position.

2. With a cover and vents on the weigh hopper to control dust during operation. Ensure that the discharge chute is not suspended from the weigh hopper or arranged so that cement or fly ash lodges or leaks from the hopper.

3. With a means to measure water, either by a meter certified in accordance with Section 209, Watering, using a calibrated measuring tank, or by weight [mass] on approved scales.

4. With a calibrated dispenser to the waterline and equipped with a manually-operated shutoff valve for introducing air-entraining agents into the mix.

2 Batch plants may be equipped to proportion aggregates and bulk cement by automatic weighing devices of an approved type.

513.3.2 Mixers

1 Provide stationary or truck mixers that are the revolving-drum or revolving-blade type, and operate them uniformly at the manufacturer's recommended mixing speed. Before use, obtain a copy of the manufacturer's operating guide showing dimensions and arrangements of blades in reference to the original height and depth. Do not use equipment or components made of aluminum or magnesium alloys that will come in contact with concrete during mixing, transporting, or pumping.

2 Equip mixers with adequate water storage and a meter for accurately measuring and controlling water used in each batch.

3 Equip stationary mixers with an automatic timing device that can be locked. Interlock the timing device and discharge mechanism to prevent discharging any part of the batch until the specified mixing time has elapsed.

4 If used, ensure the provision of revolving-drum truck mixers that are watertight and capable of distributing materials uniformly. Equip with electrically- or mechanically-actuated, continuous-registering, accurate revolution counters mounted so that the dial can be easily read.

513.3.3 Placing and Finishing Equipment

1 Do not use aluminum equipment for placing concrete. Provide internal, high-frequency vibrators that produce at least 7000 pulses per minute.

2 Provide tremies consisting of a watertight tube with a hopper at the top and a minimum diameter of 10 in [250 mm]. Equip the tube with a device to prevent water from entering while the tube charges with concrete. Support the tremie to allow free movement of the discharge end and to allow rapid lowering, when necessary to slow or stop the flow of concrete.

3 Provide concrete pumping equipment of adequate capacity for the work and pumps that produce a continuous stream of concrete without causing air pockets.

4 Provide a finishing-machine that complies with the following:

1. Is self-propelled, capable of forward and reverse travel under positive control, and equipped for raising screeds to clear the screeded surface when traveling in reverse.
2. Is equipped with at least two finishing devices for consolidating the concrete, one of which is a pan-type vibrator and the other a device with two or more rotating cylindrical drums at least 4 ft [1.2 m] long. Ensure that the vibration frequency of the devices is variable, with positive control from 3000 to 6000 vpm, and that both devices have positive control of the vertical position.
3. Is capable of finishing the surface to within 12 in [300 mm] of the placement edges.
4. Travels on supporting (screed) rails that do not deflect under the weight of the machine and can be removed without damaging new concrete.

5 Provide two portable, lightweight work bridges for touch-up work and surface texturing behind the finishing machine.

6 For a tine finish, provide a metal tining device with 4-inch to 6-inch [100 mm to 150 mm] steel tines approximately $^1/_{32}$ in [1 mm] thick and $^3/_{32}$ in [3 mm] wide, on ¾-inch [19 mm] centers.

513.3.4 Grinding Equipment

1 For corrective grinding, provide a diamond-saw cutting machine capable of cutting through mortar and aggregate without breaking or dislodging aggregate particles.

513.4 CONSTRUCTION

513.4.1 General

1 Notify the engineer at least 24 hours before placing concrete. The engineer will hold a prepour conference before the placement of concrete bridge decks and as otherwise deemed necessary.

513.4.2 Weather Limitations

1 Heat the water, aggregates, or both when air temperatures are at or below 35 ºF [2 ºC]. Provide heated enclosures during curing when the air temperature is at or below 35 ºF [2 ºC]. Maintain the concrete surface at a minimum temperature of 60 ºF [15 ºC] for at least 72 hours after placing and at 40 ºF [5 ºC] or higher for the remainder of the 7-calendar day curing period.

2 Ensure that concrete delivered in air temperatures below 40 ºF [5 ºC] arrives at the project at a temperature from 60 ºF [15 ºC] to 90 ºF [30 ºC].

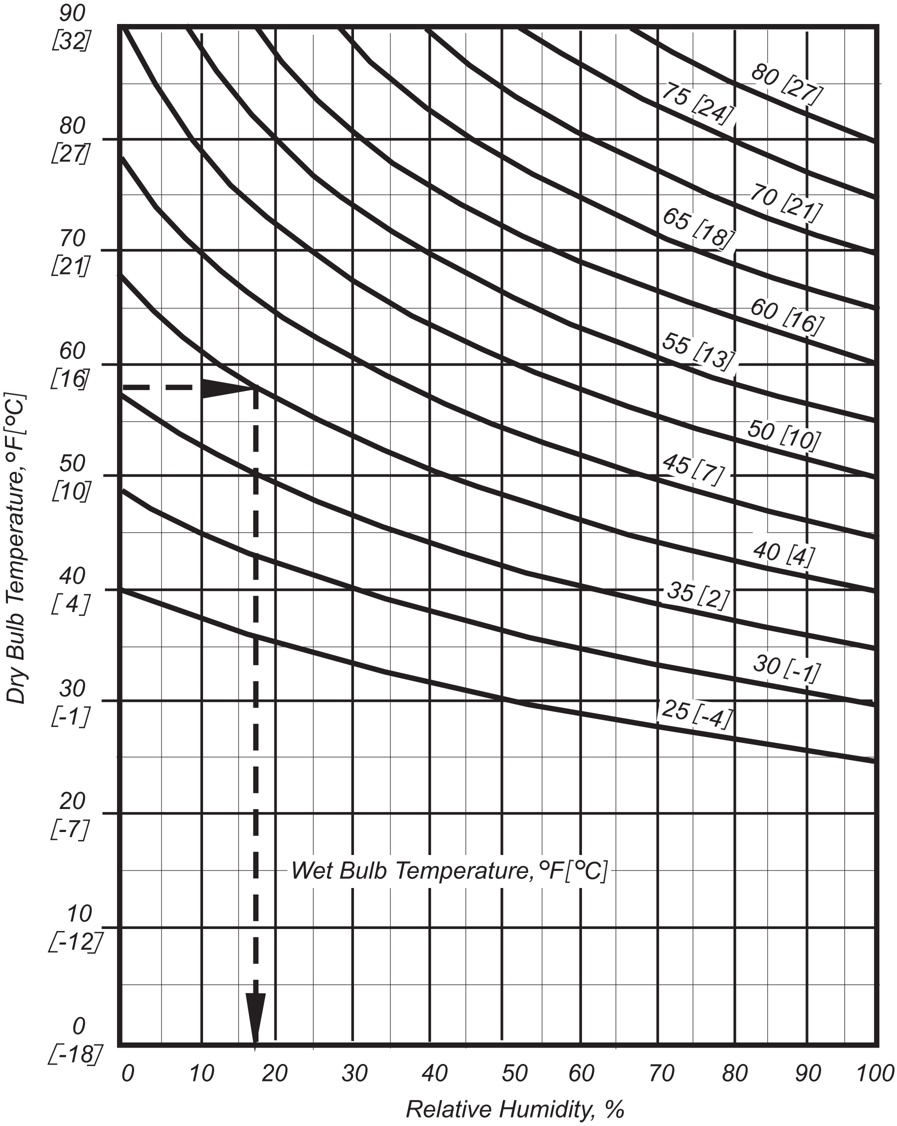
3 Heat aggregates, water, or both to a temperature from 70 ºF [20 ºC] to 150 ºF [65 ºC]. Heat aggregates by steam or dry heat and ensure that they are free of frozen lumps, ice, and snow. Do not use equipment or methods that alter or prevent air entrainment or produce hot spots in the aggregate.

4 Do not place concrete against frozen ground or in contact with materials having a temperature less than 35 ºF [2 ºC]. If necessary, heat items such as forms, reinforcing steel, adjacent concrete, and foundation materials to above 35 ºF [2 ºC] before placing concrete. During placement, keep delivery chutes or buckets at or above 35 ºF [2 ºC]. Remove and replace concrete damaged by frost or over-heating at no additional cost to the department.

5 The department will use the critical rate of evaporation as a limiting factor for the placement of concrete on bridge decks during hot weather. Do not start work if the evaporation rate is greater than 0.2 lb/ft^2/h [1 kg/m^2/h]. Stop placing concrete if the evaporation rate rises above 0.2 lb /ft^2/h [1 kg/m^2/h], or take action to reduce evaporation, such as by providing shade, using ice or other cooling methods in the concrete mix, and providing wind barriers.

6 The engineer will determine the deck surface evaporation rate from Figure 513.4.2-2, Evaporation Nomograph, by measuring relative humidity near the deck, wind velocity, air temperature, and concrete deck temperature (concrete mix temperature). The engineer will determine the relative humidity from Figure 513.4.2-1, Relative Humidity, using the wet-bulb and dry-bulb temperatures. Discuss cold or hot weather operations at the prepour conference.

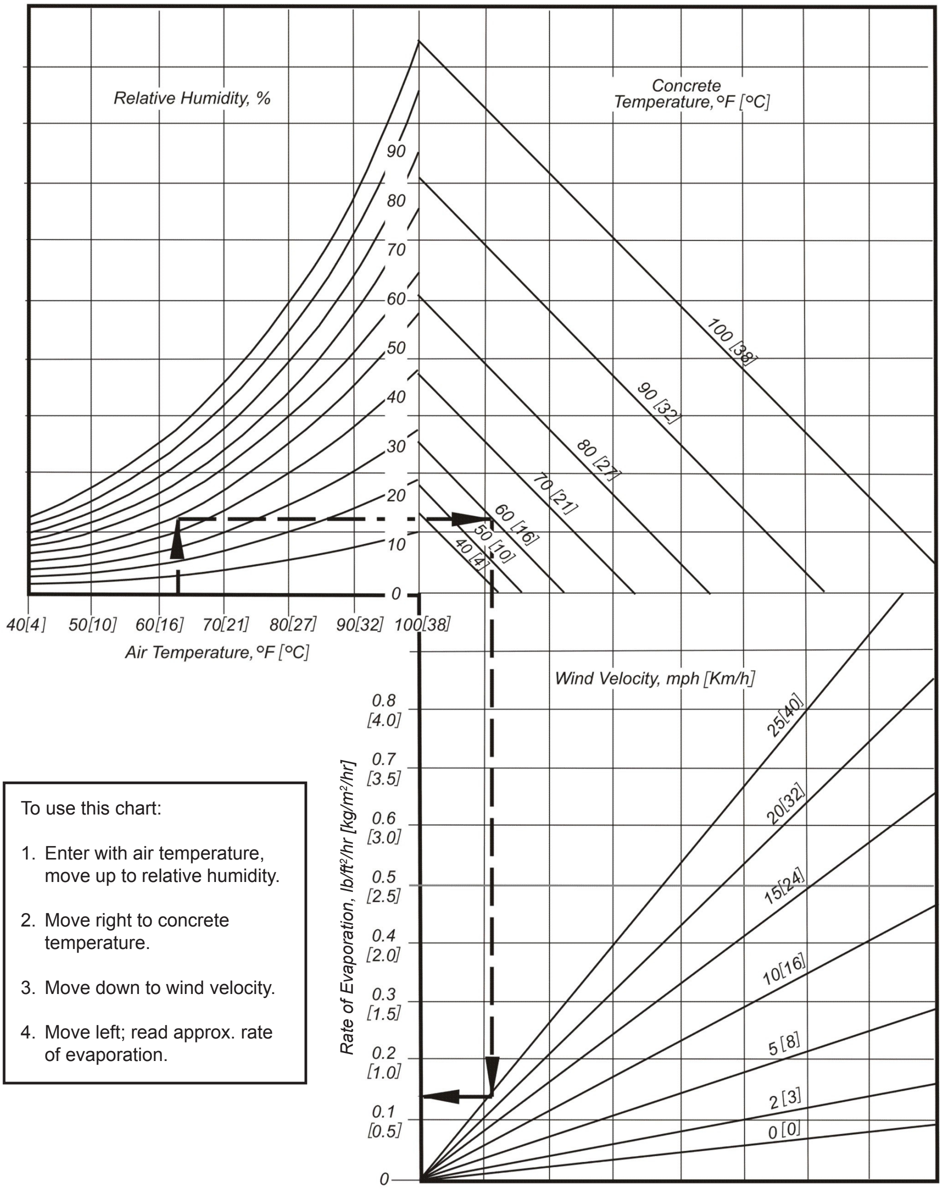
Figure 513.4.2-1
Relative Humidity



To use this Chart:

1. Enter with dry bulb temperature, move right to wet bulb temperature.
2. Move down; read approx. Relative humidity.

Figure 513.4.2-2
Evaporation Nomograph



To use this chart:

1. Enter with air temperature, move up to relative humidity.
2. Move right to concrete temperature.
3. Move down to wind velocity.
4. Move left; read approx. rate of evaporation.

513.4.3 Shipping and Storage

1 Protect cement from moisture damage. Store cement of different brands, type, or from different mills separately. Deliver portland cement and fly ash, unless provided as a blended cement, separately, and store them separately at the plant site location.

513.4.4 Mix Design

1 At least 30 calendar days before concrete production, send a mix design request to the Materials Program that includes the following:

1. Samples of the actual materials to be used, in the minimum quantities indicated:
    - 1.1. 50 lb [20 kg] of fly ash;
    - 1.2. 140 lb [60 kg] of portland cement;
    - 1.3. 400 lb [180 kg] of fine aggregate;
    - 1.4. 600 lb [270 kg] of coarse aggregate; and
    - 1.5. 1 pt [0.5 L] of each admixture.
2. The procedure and sequence for adding each ingredient to the batch.

2 The Materials Program will complete two mix designs per class of structural concrete at no cost to the contractor; however, the contractor will be charged $1,500 for each additional mix design requested.

3 For the specified class of concrete (use class A or B when not specified), supply structural concrete in accordance with Table 513.4.4-1, Concrete Class Table.

Table 513.4.4-1
Concrete Class Table

Parameter		Class		
		A	B	S
Ultimate Design Strength—f'_c @ 28 d (psi [MPa])		3750 [26]	3250 [23]	3750 [26]
Min. Cement Content (lb/yd^3 [kg/m^3])		611 [362]	564 [335]	611 [362]
Max. Water : Cement Ratio		0.45	0.45	0.45
Max. Water: (Cement + Fly Ash) Ratio	1.00 : 1.0(1)	0.45	0.45	0.45
	1.33 : 1.0(1)	0.43	0.43	0.43
Percent Entrained Air Content—Range		4.5 - 7.5	4.5 - 7.5	4.5 - 7.5
Consistency—Max. Slump (in [mm])(2)		6 [150]	6 [150]	6 [150]
Percent Fine Aggregate(3)		41 ± 3	41 ± 3	41 ± 3

(1) Fly ash to cement replacement ratio.

(2) Ensure that concrete with slump greater than 4 in [100 mm] contains a water-reducing admixture.

(3) Percent by weight [mass] of the total aggregate.

4 For the class specified, the Materials Program will determine the material proportions to be used for producing a workable mix within the specified consistency and proportions of ingredients shown in Table 513.4.4-1, Concrete Class Table.

5 Fly ash may be substituted for portland cement to a maximum of 20 percent by weight [mass] at a 1:1 replacement ratio, when approved by the Materials Program, based on a satisfactory trial mix. Use a fly ash-to-cement replacement ratio of 1.33:1 for fly ash with a calcium oxide content of less than 20 percent. Do not allow the total combined weight [mass] of portland cement and fly ash to vary more than 1 percent from the approved trial mix.

6 Do not change the material source, properties, or gradation specification without the engineer's approval. Do not work with changed or new materials until the engineer has determined and designated an appropriate mix design based on the new or altered materials, including cement, fly ash, and admixtures.

513.4.5 Forms

513.4.5.1 General

1 Use forms that are sufficiently rigid to prevent distortion from concrete pressure and other loads incidental to construction, including vibration. Construct and maintain forms mortar-tight and to prevent joints from opening. Ensure that forms produce smooth, even concrete surfaces in proper alignment. Keep forms free of dents and their surfaces free from foreign matter.

2 Clean previously used forms of all foreign material. Maintain the shape, strength, rigidity, water-tightness, and surface smoothness of reused forms.

3 Remove forms from inside box girders and clear of loose debris.

4 Use plywood or a similar product for forming exposed concrete surfaces. Chamfer corner angles measuring less than 120 degrees that will be exposed in the finished structure with a 1-inch [25 mm] triangular strip.

5 Countersink bolt and rivet heads on the inside of forms. Use clamps, pins, or other connecting devices designed to hold the forms rigidly together and allow removal without damaging the concrete.

6 To prevent the adherence of concrete, treat forms with a form-release agent before placing reinforcement, or saturate untreated wood forms with water immediately before concrete placement. Do not use agents that will adhere to or discolor concrete.

513.4.5.2 Stay-in-Place Forms

513.4.5.2.1 General

1 The department will allow the use of stay-in-place slab forms for bridge deck construction; however, the department will not pay for any increase in the quantity of concrete due to such use.

2 Store stay-in-place forms above the ground surface and, to facilitate drainage, at an angle of at least 5 degrees from horizontal. Protect forms from moisture.

513.4.5.2.2 Design and Shop Drawings

1 Design stay-in-place forms and angle supports to support the dead load of the form, reinforcing steel and concrete, and an additional 50 lb/ft² [2.4 kPa] for construction live load. Ensure a unit working stress in the steel sheet of less than 0.725 times the specified minimum yield strength of the material furnished or 36,000 psi [248 MPa], whichever is less. Compute physical design properties in accordance with the latest published edition of *American Iron and Steel Institute Specification for the Design of Cold-Formed Steel Structural Members*. Ensure a maximum dead load deflection of forms supporting slabs no greater than $^1/_{180}$ of the span or ½ in [12 mm], whichever is less. Ensure a distance from the face of stay-in-place forms to the face of reinforcing steel of at least 1 in [25 mm].

2 Submit shop drawings to the State Bridge Engineer, in accordance with Subsection 105.2, Working Drawings. Ensure that the stay-in-place form fabricator verifies the appropriate girder dimensions with the girder fabricator before providing shop drawings so that the drawings are representative of actual girder dimensions.

513.4.5.2.3 Stay-in-Place Form Installation

1 Attach stay-in-place forms to concrete girders by welding or bolting to cast-in anchors. Ensure that the form fabricator supplies the anchors to the girder fabricator.

2 Use attachment devices from the form fabricator to attach stay-in-place forms to steel-girder bridge superstructures; do not weld or bolt.

3 When required, perform cutting with a saw, gas torch, or shears.

4 Repair galvanized coating damaged during fabrication, shipping, storage, or installation of stay-in-place forms in accordance with Subsection 501.4.2.9, Repair of Galvanizing.

5 Place concrete in accordance with Subsection 513.4.11, Placing Concrete. Do not dump concrete near laps in forming, at mid-span of corrugated sheets, or in any manner causing excessive concentrated construction loads.

6 When required by the engineer, remove sections of stay-in-place forms to examine concrete surfaces for cavities, honeycombing, and other defects. If defects are found, repair them or replace the concrete, as approved by the engineer. The department does not require the replacement of removed forms; however, repair adjacent forms to present a neat appearance and ensure their satisfactory retention.

513.4.6 Falsework

1 Build falsework on a firm foundation and strong enough to carry the superimposed load without excessive deflection, settlement, or stress. Design falsework to allow for normal settlement so that the final position of the parts of the structure will meet specified dimensions and elevations. Leave falsework in place during placement of the entire superstructure, except curbs. Remove supports so as to allow the concrete to uniformly and gradually take the stresses of its own weight [mass]. Remove falsework piling to at least 24 in [600 mm] below the original ground or finished surface, whichever is lower. Remove and replace any part of the structure damaged or not true to line and grade because of sag, settlement, or failure of the falsework, at no additional cost to the department.

513.4.7 Deck Drains, Weep Holes, and Eye Bolts

1 If specified, install deck drains along the front face of the curb. If specified, provide and install structural steel drains in accordance with Section 501, Structural Steel.

2 Provide and install weep holes in abutment walls, wingwalls, and retaining walls, as specified.

3 When specified for attaching fence to box culverts and bridges, anchor eye bolts in the concrete.

513.4.8 Batching

1 Measure and batch materials at a batch plant. Control the weight [mass] of individual aggregates and admixtures to within 1 percent of requirements.

1. **Cement and Fly Ash.** Use sacked or bulk cement. Do not use fractions of a sack unless the fractional weight [mass] is known. Do not use cement damaged by moisture. Weigh bulk cement and fly ash on approved scales in accordance with Subsection 109.1.4, Weighing Procedures and Equipment.

2. **Aggregates.** Handle and deliver aggregates to the batch plant without segregation. Do not use segregated aggregates or those mixed with earth or foreign material.

Stockpile or bin aggregates that have been washed, produced, or handled hydraulically to drain at least 12 hours before batching. The department will accept rail shipment lasting more than 12 hours as adequate binning if the cars allow free drainage. The department may require longer storage if aggregates have a high or nonuniform moisture content.

3. **Air-Entraining and Other Admixtures.** Store air-entraining admixtures in sealed containers, and protect them from freezing. Before use, mix the admixture thoroughly with a mechanical stirring device. Except as indicated below, introduce air-entraining admixtures with a calibrated dispenser into the stream of mixing water. Fully discharge the required quantity before all the mixing water has entered the drum.

   Add air-entraining and other approved admixtures to the concrete mix separately and do not intermingle them before entering the concrete batch. Before adding admixtures other than those for air-entraining, obtain the engineer's approval for the proposed methods and equipment.

513.4.9 Mixing and Delivery

513.4.9.1 General

1 Use a concrete plant with sufficient capacity and hauling vehicles to ensure continuous concrete delivery at the rate required for uninterrupted placement and without allowing intervals between batches longer than 20 minutes.

2 Mix and deliver concrete to the site by one of the following:

1. Mix completely in a central plant and transport to the point of delivery in truck agitators.
2. Mix partially in a central plant and complete mixing in a truck mixer.
3. Mix completely in a truck mixer.

3 Clean mixers to prevent build-up of materials. Repair or replace the pick-up and throw-over blades in the drums when worn 1 in [25 mm] or more. Repair or replace mixers and agitators with accumulated hard concrete or worn blades. When blade wear or mixing uniformity is questionable, the engineer will take consistency tests. If the measured consistency falls outside limits specified, do not use the concrete, and repair or replace the mixing unit. The engineer will conduct uniformity tests for mixing time or mix consistency in accordance with AASHTO M 157.

4 Use a mixer drum speed in accordance with the manufacturer's plant operating directions. Do not mix a volume of concrete greater than the mixer's rated capacity or greater than the amount needed for immediate use. Do not use concrete that has developed an initial set or retemper concrete by adding water or additives.

5 Empty the mixer, including rinse water, at the plant in view of the engineer before charging a batch of concrete.

6 Before charging the mixer, wet the inside of the drum thoroughly and eject free water. Charge the batch into the mixer so that some water enters before the cement and aggregates. If approved, a portion of the mixing water may be withheld from the batch materials in order to adjust the consistency of concrete at the placement site. Charge into the drum the water that is used in batching within the first one-quarter of the specified mixing time. Batch and charge cement into the mixer with no loss of cement.

7 Ensure that concrete is homogeneous and mixed thoroughly with no evidence of lumps or undispersed cement. Mix admixtures uniformly throughout the batch.

8 When the concrete temperature is from 50 ºF [10 ºC] to 70 ºF [21 ºC], place within 90 minutes of introducing the cement to the aggregates or water. For each one degree increase in concrete temperature above 70 ºF [21 ºC], reduce the 90-minute placing time by 2 minutes [4 minutes for one degree Celsius]. Other conditions that speed the stiffening of the concrete may warrant shortening the placing time to 45 minutes or less.

9 Ensure that the mixed concrete temperature immediately before placing is from 50 ºF [10 ºC] to 90 ºF [32 ºC]. If ice is used as part of the mixing water, do not discharge concrete from the mixer until the ice melts.

513.4.9.2 Mixing Time

1. **Central Mixers.** The department defines mixing time as beginning when all dry materials are in the drum and ending with the start of the discharge. For central mixers with a capacity of 10 yd^3 [8 m^3] or less, mix for at least 60 seconds. For larger mixers, mix for the time recommended by the mixer manufacturer.

2. **Truck Mixers.** Mix each batch of concrete from 70 to 100 revolutions of the drum or blades, at the manufacturer's recommended mixing speed. At the plant, mix in the presence of the engineer, and record the number of revolutions at mixing speed on the concrete batch ticket. Actuate the revolution counter after all materials, including mixing water, are in the mixer drum. After mixing, rotate the drum at the agitating speed recommended by the manufacturer. Do not exceed a total of 300 revolutions.

1 Adjust mixing time as necessary to obtain a uniform mix.

513.4.9.3 Transporting

1 Transport mixed concrete in truck agitators or mixers operating at the agitating speed designated by the manufacturer. Provide mixed concrete at the delivery point suitable for placement and meeting specified requirements.

2 Deliver each load of concrete with an accompanying department-furnished "Concrete Batch Ticket" (Form E-117) or with a computer-generated ticket providing the same information.

513.4.9.4 On-Site Mix Adjustment

1 Do not add mixing water to the concrete while hauling; if necessary to increase the slump, add remaining mixing water at the placement site. Accurately meter added water. Do not exceed the allowable ratios of water-to-cement or water-to-cement-plus-fly-ash specified in Table 513.4.4-1, Concrete Class Table. If water is added on-site, use up to 30 additional mixing revolutions, if necessary.

2 The engineer may approve the use of on-site admixtures for slump and air enhancement; if used, mix additionally in accordance with the admixture manufacturer's recommendations.

3 Do not make more than two on-site mix adjustments, defined as the addition of water or an on-site admixture. Do not redose partial loads. Adjust the mix on-site while the concrete is plastic and within 45 minutes of starting the initial mixing. Do not add water or other materials to concrete that has started to set.

513.4.10 Testing

1 The engineer may test for consistency of individual loads at approximately the beginning, midpoint, and end of the load. If slump tests on any one load vary by more than 1½ in [38 mm], do not use the mixer until the condition is corrected.

2 The engineer will take concrete samples for slump and air content tests at the outlet of the mixer truck. For pumped concrete, slump and compressive strength samples will be taken either after pumping and before screeding or before pumping. Air content samples for pumped concrete will be taken after pumping and before screeding. Samples represent the entire batch.

513.4.11 Placing Concrete

513.4.11.1 General

1 Place concrete after forms and reinforcing steel have been checked, with the engineer present, after forms have been cleaned, and immediately after wetting surfaces on which concrete will be placed.

2 Place unsegregated concrete without displacing reinforcement. Do not deposit a large quantity at any point and run, work, or drop concrete into or along forms for a distance of more than 5 ft [1.5 m], unless confined by closed chutes or pipes. Fill forms by depositing concrete as near final position as possible. Work coarse aggregate back from the forms and around reinforcement without displacing the bars. After the concrete obtains initial set, do not jar forms or place stress on reinforcing steel.

3 Incline chutes to allow the free flow of concrete. Do not add water to concrete to promote flow in chutes.

4 When the air temperature exceeds 90 ºF [32 ºC], cool the forms, reinforcing steel, steel beam flanges, and other surfaces contacting the concrete mix, with a water spray.

5 Place concrete continuously in each section of the work to complete integral placements. Place and consolidate concrete in horizontal layers no deeper than 18 in [450 mm] for beams and slabs or 30 in [750 mm] for footings, walls, or columns. Place layers before the previous layer obtains an initial set. Do not taper the ends of layers; place with nearly square ends and level tops. Consolidate each layer to prevent separation planes between layers.

6 Consolidate the external surface of concrete during placement with spading tools and vibrators. Place concrete so as to force coarse aggregate from the surface and bring mortar against the forms producing a dry, smooth finish, without air pockets or honeycombs.

7 For pumped concrete, arrange equipment to protect fresh concrete from vibrations. After pumping, discharge remaining concrete in the pipeline without contamination or segregation. When using a pump for placements, such as decks or structural girders, have backup placement equipment on-site.

8 Keep chutes, troughs, and pipes clean by flushing with water after each run. Discharge flushing water away from the placed concrete.

513.4.11.2 Consolidation

1 Consolidate concrete with mechanical vibrators operating in the concrete; supplement by hand spading as necessary. Provide at least two vibrators at the site when placing more than 10 yd^3 [8 m^3] of concrete. Work the concrete around the reinforcement and embedded fixtures and into form corners and angles. Do not use vibrators to flow or run concrete into position. Vibrate long enough to compact but do not cause segregation.

2 Insert the vibrator vertically with a distance between insertions of approximately 1½ times the radius of influence, defined as the area visibly affected by the vibrator. Overlap adjacent radii of influence by approximately 2 in [50 mm]. With the vibrator, penetrate rapidly to the bottom of the layer and hold in place from 5 to 15 seconds. Stop vibrating in one location when large aggregate is embedded and escaping air bubbles stop appearing.

513.4.11.3 Joints

1 Locate construction joints as specified or approved by the engineer. For an emergency joint, form a keyway or insert dowel bars to provide adequate bond across the joint.

2 Rough-float horizontal joints to consolidate the concrete surface; do not key. When placing new concrete on the joint, draw the forms tight against existing concrete. Clean the joint surface of foreign matter with wire brushes, brooms, or sand-blasting, and wet immediately before placing concrete.

3 Key vertical joints; form with oiled, beveled timber.

4 Do not make joints with concrete sloping to a thin feathered edge. Use bulkheads for nonhorizontal joints and for horizontal joints that would otherwise lead to a feathered edge in the next layer. Form such joints with a temporary bulkhead so that the next layer will end in a body of concrete at least 6 in [150 mm] thick.

5 Sandblast construction joints at the tops and bottoms of T-girder stems, box girder webs, and box culvert side walls to remove foreign matter, including laitance and curing compound, and to expose clean aggregate. Sandblast or otherwise clean openings for joint materials before placement to ensure proper bonding with concrete. Let joints dry before placing joint material.

513.4.11.4 Grout Work

1 Clean areas to be grouted of material that would prevent bonding of mortar and concrete; keep the areas wet for at least 24 hours immediately before grouting. Fill completely and pack grout into recesses and holes on surfaces, under structural members, and at other locations specified. Ensure that locations where grout could escape are mortar-tight before placing. For at least three calendar days after placement, cure grout surfaces by the water method and keep free of loads. Remove and replace improperly cured or otherwise defective grout at no additional cost to the department.

513.4.11.5 Footings

1 When approved by the engineer, forms may be omitted on sides of concrete footings not exposed in the finished structure; if doing so, place concrete directly against the sides of the footing excavation.

2 Below specified footings, use concrete subfootings of the same class and placed monolithically with the footings. For subfootings thicker than 12 in [300 mm], step out beyond the edges of the specified footings by half the depth of the subfooting.

513.4.11.6 Cofferdam Seals

1 If excavations cannot be dewatered before placing concrete, construct an underwater concrete cofferdam seal at least 24 in [600 mm] thick from concrete containing 25 percent extra cement. Do not build the top of the seal higher than the specified bottom of the footing. Place the concrete in a compact mass, in its final position, using a tremie. Maintain still water at the point of deposit, and use watertight cofferdam forms. Do not place concrete other than that for cofferdam seals underwater. Fill the tremie by a method that prevents washing of the concrete. Submerge the discharge end completely in concrete to prevent water entry. With a batch in the hopper, start the flow of concrete by slightly raising the discharge end but still keeping it submerged in deposited concrete. Continue the flow until completion of a monolithic, homogeneous seal.

2 Cure the concrete at least five calendar days before dewatering. Increase the time if the seal is to withstand hydrostatic pressure and the seal has been placed in water less than 45 ºF [7 ºC]. Exclude from the counted curing time periods when water temperature is continuously below 40 ºF [5 ºC]. Take concrete test cylinders and cure in similar conditions to determine strength. After sufficient time to ensure adequate seal strength, dewater the cofferdam, and clean the concrete top of scum, laitance, and sediment.

513.4.12 Finishing Concrete Surfaces

513.4.12.1 Finish Types

1. **Ordinary Finish.** Give formed concrete surfaces an ordinary surface finish immediately after form removal. Finish horizontal surfaces while concrete is plastic.

   Do not add water to concrete surfaces for finishing operations. If approved by the engineer and applied in accordance with the manufacturer's recommendations, a commercial evaporation retardant may be used.

   Remove fins and irregular projections from exposed surfaces. Clean cavities and other defects thoroughly, saturate with water, and carefully point and true with a mortar of cement and fine aggregate mixed in the proportions of the concrete being finished. Use mortar for pointing within 30 minutes of mixing. Use commercial patching mixtures only when approved by the engineer. Cure patches in accordance with Subsection 513.4.13, Curing Concrete. Tool construction and expansion joints in completed work, and free from mortar and concrete.

2. **Rubbed Finish.** Keep concrete to receive a rubbed finish saturated with water. Ensure the mortar used in pointing is set before wetting. Rub surfaces with a medium-coarse carborundum stone faced with a small quantity of mortar composed of cement and fine sand mixed in proportions of the concrete being finished. Rub until form marks, projections, and irregularities have been removed; all voids are filled; and a uniform surface is obtained. Leave the paste produced by rubbing. After placing concrete above the treated surface, obtain the final finish by rubbing with a fine carborundum stone and water until the entire surface is smooth and uniform in color. After final rubbing, and when the surface is dry, rub with burlap to remove loose powder.

3. **Float Finish.** Obtain a float finish for horizontal surfaces by placing an excess of material in the form and removing or striking off the excess with a template, forcing coarse aggregate below the mortar surface without creating a concave surface. After striking-off, work and float the surface with a floating tool. Do not use aluminum floats. Before the finish sets, remove the surface cement film with a fine brush, leaving a fine-grained, smooth, sanded texture.

513.4.12.2 Finishing Bridge Decks

513.4.12.2.1 General

1 Finish bridge decks with a deck finishing machine on rails. Use hand tools only where necessary. Set up finishing machines 24 hours before use to allow inspection by the engineer in daylight before each placement.

2 Before placing concrete, and under the engineer's inspection, verify the adjustment and operation of deck finishing machines by moving the machine over the full length of the deck section and traversing the float completely across end bulkheads. Check the specified cover over reinforcing steel and make necessary adjustments.

3 The engineer will randomly check the depth of fresh concrete immediately behind the screed and over reinforcing steel across the full width and length of the bridge deck. If depth checks indicate variations greater than ½ in [12 mm], take corrective action immediately, which may involve additional tie downs for reinforcing steel or adjusting screed elevations. Provide a working bridge behind the screed that can be used for depth checks.

4 Immediately after screed floating and while concrete is plastic, test the slab surface for irregularities using a 10-foot [3 m] straightedge. Hold the straightedge in successive positions parallel to the road centerline and in contact with the slab surface for the entire area of the slab. Move the straightedge in stages of no more than half its length. Correct variations immediately; fill depressions with freshly-mixed concrete or strike off projections. Consolidate and refinish corrected areas. Repeat straightedge testing and refloating until the slab surface has no deviations greater than ¼ in [6 mm].

5 After finishing the slab surface and allowing water sheen to evaporate, finish the concrete surface by dragging a seamless strip of damp burlap over the full width of the surface. Use a drag consisting of burlap layers with sufficient length in contact with the concrete to slightly groove the surface. Move the drag forward with a minimum bow of the lead edge. Keep the drag damp, clean, and free of hardened concrete particles.

513.4.12.2.2 Tine Finish

1 Immediately after the burlap drag finish, give the surface a transverse metal tine finish. Control the method and application time of the finish to avoid tearing the surface and unseating aggregate particles.

2 Produce grooves in the concrete from ⅛ in [3 mm] to $^3/_{16}$ in [5 mm] deep, at right angles to the roadway centerline on all bridges, regardless of skew. Operate the metal tine device mechanically or manually, and do not overlap passes. Other texturing equipment, such as a finned float, may be used if they produce equivalent grooves. Leave the last 12 in [300 mm] of deck next to the curbs untextured for drainage. Use an edging tool at unarmored expansion joints.

3 As approved by the engineer, remove or correct concrete without a satisfactory finish at no additional cost to the department.

513.4.12.2.3 Surface Tolerance

1 When concrete has set sufficiently to allow walking, and no later than the day after placement, the engineer will check the surface with a straightedge and mark variations in excess of ¼ inch in 10 ft [6 mm in 3 m]. Grind high spots with a diamond-saw cutting machine. Repair low spots as approved by the engineer. Grind or patch to smooth the surface. At no additional cost to the department, remove portions or all of the deck if corrective work is not satisfactory.

2 Protect concrete against damage until it obtains final set.

513.4.13 Curing Concrete

1 If forms are removed in less than five calendar days, cure concrete immediately with water or impervious compound methods after removal of forms; curing is not necessary if concrete is protected by metal or treated wooden forms for five calendar days or more. Keep untreated wood forms moist during curing period.

2 When the weather would otherwise cause concrete mixing water to evaporate rapidly, apply a fine mist to concrete surfaces until curing is complete. Alternatively, use a commercial evaporation retardant approved by the engineer and applied in accordance with the manufacturer's recommendations.

3 When using the water method, keep concrete continuously damp for at least five calendar days by applying water with an atomizing nozzle that produces a fog mist; do not direct water under pressure on the concrete or allow water to accumulate, causing concrete to flow or wash. Keep surfaces damp throughout curing, and use burlap or other covering approved by the engineer to retain moisture.

4 When using impervious curing compound, give surfaces the required surface finish before applying compound. Apply curing compounds in accordance with Table 513.4.13-1, Impervious Curing Compound Applications. During finishing, protect concrete by the water curing method. Mix compound thoroughly an hour or less before use, and apply uniformly. Apply twice, each time at a rate of 1 gal per 300 ft^2 [1 L per 7 m^2] of surface area. For concrete bridge decks and other exposed concrete, apply the first time immediately after the disappearance of free water from the surface. For formed concrete, apply immediately after removing forms. If the concrete surface is dry, spray with a fine water mist, and apply curing compound immediately after the disappearance of free water from the surface. Apply compound the second time after the first application

has set and at right angles. During curing, spray any uncovered surfaces with a fine water mist. Protect the coating against marring for at least ten calendar days after application. Recoat marred surfaces at the specified rate. Stop using compound if it leaves a streaked or blotchy appearance; cure with water until the cause of the problem is corrected.

Table 513.4.13-1
Impervious Curing Compound Applications

Application	Material
Concrete Pavement	Premium White
Approach Slabs	Premium White
Bridge Decks	Premium White
Silica Fume Concrete	Premium White
Curb and Gutter, Double Gutter	Premium White or Premium Clear
Sidewalks and Bike Paths	Premium White or Premium Clear
Median Paving	Premium White or Premium Clear
Concrete Pavement Repair	Premium White or Premium Clear
Concrete Barrier	Premium White or Premium Clear
Cast-in-Place Drainage Elements	Premium White or Premium Clear
Decorative Concrete	Premium Clear
Slope Paving	Basic
Ditch Paving	Basic
Erosion Control	Basic
Culvert Boxes	Basic
Exposed Horizontal Surfaces of Formed Structures	Basic
Surfaces Exposed After Form Removal	Basic

5 Polyethylene sheeting meeting the requirements of AASHTO M 171 may be used along with the preceding methods. Overlap sheets at least 18 in [450 mm] and extend at least 12 in [300 mm] beyond the outer edges of the concrete. Seal, weight, cover, or tie sheet edges to prevent premature removal.

6 Cure all concrete at least five calendar days. Do not use the water method in temperatures below 35 ºF [2 ºC].

7 Do not allow vehicles on any span until concrete has obtained at least 80 percent of its ultimate design compressive strength (f'_c). Do not allow loads greater than 6000 lb [2700 kg] on any span until the concrete obtains f'_c.

513.4.14 Removal of Forms and Supports

1 Do not remove structural forms until concrete is strong enough to withstand damage once forms are removed. Remove forms and supports such that concrete gradually and uniformly takes stresses due to its own weight. Remove forms by methods that do not mar, gouge, or chip concrete surfaces; overstress concrete members; or distort formwork. Leave surfaces clean and umblemished.

2 Forms and their supports may be removed and subsequent loads may be placed when both conditions of Table 513.4.14-1, Form and Support Removal and Loading of Concrete, are met, as approved by the engineer.

Table 513.4.14-1
Form and Support Removal and Loading of Concrete

Structural Element	Form and Support Removal		Subsequent Loading[3]	
	Strength of Concrete Based on % of Design Strength	Time (1), (2)	Strength of Concrete Based on % of Design Strength	Time in Days (1), (2)
Footings/Sleeper slabs	60	12 h	80	2
Drilled shafts	60	12 h	80	3
Columns/Pier Walls	60	1 d	80	3
Abutment/Sills/ Diaphragms	60	12 h	80	3
Bent Caps/Pier Caps	80	7 d	100	14
Concrete superstructures (T-beam, flat slab)	80	7 d	100	14
Bridge Decks	80	7 d	80	7
Floor and wingwall footings of box culverts	60	12 h	80	2
Walls of box culverts	60	1 d	80	3
Top slab of box culverts	80	7 d	80	7
Wingwalls / Retaining walls	60	12 h	80	3
Other vertical surfaces not carrying load	60	12 h	–	–

(1) From time of the last placement in the forms and without counting days when air temperature is below 40°F [5 °C].

(2) When using high early-strength (type III) cement, the specified time limits may be decreased as determined by the engineer and agreed upon before placing the concrete.

(3) Ensure 80 percent of design strength is attained before setting formwork and reinforcing steel or further concrete placements.

3 Without damaging the concrete, remove metal ties or anchorages within the forms to a depth of at least ½ in [12 mm] below the surface. If the engineer has allowed wire ties, cut the wires back at least ¼ in [6 mm] below the face of the concrete after removing forms. Immediately after removing forms, fill the cavities with cement mortar, and ensure the final surface is sound, smooth, even, and uniform in color.

513.5 MEASUREMENT and PAYMENT

1 The engineer will measure Class A Concrete, Class B Concrete, and Class S Concrete as one complete unit or by the cubic yard [cubic meter]. The engineer will compute volumes from the neat lines specified.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Class A Concrete	LS, CY [LS, m^3]	LS, 0.1 ft [LS, 0.5 m]	LS, 0.1 CY [LS, 0.1 m^3]
Class B Concrete	LS, CY [LS, m^3]	LS, 0.1 ft [LS, 0.5 m]	LS, 0.1 CY [LS, 0.1 m^3]
Class S Concrete	LS, CY [LS, m^3]	LS, 0.1 ft [LS, 0.5 m]	LS, 0.1 CY [LS, 0.1 m^3]

SECTION 514
Reinforcing Steel

514.1 DESCRIPTION

1 This section describes the requirements for furnishing and placing reinforcing steel.

514.2 MATERIALS

514.2.1 Reinforcing Steel

1 Provide materials in accordance with the following:

Material	Subsection
Reinforcing Steel	811.1

514.2.2 Reinforcing Steel Supports and Ties

1 When using metal supports, provide with legs curved to form a hook, with the ends at least ⅛ in [3 mm] above the form work. Protect metal supports for uncoated reinforcing steel that are in contact with the exterior surface of the concrete by galvanizing or coating with plastic or epoxy. Ensure that coatings do not chip, crack, deform, or peel. Extend protection at least ½ in [12 mm] above the form work. Apply plastic protection by dipping; ensure a minimum thickness of $^{1}/_{16}$ in [2 mm] at points of contact with form work.

2 Coat metal supports for epoxy-coated reinforcing steel completely with epoxy or plastic. Use galvanized metal supports for galvanized reinforcing steel. For coated bars, provide support legs in accordance with the dimensional and coating requirements for uncoated bars.

3 Use plastic- or epoxy-coated tie wires for epoxy-coated reinforcing steel, galvanized tie wires for galvanized reinforced steel, and stainless-steel tie wires for use with mechanical tying equipment.

514.2.3 Mechanical Reinforcing Steel Splices

1 Provide mechanical reinforcing steel splices consisting of a lap or butt splice system capable of developing at least 125 percent of the AASHTO specified

yield strength for the reinforcing steel. When epoxy coating is specified, shop- or field-coat the splice and adjacent material as necessary with epoxy in accordance with Subsection 811.1, Reinforcing Steel, or seal the splice with an approved heat-shrink plastic sleeve in accordance with the sleeve manufacturer's recommendations.

514.3 EQUIPMENT

1 Automated equipment for tying reinforcing steel may be used provided it produces ties as strong and tight as those tied by hand and does not damage coatings.

514.4 CONSTRUCTION

514.4.1 General

1 The engineer will test reinforcing steel before use. Provide two test samples 4.5 ft [1.5 m] long for each manufacturer, heat number, and size of reinforcing bar and spiral wire delivered; include a certification indicating the heat number and sizes of material.

2 The engineer may also require two flame- or saw-cut samples 4.5 ft [1.5 m] long of any grade 60 [400] bar delivered. Replace samples with splice bars from the same heat number and long enough to lap the bar from which the sample was cut, in accordance with Table 514.4.5-1, Minimum Lap Lengths for Reinforcing Steel Splices.

514.4.1.1 Coated Reinforcing Steel

1 For coated reinforcing steel, use green epoxy-coated or galvanized reinforcing steel. Use only one type of coating on a project.

2 Handle, ship, store, and place coated reinforcing steel without damage to the coating. Use handling and bundling systems that are padded. To prevent bar-to-bar abrasion, use a strongback, multiple supports, or platform bridge to minimize sagging. Do not drop or drag bars or bundles. Store bars above the ground on wooden or padded supports.

3 Ensure that epoxy coatings damaged during fabrication are repaired before shipping. Before installation, regardless of source or cause, clean and repair damaged epoxy coatings with patching material in accordance with Subsection 811.1, Reinforcing Steel. Repair galvanized surfaces in accordance with Subsection 501.4.2.9, Repair of Galvanizing.

4 Replace the bar if more than 2 percent of its surface area is damaged.

514.4.2 Reinforcing Steel Order Lists

1 Unless the contract includes a bar list with bending diagrams, submit (on 8½ in × 11 in [210 mm × 297 mm] paper) order lists for reinforcing steel. Include all data necessary for complete fabrication and supply. For each structural unit, abutment, bent, or slab, detail the reinforcing steel, and include a complete list of bars. Do not combine lists. Indicate the name of the structure, route, station, project number, and drawing number, when applicable.

2 Before fabricating, ensure that the supplier submits two sets of complete advance order lists for each structure to the State Bridge Engineer for approval and notifies the engineer of this submittal. The State Bridge Engineer will return one set to the supplier with necessary corrections noted. Ensure that the supplier furnishes seven corrected sets of the order lists to the State Bridge Engineer, each marked “Final.” If these sets are correct, one set will be returned to the supplier to begin fabrication. Do not fabricate before obtaining the State Bridge Engineer’s approval.

3 On the final order lists and in the transmittal letter, clearly identify changes made between the advance and the final lists, other than those requested by the engineer. Do not then change size, dimensions, or material from those shown on the final order lists without the engineer’s written approval.

4 The department’s approval of an order list is an acceptance of the character and sufficiency of the list and does not relieve the contractor of responsibility for errors or omissions. Make changes to comply with the contract at no additional cost to the department.

514.4.3 Protection of Materials

1 Protect reinforcing steel from damage; ensure steel is free from dirt, detrimental scale, paint, oil or other foreign substances. Tight surface rust may remain; however, remove loose rust scale. Replace steel so rusted that it would impair bonding. Remove cement mortar adhering to exposed steel due to previous placement.

514.4.4 Bending

1 Cold bend reinforcing bars. Do not field-bend bars partially embedded in concrete. Cut and bend steel in accordance with the *ACI Manual of Practice for Detailing Reinforced Concrete Structures*. Do not use methods producing kinks or improper bends.

2 Fabricate reinforcing steel bends and hooks in accordance with the *ACI Manual of Practice for Detailing Reinforced Concrete Structures*. Except for 135-degree and 180-degree hooks, the department specifies dimensions in bending diagrams measured out-to-out.

3 Provide and use spirals with 1½ extra turns at each end for anchorage. Provide channel spacers with each spiral to hold the spiral bar firmly in place while placing concrete. Use in accordance with Table 514.4.4-1, Channel Spacer Requirements for Spiral Reinforcing Steel.

Table 514.4.4-1
Channel Spacer Requirements for Spiral Reinforcing Steel

Core Diameter	No. of Spacers
≤ 20 in [510 mm]	2
21 in [530 mm] to 30 in [760 mm]	3
≥ 30 in [760 mm]	4
No. 5 [16] spiral bars	4

514.4.5 Placing and Fastening

514.4.5.1 General

1 Place reinforcing steel accurately; hold firmly with supports in the position specified. Tie reinforcing bars securely at all intersections using No. 16 gage [1.5 mm] or heavier wire. Where bars are spaced closer than 12 in [300 mm] in each direction, tie alternate intersections. Multiple wires with combined cross-sectional areas equal to or greater than that of a No. 16 gage [1.5 mm] may also be used. Do not fasten reinforcing steel by tack welding.

2 The department specifies spacing dimensions for reinforcing steel by referring to the centers of bars.

3 When not specified, ensure a concrete cover of 2 in [50 mm] to the face of reinforcing steel.

4 Provide reinforcing steel in the full lengths specified; do not splice except to replace test samples.

5 Overlap welded wire fabric ends and sides at at least one mesh opening and fasten with wire or other approved fasteners at intervals of 12 in [300 mm].

6 Tie bundled bars together at a maximum of 6 ft [1.8 m] centers.

7 Hold reinforcing bars in position with precast mortar blocks, ferrous metal chairs, spacers, metal hangers, plastic supports, and supporting wires capable of supporting applied loads. Do not use wooden or aluminum supports. Do not place bars on fresh concrete, adjust bars during concrete placement, or insert bars after placing concrete.

514.4.5.2 Reinforcing Steel Splices

514.4.5.2.1 Lap Splices

1 Overlap splices in accordance with Table 514.4.5-1, Minimum Lap Lengths for Reinforcing Steel Splices.

Table 514.4.5-1
Minimum Lap Lengths for Reinforcing Steel Splices

Bar Size (No.)	Lap Length	
	Uncoated Bars	Coated Bars
4 [13]	2 ft 5 in [710 mm]	2 ft 11 in [860 mm]
5 [16]	3 ft 0 in [880 mm]	3 ft 8 in [1070 mm]
6 [19]	3 ft 9 in [1070 mm]	4 ft 6 in [1300 mm]
7 [22]	5 ft 1 in [1460 mm]	6 ft 1 in [1770 mm]
8 [25]	6 ft 8 in [1930 mm]	8 ft 1 in [2340 mm]
9 [29]	8 ft 5 in [2430 mm]	10 ft 2 in [2950 mm]
10 [32]	10 ft 8 in [3090 mm]	12 ft 11 in [3750 mm]
11 [36]	13 ft 1 in [3790 mm]	15 ft 10 in [4610 mm]

2 Distribute splices well or locate at points of minimum tensile stress. Wire splice bars together rigidly. Where bars are offset from each other, wiring may be omitted if the bar ends are held in proper position, as specified. When approved by the engineer, make splices in spiral reinforcement with an overlap of 1½ turns. Do not use overlap splices on bars larger than No. 11 [36].

514.4.5.2.2 Welded Splices

1 When specified or approved by the engineer, splice reinforcing bars by welding in accordance with AASHTO/AWS D1.4, Structural Welding Code - Reinforcing, and using AASHTO/AWS E 7018 welding electrodes. Use electrodes from hermetically sealed containers within four hours of opening the container, unless stored in ovens at a temperature of at least 250 ºF [120 ºC]. Before welding, obtain department approval of the proposed procedure and welder qualifications.

2 Weld splices in accordance with the following:

1. **Splices**

   1.1. For No. 6 [19] bars and smaller, use a splice consisting of a single lap bar with double-flare, V-groove welds 6 in [150 mm] long.

1.2. For No. 6 [19] bars and smaller, when only one side is accessible for welding, use a splice consisting of two lap bars with single-flare, V-groove welds 6 in [150 mm] long.

1.3. For No. 7 [22] bars and larger, use a splice consisting of two lap bars with double-flare, V-groove welds 6 in [150 mm] long. For No. 7 [22] bars and larger, when only one side is accessible for welding, use a splice consisting of two lap bars with single-flare, V-groove welds 12 in [300 mm] long.

1.4. Use a lap bar the same size as the spliced bar.

1.5. When splicing to an existing bar embedded in concrete, expose the embedded bar for at least the required weld length plus 6 in [150 mm].

2. **Welding**

2.1. Do not weld when air temperature is below 0 ºF [-18 ºC].

2.2. Free surfaces to be welded and those adjacent from loose or thick scale, slag, rust, grease, or other foreign material that would prevent proper welding. Mill scale that withstands vigorous wire-brushing may remain. Remove epoxy coating from surfaces to be welded and those adjacent for at least 3 in [75 mm].

2.3. Do not allow gaps greater than ⅛ in [3 mm] between the bar being spliced and the lap bar. If necessary, grind deformations to achieve this gap.

2.4. Do not undercut deeper than $^1/_{16}$ in [2 mm] where welds intersect the raised pattern of deformations; elsewhere, undercut no deeper than $^1/_{32}$ in [1 mm].

2.5. Preheat bars to be welded to at least 500 ºF [260 ºC] at the cross-section of the weld area and 6 in [150 mm] on each side, as indicated by temperature-indicating crayons provided at no additional cost to the department. Cool bars naturally to air temperature after welding.

2.6. Make tack welds at least 2 in [50 mm] long, using preheat and quality requirements applicable to permanent welds. Do not make tack welds that will not become part of the permanent weld.

2.7. When welding in the vertical position, make passes upward.

2.8. Avoid arc strikes outside permanent weld areas. If they occur, grind them smooth.

2.9. Fill the cross-section of flare, V-groove welds at least flush with the bar surface.

2.10. Use welders that have been qualified beforehand in accordance with the department's welder qualification process for each position in which welds will be made.

2.11. After welding epoxy-coated bars, clean welds and adjacent uncoated areas of slag and other foreign material that would interfere with adhesion of epoxy coating, and recoat with material in accordance with Subsection 811.1, Reinforcing Steel.

514.4.5.2.3 Mechanical Splices

1 When specified or approved by the engineer, install mechanical reinforcing steel splices in accordance with manufacturer's recommendations. Expose a sufficient length of reinforcing steel to allow mechanical splicing; clean and straighten as required. Remove and replace improper splices at no additional cost to the department.

514.4.6 Deck Slab Reinforcing Steel System

1 Construct a support system to stabilize the bridge deck slab reinforcing steel mats in all directions, to prevent movement by workers placing concrete, and to support the weight [mass] of the concrete. Do not use mortar blocks, bricks, wood, or aluminum supports. At the least, support the top and bottom layers of steel in the different types of reinforcing systems as follows:

1. **Truss-Bar Type Deck Slab Reinforcement.** The truss-bar type uses a bent or "crank" reinforcing bar in the deck slab reinforcement. Support

the bottom layer of reinforcing steel with continuous, longitudinal, slab-bolster supports spaced transversely between girders. Place the first supports no more than 24 in [600 mm] from the centerline of a girder. Place one support at each bend of the crank bar. Do not place transverse supports farther than 4 ft [1.2 m] apart. Use additional supports if the distance between bends, or to a bend from the first support location of the crank bar exceeds 4 ft [1.2 m]. Support the top layer of reinforcing steel with either continuous, longitudinal, high-slab bolsters or individual high supports. Place the first supports no more than 24 in [600 mm] from the centerline of girders, with other supports placed at bends with the same limits, not exceeding 4 ft [1.2 m], as described for the bottom layer. When using individual high supports, place under a longitudinal deck reinforcing bar in a continuous row, spaced no more than 4 ft [1.2 m] apart longitudinally.

If crank bar placement leaves the top mat of reinforcing too high to provide the specified clearance, lay it over slightly.

2. **Cantilever Support for Truss-Bar Type Deck Slab Reinforcement.** Support the bottom layer of reinforcing steel for the deck cantilever with continuous, longitudinal, slab-bolster type supports. If the cantilever exceeds 24 in [600 mm] from the centerline of the exterior girder, place one support near the end of the cantilever and one midway between the centerline of the exterior girder and the cantilever deck end.

   Support the top layer of reinforcing steel with continuous, longitudinal, high-slab bolsters or individual high supports. Place the supports in the same manner as, and within the limits imposed for, the bottom layer of the cantilever. When using individual high supports, place under a longitudinal deck reinforcing bar in a continuous row, spaced no more than 4 ft [1.2 m] apart longitudinally.

3. **Independent Type Deck Slab Reinforcement.** Support the bottom layer of reinforcing steel with continuous, longitudinal, slab-bolster type supports, spaced transversely between girders. Place the first supports no more than 24 in [600 mm] from the centerline of a girder and additional supports between the first supports, spaced no more than 4 ft [1.2 m] apart.

Support the top layer of reinforcing steel of separate mats with continuous, longitudinal, high-slab bolsters; individual high supports; or continuous, transverse slab supports spaced longitudinally. Place the first supports no more than 24 in [600 mm] from the centerline of girders and other supports with the same limits, no more than 4 ft [1.2 m] apart, described for the bottom layer. When using individual high supports, place under a longitudinal deck reinforcing bar in a continuous row, spaced no more than 4 ft [1.2 m] apart longitudinally.

When using continuous transverse slab bolsters with runners, place the bolsters between the bottom and top layers of reinforcing steel, spaced no more than 4 ft [1.2 m] apart longitudinally. Secure the top and bottom layers of reinforcement together with No. 16 gage [1.5 mm] or heaver tie wire, or with multiple ties of equivalent cross-sectional area, at intervals of 4 ft [1.2 m] in each direction.

4. **Cantilever Support for Independent Type Deck Slab Reinforcement.** Support the bottom layer of reinforcing steel for this system in the same manner and with the same limits used for the truss-bar type. Support the top layer in the same manner and with the same limits used for the truss-bar type or by using transverse slab bolsters with runners. Extend the bolsters and runners to the end of the cantilever.

2 These slab reinforcement methods are minimum requirements. Do not use them to support concrete buggies, material carts, or other equipment. If additional equipment is anticipated or used, reduce the spacing as necessary to provide the needed support.

3 Secure the entire network of reinforcing steel by fastening to each girder line. Tie the top layers of reinforcing bars down to deck form-hangers, shear connectors, or exposed stirrup tops with No. 16 gage [1.5 mm] or heavier wire, or multiple ties of equivalent cross-sectional area. Space the ties at intervals no farther apart than 4 ft [1.2 m] on-center longitudinally for the length of girder.

4 After placing and adjusting screed supports and rails, make a “dry run” with the screed machine along the deck to ensure the specified top clearance to the reinforcing steel. Ensure that the top and bottom clearance is not more than ¼ in [6 mm] less than the clearance specified. Ensure that the spacing between the top and bottom layers of reinforcing steel is within ¼ in [6 mm] of that specified. If these tolerances are not met, adjust screed line elevations or reset the top reinforcing steel at no additional cost to the department.

514.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Mechanical Splices as one complete unit or by each splice installed. Modifications required for the placement of the selected mechanical splices will not be measured for additional payment.

2. Reinforcing Steel and Reinforcing Steel (Coated) as one complete unit or by the pound [kilogram] for the quantity specified.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Mechanical Splices	LS, EA [Ea]	LS, EA [Ea]	LS, EA [Ea]
Reinforcing Steel	LS, LB [LS, kg]	LS, lb [LS, kg]	LS, 10 LB [LS, 5 kg]
Reinforcing Steel (Coated)	LS, LB [LS, kg]	LS, lb [LS, kg]	LS, 10 LB [LS, 5 kg]

SECTION 515
Silica Fume Modified Concrete Bridge Deck Repair

515.1 DESCRIPTION

1 This section describes the requirements for repair and resurfacing of concrete bridge decks with silica fume modified concrete.

515.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Admixtures	801.4
Aggregate for Concrete	803
Curing Materials	802.1
Evaporation Retardant	802.2
Portland Cement	801.1
Silica Fume Admixture	801.4
Synthetic Fibers	801.5
Water	814.1

2 For filling cracks in the completed modified concrete overlay, provide a crack filler approved by the Materials Program. For bonding agents used in lieu of the slurry bonding method, provide a product approved by the Materials Program.

515.3 EQUIPMENT

515.3.1 Surface Preparation Equipment

1 Provide sawing, mechanical scarifying, sandblasting equipment, and all other tools necessary to complete the work.

2 Provide power-driven hand tools to remove unsound concrete. With the engineer's approval, jackhammers heavier than the nominal 30-pound [14 kg] class or 60-pound [27 kg] hammers with a spade at least 6 in [150 mm] wide may be used.

3 Provide self-propelled mechanical scarifying equipment capable of accurately establishing profile grades by referencing from the existing deck or from an independent grade control. Ensure that the equipment has the following:

1. A positive means of controlling cross-slope elevations;

2. Sufficient power, traction, and stability to maintain an accurate and uniform depth of cut; and

3. An apparatus to keep dust generated by scarifying from escaping into the air.

515.3.2 Proportioning, Batching, and Mixing Equipment

1 Ensure that equipment meets the following requirements:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2

515.3.3 Placing and Finishing Equipment

1 Provide hand tools for placing stiff plastic concrete and working material down for the screed to strike off. Provide manual screeds or metal plates with electric vibrators attached to consolidate and finish smaller areas.

2 When resurfacing is specified, provide a finishing machine. Provide a finishing machine in accordance with Subsection 513.3.3, Placing and Finishing Equipment, for finishing large areas. Provide two portable, lightweight work bridges for touch-up and surface texturing behind the finishing machine.

3 Transport material from the truck mixer to the deck surface with a discharge chute on the truck mixer directly onto the bridge deck or with motorized buggies. The engineer may prohibit the use of buggies if they cause segregation or inconsistent slump, or they delay placement. Provide runways for transport devices operating over exposed reinforcing steel. Equip trucks with diapers or cover the deck surface to prevent contamination of the bridge deck surface.

515.4 CONSTRUCTION

515.4.1 General

1 The department classifies bridge deck repair as follows:

1. **Class I Repair.** Removing the concrete deck surface with a scarifying machine and disposing of removed concrete. Depth is classified as follows:

   1.1. **Class I-A:** ¼ in [5 mm].

   1.2. **Class I-B:** greater than ¼ in [5 mm] to 2½ in [70 mm].

2. **Class II Repair.** Removing loose and unsound concrete deck portions by chipping and disposing of removed concrete. Depth is classified as follows:

   2.1. **Class II-A:** up to one-half total slab thickness.

   2.2 **Class II-B:** from one-half to total slab thickness.

515.4.2 Mix Design

1 Use silica fume-modified concrete of a workable mixture having properties or limits in accordance with Table 515.4.2-1, Silica Fume Modified Concrete Mixture Parameters.

Table 515.4.2-1
Silica Fume Modified Concrete Mixture Parameters

Parameter	Property or Limit
Ultimate Design Strength, f'_c (28 day) (min.)	7000 psi [48 MPa]
Cement Content (min.)	(1.0 part by weight) 658 lb/yd³ [390 kg/m³]
Water Content[(1)]	34.1 gal/yd³ [169 L/m³]
Silica Fume Solids Content (min.)	52.5 lb/yd³ [31.1 kg/m³]
Fine Aggregate (approx.)[(2)]	(1.8 parts by weight) 1200 lb/yd³ [710 kg/m³]
Coarse Aggregate (approx.)[(2)]	(2.5 parts by weight) 1800 lb/yd³ [1065 kg/m³]
Fibers (min.)	2 lb/yd³ [1.2 kg/m³]
Entrained Air Content	4.5 to 7.5 percent
Consistency (Slump)	4 in to 8 in [100 mm to 200 mm]
Mix Temperature Range	50 °F to 85 °F [10 °C to 29 °C]

(1) Ensure that the water-cement-plus-silica-solids ratio does not exceed 0.40.

(2) This weight [mass] is based on aggregate being in a saturated, surface dry condition.

515.4.3 Seasonal and Weather Limitations

1 Place silica fume modified concrete from May 15 to September 15, unless otherwise approved in writing by the engineer, and only when atmospheric conditions are acceptable and rain is not expected. Place between 10:00 p.m. and 8:00 a.m., unless otherwise approved in writing by the engineer. Provide adequate lights for nighttime work. Place when air temperature is above 45 ºF [7 ºC] and predicted to be above 45 ºF [7 ºC] for at least six hours after placement. Do not place when air temperature exceeds 80 ºF [27 ºC] or when the temperature of the in-situ deck concrete, after wetting, falls outside a range from 45 ºF [7 ºC] to 80 ºF [27 ºC].

2 The engineer will determine acceptable atmospheric conditions for placement by measuring deck surface evaporation rate. This rate will be obtained from Figure 513.4.2-2, Evaporation Nomograph, by measuring relative humidity near the deck, wind velocity, air temperature, and concrete deck temperature. Determine the relative humidity from Figure 513.4.2-1, Relative Humidity, using the wet-bulb and dry-bulb temperatures. During concrete placement, the engineer will use mix temperature in place of deck temperature to calculate the evaporation rate. Do not place silica fume concrete when the evaporation rate exceeds 0.10 lb/ft²/h [0.50 kg/m²/h].

3 Postpone or stop placement when any of the following conditions exist:

1. Rain is expected during the work period or rain starts to fall.
2. Air temperature hinders finishing or texturing the overlay.
3. Any condition hinders finishing, texturing, or curing the overlay.

4 Protect freshly-placed concrete from sudden rain. Remove and replace rain-damaged concrete at no additional cost to the department.

515.4.4 Surface Preparation

1 Where specified or designated by the engineer, remove unsound concrete from the bridge deck. Remove existing maintenance patches to original repair depth or deeper, as required to remove unsound concrete. Do not operate jackhammers or mechanical chipping tools at an angle in excess of 45 degrees, measured from the slab surface. Use hand tools to remove final particles of unsound concrete or achieve the required depth. Work so that saw slurry drains from, and stays away from, areas cleared of unsound concrete.

2 When resurfacing is specified, ensure that new concrete above the prepared surface or existing reinforcing steel is at least 1.0 in [25 mm] thick. Check the clearance before placing concrete. Attach a filler block to the bottom of a finishing device, and pass the finishing machine over the area to be finished on screed rails. Remove concrete and depress and tie down reinforcing steel that obstructs the filler block. If necessary, remove concrete beneath reinforcement to enable adequate depression. When placing new concrete, keep at least ¾ in [19 mm] of clear distance around these bars.

3 Avoid cutting, stretching, or damaging existing reinforcing steel. Remove and replace damaged reinforcing steel with the same size bar using splices in accordance with Subsection 514.4.5.2, Reinforcing Steel Splices, at no additioal cost to the department. In the weld or damaged areas, sandblast and repair coated reinforcing steel in accordance with Subsection 514.4.1.1, Coated Reinforcing Steel, at no additional cost to the department.

4 Specific repair requirements are as follows:

1. **Class I-A and Class I-B Repairs.** Scarify uniformly all areas designated for class I-A or I-B repair or prepare to the depth specified. Do not remove more than 1¼ in [30 mm] in one pass.

   Make a test pass from 20 ft [6 m] to 40 ft [12 m] in length with the scarifying machine. After the pass, the engineer will inspect the deck. If microcracks from scarifying are present, stop scarification and correct the problem before continuing.

   The top mat of reinforcing steel may be exposed or near the surface of the deck; do not damage this steel.

   Ensure that the resulting deck surface is free of excessive scarification marks and other damage. Correct surface irregularities greater than ¼ in [6 mm] above or below specified grade. Perform any additional scarifying required to correct irregularities, at no additional cost to the department.

2. **Class II-A Repair.** Saw-cut areas designated for class II-A repair approximately ¾ in [19 mm] deep or to the top of reinforcing bars if the bar depth is less. Cut along repair boundaries, except those next to a curb face. Make this cut initially or after removing sufficient concrete to reasonably establish the limits of the removal area.

   Remove loose and unsound material. Where at least half the circumference of a reinforcing bar is exposed or where concrete and steel are no longer bonded, remove the concrete to clear at least ¾ in [19 mm] around the bar. Do not use chipping hammers heavier than the nominal 15-pound [7 kg] class to remove concrete below reinforcing bars.

The engineer may enlarge a designated removal area if concrete is deteriorated beyond previously designated limits. Saw-cut around the enlarged area with a “dry” blade before beginning removal.

3. **Class II-B Repair.** The department requires full-depth removal and will consider the repair a class II-B in areas of class II-A repair where the depth of remaining sound concrete is less than 50 percent of the original deck depth. Remove concrete in these areas by chipping and using hand tools. Perform final removal at the edges of class II-B repair areas with 15-pound [7 kg] chipping hammers or hand tools.

   Provide forms for placing new concrete in the full-depth opening. Suspend forms from existing reinforcing bars by wire ties, or for large openings, support forms by blocking from beam flanges. In all cases, support forms using elements of the existing superstructure.

5 Clean all repair areas by sandblasting. Clean exposed reinforcement of rust and clinging concrete and existing concrete against which new concrete will be placed.

6 Before placing new concrete, clean the surface by air blasting, then flush with water. For the slurry bonding method, keep the surface wet for at least two hours before placement. Blow out water puddles with compressed air before covering with a slurry of silica fume modified concrete. Clean areas with remaining oil (indicated by the presence of water beading) or other contamination again. Remove the contamination by additional cleaning, concrete removal, or both, at no additional cost to the department.

7 On any bridge deck portion, allow only construction equipment loads between the time of old concrete removal and the new concrete’s completed curing. During the curing period for new concrete, do not prepare work in adjoining areas or adjacent lanes.

515.4.5 Proportioning and Mixing Modified Concrete

515.4.5.1 General

1 Before aggregates are incorporated into the concrete mix, ensure a uniform moisture content in each stockpile that exceeds the minimum absorbed moisture percentage specified in the laboratory test mix. Do not add moisture to stockpiles within 24 hours of anticipated use; cover with white polyethylene sheeting until mixing begins. Before conducting the trial batch, stockpile enough aggregate to complete all overlays.

515.4.5.2 Laboratory Test Mix

1 At least 30 calendar days before their use, give the following to the engineer for the laboratory test mix by the Materials Program:

1. A completed “Concrete Mix Design” (Form E-45) indicating all materials to be used, including the manufacturer and source of all materials.
2. A letter indicating proportions of all materials, including water. Indicate for aggregate proportions whether they are saturated, surface dry condition, or dry condition. Indicate total or net water based on aggregate condition.
3. An equipment letter indicating mixing equipment to be used.
4. A batch sequence letter describing the sequence of material batching and mixing times.
5. Samples of all mix constituents, with at least the following:
    - 5.1. 100 lb [45 kg] of cement;
    - 5.2. 400 lb [180 kg] each of coarse and fine aggregate;
    - 5.3. 20 lb [9 kg] of silica fume;
    - 5.4. 1 lb [0.5 kg] of fibers; and
    - 5.5. 1 pt [0.5 L] of each admixture.

515.4.5.3 Trial Batch

1 Before beginning placement, make a trial batch of silica fume-modified concrete as follows:

1. Use the same batching and truck mixing equipment, mixing sequence, batch size, and time from batching to placement as proposed for production.
2. Ensure the presence of technical representatives from the silica-fume manufacturer and the water-reducer manufacturer.

3. Ensure that the trial batch is free of lumps and meets all requirements specified in Table 515.4.2-1, Silica Fume Modified Concrete Mixture Parameters.

4. If the trial batch does not meet requirements, demonstrate appropriate corrective measures before batching concrete for placement. The engineer may require another trial batch.

5. Monitor the initial set of the mix during the trial batch.

6. Do not include trial batch materials in the final resurfacing work.

7. Submit modifications of the mix proportions, batching sequence, or mixing times to the engineer.

515.4.5.4 Mixing

1 Ensure that the batch plant accurately proportions all materials for the specified mixture and that batch size is the same as the trial batch.

2 Mix materials thoroughly and in accordance with the specified requirements for the batching equipment used. Do not allow the batch size to exceed 70 percent of the rated capacity of the mixer. Ensure that the mixture discharged from the truck mixer is uniform in composition and consistency. At mixing speed, use at least 70 revolutions to achieve uniformity. Proceed with mixing at a rate that enables a steady pace for finishing.

3 Dose with water-reducer in accordance with manufacturer's recommendations. Use a dosage of normal-range water-reducer as required to control consistency during batching and mixing, but do not exceed the manufacturer's recommendations. Be prepared to redose the mixture at the placement location with high-range water-reducer and air-entraining admixture. Do not operate trucks at mixing speed on the bridge deck. For additional mixing or remixing, position trucks off the deck.

4 If a workable mix cannot be obtained with the trial batch properties, stop production mixing until the problem is corrected.

515.4.6 Placing

1 After the finishing machine has been set and the screed and deck checked and approved, give the engineer at least 24 hours notice before the pour, unless otherwise approved.

2 During initial concrete placement, ensure the availability for consultation of technical representatives of the silica- fume manufacturer.

3 Twenty-four hours before placement, install bulkheads to the required grade and profile in transverse joints; seal with caulk or other suitable means to prevent concrete from getting into joints. Do not cast across existing transverse joints and saw later.

4 When required, place and fasten screed rails to ensure that concrete can be finished to the required profile. Ensure that anchorage for supporting screed rails provides horizontal and vertical stability. Do not treat screed rails with parting compound.

5 Before placing concrete and in the presence of the engineer, verify the vibration frequency of finishing devices meet the requirements of Subsection 515.3.3, Placing and Finishing Equipment.

6 Brush a slurry of the silica fume-modified concrete onto the wetted, prepared surface. Coat vertical and horizontal surfaces with a thorough, even coating, and limit progress so that brushed material is still wet when covered by new concrete. Use only the paste portion of the material. Remove and discard aggregate larger than the No. 4 [4.75 mm] sieve that separates from the paste during brushing. Alternatively, apply an approved bonding agent in accordance with the manufacturer's recommendations.

7 Limit traffic to 10 mph [20 km/h] on adjacent lanes during placement and for 4 hours afterward, then limit traffic to 25 mph [40 km/h] for the next 20 hours.

8 Place concrete in a continuous operation and in accordance with Table 515.4.6-1, Minimum Mixing and Placement Rate.

Table 515.4.6-1
Minimum Mixing and Placement Rate

Total Repair Area Per Bridge (yd^2 [m^2])	Rate (yd^3/h [m^3/h])
≤ 328 [≤ 274]	1.0 [0.8]
329 - 492 [275 - 411]	1.5 [1.1]
493 - 656 [412 - 548]	2.0 [1.5]
> 656 [> 548]	2.5 [1.9]

9 When mixing and placing at the specified minimum rate under normal conditions, perform final screeding no more than 30 minutes after depositing concrete on the deck. Remove concrete not screeded within 30 minutes or that has reached a slump below 4 in [100 mm] before being screeded.

10 When placement delays exceed one hour, install a construction dam or bulkhead. During shorter delays, keep the end of the placement from drying with several layers of wet burlap.

515.4.7 Finishing

1 Manipulate and strike off silica fume-modified concrete to approximately ¼ in [6 mm] above final grade; consolidate and finish at final grade with vibrating screeds or finishing devices. The department may require hand-finishing with a wood float along pour edges or on smaller class II-A and II-B repair areas. Do not add water directly to the concrete surface while finishing. A fog mist may be used to slow evaporation. Vibrate the end of the deck, bulkheads, class II-A and II-B repair areas, and curb lines by hand to ensure maximum consolidation.

2 For class II-A and II-B repairs where no resurfacing is specified, leave a finished surface flush with existing adjacent concrete.

3 After obtaining a uniform surface, give concrete a burlap drag finish and immediately apply an evaporation retardant to the surface, in accordance with the manufacturer's recommendations. Reapply retardant in areas requiring hand finishing. Do not use evaporation retardants as a finishing aid.

4 Provide a tined, transverse groove texture as specified in Subsection 513.4.12.2.2, Tine Finish, and at right angles to the centerline of the roadway on all bridges, regardless of skew. Use the tining device at a vertical angle of 45 degrees or less to achieve proper groove depth. Avoid overlapping and tearing the surface. Do not texture the last 12 in [300 mm] of deck next to the curb.

5 Immediately after tining, cure the surface with two applications of impervious curing compound compatible with wet curing, in accordance with Subsection 513.4.13, Curing Concrete. Apply at a rate of 150 ft²/gal [0.25 L/m²].

6 After the last application of curing compound has set and as soon as possible without causing deformation, cover the surface with a single layer of clean, wet burlap. Keep the burlap wet, and within one hour cover tightly with a layer of 4-mil [0.1 mm] polyethylene film, leaving no air spaces. A composite burlap-polyethylene material may be used. Keep the burlap moist, and leave the wet-cure material in place for four calendar days.

7 Screed rails may be removed after the concrete obtains initial set; do not damage new surface edges during removal.

8 Separate construction dams from newly placed material by passing a pointing trowel along their inside face for the entire depth and length of dams once the concrete stiffens sufficiently to not flow back.

515.4.8 Curing

1 Do not allow traffic on the concrete surface for seven curing days after placement and until concrete obtains a minimum compressive strength of 5000 psi [35 MPa]. After completing placement, consider a curing day to be each consecutive 24-hour period when air temperature remains above 45 ºF [7 ºC].

515.4.9 Unacceptable Work

1 Before opening to traffic, the engineer will examine the new overlay using visual and sounding techniques. Remove and repair areas with a significant number and size of cracks or that are not intimately bonded to the underlying deck as specified for class II-A repair. Remove and repair as follows:

1. Before removal, saw cut at least 4 in [100 mm] outside each edge of the repair area.
2. Make repair areas rectangular or square in shape and at least 12 in [300 mm] on each side.
3. Do not place longitudinal repair joints within 12 in [300 mm] of a wheel path (a wheel path is 3 ft [1 m] from a lane line in the traveled way).
4. For repair areas within 3 ft [1 m] of each other, make one large repair, as approved by the engineer.
5. Place silica fume-modified concrete in repair areas in accordance with Subsection 515.4.6, Placing.
6. Fill joint edges of repair areas as specified below for small cracks.
7. The engineer will examine repair areas again.

2 For cracks greater than 6 mil [0.15 mm] wide that are not significant enough to require removal of the overlay, fill them completely with crack filler, in accordance with the manufacturer's recommendations. Gravity-feed cracks designated to be filled to refusal, repeating as necessary. Then, apply crack filler, using the method, coverage rate, and cure specified by the manufacturer. If necessary, use two coats. If manufacturer's specifications indicate that deck surface skid resistance may be impaired, broadcast silica sand at a rate of 1.5 lb /yd² [0.8 kg /m²]. Repair cracks at no additional cost to the department.

515.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Bridge Deck Repair Class I-A, Bridge Deck Repair Class I-B, Bridge Deck Repair Class II-A, and Bridge Deck Repair Class II-B by the square yard [square meter].

   The engineer will measure Bridge Deck Repair Class I-A and Bridge Deck Repair Class I-B for all areas scarified, including the area of Class II repairs. Areas measured as Bridge Deck Repair Class I-B will not be included in the measured quantity of Bridge Deck Repair Class I-A. Areas measured as Bridge Deck Repair Class II-B will not be included in the measured quantity of Bridge Deck Repair Class II-A.

   When additional removal for relatively high areas is specified by the engineer for Bridge Deck Repair Class I-A, or when the required removal depth for Bridge Deck Repair Class I-B exceeds 1¼ in [30 mm], the engineer will measure for payment a second time.

2. Silica Fume Modified Concrete by the cubic yard [cubic meter] based on batch volumes ordered and placed in the work. Silica Fume-Modified Concrete produced for trial batches will not be measured for payment.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Bridge Deck Repair Class I-A	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Bridge Deck Repair Class I-B	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Bridge Deck Repair Class II-A	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Bridge Deck Repair Class II-B	SY [m^2]	0.1 ft [0.05 m]	SY [m^2]
Silica Fume Modified Concrete	CY [m^3]	0.1 yd^3 [0.1 m^3]	0.1 CY [0.1 m^3]

SECTION 516
Paint Repair

516.1 DESCRIPTION

1 This section describes the requirements for paint repair on structural steel.

516.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Paint	809

516.3 EQUIPMENT—Vacant

516.4 CONSTRUCTION

1 Clean and paint deteriorated paint systems on existing structural steel to limits specified. When required, paint steel piling after exposing to 12 in [300 mm] below ground. Clean and paint from this point to the bottom of the pile cap.

2 Prepare structural steel surfaces for painting in the following sequence:

1. Wire-brush, abrade, or scrape with hand or power tools all areas of heavy rusting, deep rust pitting, loose paint, or built-up foreign matter.

2. Remove oil, grease, and contaminants from the surface with clean rags wetted with cleaning solvent.

3. Using rags wetted with clean, uncontaminated water, remove dirt, oxidation, and other contaminants from steel areas. Use a minimal amount of water for cleaning. Obtain the engineer's approval for cleaning by other methods.

4. Let surfaces air-dry before painting. Compressed air, free of water and oil, may be used to accelerate drying.

3 Ensure that the final prepared surface is free of oil, grease, dirt, soluble contaminants, moisture, rust scale, loose mill scale, loose rust, and loose paint or coatings. Tight mill scale and tightly adhered rust, paint, and coatings may remain.

4 Paint structural steel in accordance with Subsection 501.4.2.8.3, Field Paint Application, for the type of paint system selected, using the color specified.

5 The department does not require a prime coat when specifying epoxy-mastic paint. Use aluminum-colored epoxy-mastic paint.

6 Protect other portions of the structure, traffic, and surrounding property from paint overspray. Correct overspray damage at no additional cost to the department.

516.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. Paint Repair—Bridge Railing as one complete unit or by the foot [meter] of railing painted.

2. Paint Repair—Structural Steel and Paint Repair—Steel Piling as one complete unit or by the square foot [square meter] of surface area painted.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Paint Repair—Bridge Railing	LS, FT [m]	LS, 0.1 ft [0.05 m]	LS, FT [0.5 m]
Paint Repair—Steel Piling	LS, SF [m^2]	LS, 0.1 ft [0.05 m]	LS, SF [0.1 m^2]
Paint Repair—Structural Steel	LS, SF [m^2]	LS, 0.1 ft [0.05 m]	LS, SF [0.1 m^2]

DIVISION 600

Miscellaneous Construction

SECTION 601
Vacant

SECTION 602
Vacant

SECTION 603
Culverts and Storm Drains

603.1 DESCRIPTION

1 This section describes the requirements for constructing or relaying culverts and storm drains.

603.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Aggregate for Flowable Backfill	803
Aluminum-Coated Pipe	808.5
Bituminous-Coated Corrugated Steel Pipe	808.5
Bolts, Nuts and Washers	815.6
Class B Bedding	803
Corrugated Aluminum Alloy Culvert Pipe	808.6
Corrugated Metal Units	808.7
Corrugated Steel Pipe and Pipe-Arches	808.5
Curing Materials	802.1
Fly Ash	801.2
Galvanized Coating	815.14
Pipe Joint Mortar	808.14
Polymeric Precoated Galvanized Steel Pipe	808.5
Portland Cement	801.1
Reinforced Concrete Pipe	808.1
Reinforcing Steel	811.1
Rubber Ring Gaskets	808.15
Steel Mitered End Sections	808.16
Water	814.1

603.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

2 To mix flowable backfill, provide a rotary drum or other approved mixer capable of thoroughly dispersing all ingredients.

603.4 CONSTRUCTION

603.4.1 General

1 The following abbreviations, when used in the contract, represent the full text shown.

1. **Rigid Pipe**

RCP	Reinforced Concrete Pipe
HERCP	Horizontal Elliptical Reinforced Concrete Pipe

2. **Flexible Pipe**

CSP	Corrugated Steel Pipe
CAP	Corrugated Aluminum Alloy Pipe
CMP	Corrugated Metal Pipe

3. **End Sections**

FE	Flared End
SME	Steel Mitered End

2 When the contract specifies CMP, the department allows the use of CSP or CAP meeting specifications. The department will designate pipe-arches of the above types of pipe by using the word “arch.”

3 Ensure that plants producing RCP and HERCP are certified in accordance with Subsection 502.4.1, Plant Certification. Submit a copy of the precast concrete manufacturer's certification current at the time of manufacture to the engineer seven calendar days prior to delivery of RCP and HERCP to the project.

4 Use an end finish consisting of FE, bevel end, step bevel end, square-cut end, or SME sections. Provide SME sections with the specified slope and grate type and parallel drainage (PD) or cross drainage (CD) grate.

5 Maintain cover over pipes during construction to prevent damage. At pipe ends, construct embankment slopes to match flared end section slopes.

603.4.2 Pipe Selection

1 When extensions of existing pipes are required, provide and install the same type and size of pipe. For flexible pipe, use extensions made of the same base metal.

2 Base the strength class of rigid pipe on the fill height tables specified and method of bedding and installation selected.

3 Furnish and install flexible pipe of a thickness based on the design information specified. Select the type of metal, seams, and corrugation sizes. A thicker gage metal pipe than required may be used at no additional cost to the department.

4 The department will allow substitution of equivalent sizes and classes of RCP arch and HERCP for each other when either is specified. For extensions, use the same size and class as existing pipe.

5 Select and provide pipe from among those allowed under the corrosion resistance number in Table 603.4.2-1, Corrosion Resistance Acceptability. Use the CR1 classification when no number is specified.

Table 603.4.2-1
Corrosion Resistance Acceptability

Type of Pipe	Corrosion Resistance Number								
	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9
Galvanized Steel	yes	no	no	no	no	no	no	no	no
Aluminum Coated Steel (Type 2)	yes	no	no	no	no	no	no	no	no
Bituminous Coated Galvanized Steel	yes	yes	no	no	no	no	no	no	no
Aluminum Alloy	yes	yes	yes	yes	no	no	no	no	no
Polymeric Precoated Galvanized Steel	yes	yes	yes	yes	yes	no	no	no	no
RCP (Type II Cement)	yes	yes	yes	yes	yes	no	no	no	no
RCP (Type V Cement)	yes	yes	yes	yes	yes	yes	yes	no	no
RCP (Type V Cement/Fly Ash)	yes	yes	yes	yes	yes	yes	yes	yes	no
Epoxy Coated RCP (Type II or Type V Cement)	yes	yes	yes	yes	yes	yes	yes	yes	yes

6 Ensure that connecting bands and end sections have the same corrosion protection as the pipe. If bands or end sections for certain pipes are not available, use bituminous coated bands or end sections.

603.4.3 Excavation

1 Excavate trenches or channels in accordance with Section 206, Excavation and Backfill for Culverts. Where required, camber the channel longitudinally. Vary the amount of camber for the fill height and supporting soil; do not reverse the pipe gradient.

603.4.4 Pipe Bed Preparation

1 Ensure that soil is undisturbed or compacted for the full length and width of the completed channel bottom. Shape the excavation to fit the pipe bottom, and allow any required placement of bedding material. Shape recesses in the trench bottom to accommodate the bell and spigot.

1. **Class B Installation**. Bed on class B bedding material.

2. **Class C Installation**. Bed on uniformly-compacted earth materials or undisturbed trench bottom. Clear the area of stones large enough to cause damage. Install flexible pipe, RCP arch, and HERCP using the class C installation method.

2 The department requires no specific preparation for pipes placed under approaches and median crossovers.

603.4.5 Installing Pipe

1 Begin pipe installation at the downstream end. Ensure that the full length of each pipe segment bottom is in contact with the shaped bedding. Place bell or groove ends of rigid pipe and outside circumferential laps of flexible pipe facing upstream. Place flexible pipe with longitudinal laps or seams at the sides. Place reinforced-concrete elliptical pipe with the minor axis vertical and the major axis horizontal.

603.4.6 Joining Pipe and End Sections

603.4.6.1 General

1 Use rubber gaskets when watertight joints are specified. When pipe joint mortar is specified, place within 30 minutes of the mortar's preparation. Use galvanized tie bolts, washers, and nuts.

1. **Rigid Pipe.** Use bell-and-spigot or tongue-and-groove design. On slopes of 10 percent or steeper, use bolted joint ties or bell-and-spigot pipe. Join the sections with ends tight and inner surfaces flush and even.

2. **Flexible Pipe.** Join firmly by coupling bands.

603.4.6.2 RCP FE Sections

1 Match the FE section joint configuration to the pipe joint. Use tie bolts on sections 60 in [1500 mm] or more in diameter. Use the bolts to hold ends together, not to pull sections tight. If the pipe is accessible to people and animals, ensure that tie bolt threads do not project inward.

603.4.6.3 SME Sections

1 Provide and install required hardware and appurtenances (including the tapered sleeve required for RCP connections). Ensure a smooth, tight juncture consistent with flow characteristics of the pipe. Attach end sections using connectors in accordance with Table 603.4.6-1, SME Section Connectors.

Table 603.4.6-1
SME Section Connectors

Pipe Size	Connector Type
Round ≤ 24 in [600 mm]	1 (Straps)
Round > 24 in [600 mm] and All Other Pipe	2 (Rods and Lugs)

603.4.7 Pipe Collars

1 When required, provide and place reinforcing steel as specified in accordance with Section 514, Reinforcing Steel. Use class B concrete in accordance with Subsection 513.4.4, Mix Design.

2 Remove fill to expose the existing pipe end, and if required, remove the existing end section.

3 Form collars to the dimensions specified. Form, place, and cure concrete in accordance with applicable portions of Subsection 513.4, Construction. The engineer may waive forming of concrete for pipe collars if the final collar dimensions meet specified minimum dimensions.

603.4.8 Repair of Damaged Coating

1 Repair damage to metallic coatings in accordance with Subsection 501.4.2.9, Repair of Galvanizing. Repair damage to polymeric coating by applying a polymeric coating similar to and compatible with the original. Do not backfill around the pipe before inspection and approval by the engineer.

603.4.9 Backfilling

1 Do not backfill before the engineer inspects the pipe. Relay or replace misaligned, settled, or damaged pipe.

2 Place and compact backfill material in accordance with Section 206, Excavation and Backfill for Culverts. When specified, use flowable backfill in accordance with Subsection 206.4.5, Backfilling.

603.4.10 Relaying Pipe

1 Relay removed pipe, including end sections, using the existing hardware and appurtenances to join the pipe and connect the end sections in accordance with Subsection 603.4.6, Joining Pipe and End Sections.

603.5 MEASUREMENT and PAYMENT

603.5.1 General

1 The engineer will measure pipe with beveled, step-beveled, or square-cut ends along the invert from end to end, and, when FE or SME sections are used, will not include the length of the end section for new pipe but will include it for relaying pipe. The length for payment will not exceed the length staked.

2 The engineer will measure new or relaid pipes installed in a storm sewer system along the centerline of the pipe from invert to invert of manholes or invert of inlet to invert of manhole.

3 The engineer will measure branch connections along their inverts from the intersection of their flow line with the flow line of the trunk line to the center of the manhole or inlet.

4 The engineer will measure:

1. Pipe _____ in [mm], Pipe Arch _____ × _____ in [mm], RCP _____ in [mm], RCP Arch _____ × _____ in [mm], RCP Elliptical _____ × _____ in [mm], CMP _____ in [mm], CMP Arch _____ × _____ in [mm], and Relaying Pipe _____ in [mm] by the foot [meter].

2. Pipe FE Sect _____ in [mm], Pipe-Arch FE Sect _____ × _____ in [mm], RCP FE Sect _____ in [mm], RCP Arch FE Sect _____×_____in [mm], RCP Elliptical FE Sect _____×_____in [mm], CMP FE Sect _____ in [mm], CMP Arch FE Sect _____ × _____ in [mm], SME Sect _____ in [mm], SME Sect _____ in [mm] w/Grate, SME Arch Sect _____ × _____ in [mm], and SME Arch Sect _____ × _____ in [mm] w/Grate by the installed number of units of each size.

3. Pipe Collars by the cubic yard [cubic meter] of concrete not to exceed the quantity derived from the minimum collar dimensions specified.

5 The department will pay for approved alternate types of pipe as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Pipe _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Pipe Arch _____ × _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Pipe FE Sect _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
Pipe Arch FE Sect _____ × _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]

6 The department will pay for specific types of pipe as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
CMP _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
CMP Arch _____ × _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
CMP FE Sect _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
CMP Arch FE Sect _____ × _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
Pipe Collars	CY [m^3]	0.1 ft [0.05 m]	0.1 CY [0.1 m^3]
RCP _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
RCP Arch _____ × _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
RCP Elliptical _____ × _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
RCP FE Sect _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
RCP Arch FE Sect _____ × _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
RCP Elliptical FE Sect _____ × _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
Relaying Pipe _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
SME Sect _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
SME Sect _____ in [mm] w/ Grate	EA [Ea]	EA [Ea]	EA [Ea]
SME Arch Sect _____ × _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
SME Arch Sect _____ × _____ in [mm] w/Grate	EA [Ea]	EA [Ea]	EA [Ea]

603.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Flowable Backfill in accordance with Section 206, Excavation and Backfill for Culverts.

2. Removal of Pipe in accordance with Section 202, Removal; however, when relaying is specified, the removal is incidental to relaying.

SECTION 604
Vacant

SECTION 605
Underdrains

605.1 DESCRIPTION

1 This section describes the requirements for furnishing, installing, and backfilling underdrains.

605.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Bituminous Coated Corrugated Steel Pipe	808.5
Corrugated Aluminum-Alloy Pipe	808.6
Corrugated Steel Pipe	808.5
Curing Materials	802.1
Drainage and Filtration Geotextile	805
Fly Ash	801.2
Gravel for Drains	803
Hardware Cloth for Drains	808.4.2
Metal Delineator Posts	816.5
Plastic Pipe & Fittings	808.4
Portland Cement	801.1
Water	814.1
Wood Post	812.8

605.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

605.4 CONSTRUCTION

605.4.1 Underdrain Selection

1 Use only the designated type and size of underdrain. If the strength class is not designated, use any strength class. Use only one type of underdrain throughout the project.

605.4.2 Pipe Installation

1 When installing underdrains along the edge of interstate highways, install under the outside shoulder unless the median shoulder is lower.

2 Excavate trenches in accordance with Subsection 206.4.1.2, Trench Excavation. Do not leave trenches open during nonworking hours unless approved by the engineer. Install drainage and filtration geotextile as specified and in accordance with Section 217, Geotextiles.

3 Install gravel backfill, perforated and nonperforated underdrain pipe, and outlets as specified. Orient perforations towards the trench bottom. In locations with a high rate of flow causing possible leakage into the embankment or subgrade to be drained, orient perforations towards the top of the trench. Use grading B gravel for drains. Cap the high point of the end of an underdrain.

605.4.2.1 Plastic Pipe

1 Prime-coat and cement the mating surfaces of pipe and pipe fittings. Use solvent cement and primer from the same manufacturer and in accordance with the manufacturer's recommendations. Use primer that contrasts with the color of the pipe fittings.

605.4.3 Underdrain Outlets

1 Use nonperforated outlet pipes. Daylight underdrain outlets outside of the clear zone using a concrete head wall/stilling basin, rodent screen, and outlet location post as specified.

2 Install outlet pipes on a 2 percent or steeper slope. Where the engineer determines that conditions do not allow the specified slope, install with at least a 1 percent slope.

3 Use class B concrete for head walls and stilling basins in accordance with Subsection 513.4.4, Mix Design. The engineer may approve a local commercial mix. Form, place, and cure concrete in accordance with applicable portions of Subsection 513.4, Construction. The engineer may approve the use of alternate concrete head walls and stilling basins that meet the general requirements specified.

605.4.4 Trench Backfill

1 After the engineer inspects and approves the pipe installation, backfill and compact the trench as specified and in accordance with Subsection 206.4.5, Backfilling.

605.5 MEASUREMENT and PAYMENT

605.5.1 General

1 The engineer will measure:

1. Underdrain Pipe (Perf) _____ in [mm] and Underdrain Pipe (Non-Perf) _____ in [mm] by the foot [meter] along the pipe, before backfilling. The length for payment will not exceed the length staked.

2. Gravel for Drains by the short ton [metric ton] or cubic yard [cubic meter]. The engineer will use neat lines for measurement by the cubic yard [cubic meter], with no reduction in volume for the underdrain pipe.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Gravel for Drains	TON, CY [t, m^3]	0.05 ton, 0.1 ft [0.05 t, 0.05 m]	0.05 TON, CY [0.05 t, m^3]
Underdrain Pipe (Perf) _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Underdrain Pipe (Non-Perf) _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

605.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure Geotextile Drainage and Filtration by computing the surface area covered based on the neat lines. The department will pay in accordance with Section 217, Geotextiles.

SECTION 606
Guardrail and Median Barrier

606.1 DESCRIPTION

1 This section describes the requirements for:

1. Constructing corrugated and box beam guardrail, corrugated and box beam median barrier, and end terminals.
2. Resetting removed or salvaged corrugated, box beam, and median barrier guardrail components and associated hardware, when required.
3. Constructing temporary guardrail and bridge end connections.
4. Installing and removing temporary guardrail, and the appropriate end treatment, at the reverse ends of bridges on multi-lane, divided highways.

606.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Admixtures	801.4
Aggregate for Concrete	803
Box Beam Barrier	813.3
Bolts, Nuts and Washers	815.6
Corrugated Beam Guardrail (Self-Oxidizing)	813.4
Corrugated Metal Beam Rail	813.1
Fly Ash	801.2
Galvanized Coating	815.14
Guardrail or Median Barrier Posts	813.6
Guardrail Hardware	813.2
High-Strength Bolts and Fasteners	815.2
Portland Cement	801.1
Reflective Sheeting	816.4
Sheet Metal	815.3

Structural Steel	815.1
Timber Posts and Blockouts	813.6.2
Water	814.1
Wire Cable	811.3
WYBET End Terminals	813.5

2 Where “Guardrail Bolts” are specified, provide bolts of the button head design with an oval shoulder and that meet the requirements of Subsection 815.6, Bolts and Fasteners.

606.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

606.4 CONSTRUCTION

606.4.1 General

1 Use fabricated components with corners, edges, and burrs ground smooth before galvanization. Repair damaged galvanized components in accordance with Subsection 501.4.2.9, Repair of Galvanizing.

2 Use new, shop-fabricated guardrail components galvanized after welding. When fabricating or modifying after galvanization, clean cut edges and welded joints with a wire brush. Paint the cleaned area in accordance with Subsection 501.4.2.9, Repair of Galvanizing. After cleaning, give bolt holes one coat of paint.

3 Avoid gouges, scratches or dents to steel parts. Do not allow foreign material, including paint, grease, oil, or crayon, to contact the surface. Do not use damaged steel parts. Position steel parts allowing for free drainage and air circulation during shipping and storage. The department will allow natural oxide formation on steel surfaces.

4 Remove existing guardrail in accordance with Subsection 202.4.3, Removal of Guardrail, Barrier, Bridge Railing, and Pedestrian Railing.

5 Before installing guardrail, complete grading and shoulder construction through the top course to match the specified slopes.

606.4.2 Shop Drawings and Fabrication

1 Submit shop drawings for new box beam guardrail and median barrier to the Highway Development Program for review in accordance with Subsection 105.2, Working Drawings. Include layout diagrams, shop details and dimensions, piece marks, thicknesses of material, and other data necessary to fabricate and install rail elements. To aid in identification and erection, ensure that box beam railing has clearly visible piece marks corresponding to the approved "Final" shop drawings.

2 When shop-bending of box beam rail elements is required, indicate the locations, limits, and curving method on the shop drawings.

3 Use box beam rail elements with a nominal length of at least 18 ft [5.5 m]. Unless physical constraints require odd lengths, provide elements in nominal lengths enabling from 3 to 6 post spaces. Use a standard post spacing of 6.0 ft [1.8 m] and a minimum of 4.0 ft [1.2 m]. Provide rail elements so that a joint occurs at the point of tangency (PT) of the flare.

4 Place expansion splices in box beam installations over 300 ft [90 m] in length and at intervals not exceeding 500 ft [150 m]. Space them approximately equally in the guardrail run.

5 Galvanize WYBET end anchorages in accordance with Subsection 501.4.1.25, Galvanizing. Ensure that the outer rail of a WYBET end anchorage slides freely over the inner rail after galvanization.

606.4.3 Installation

606.4.3.1 General

1 After erection, thoroughly clean damaged galvanized surfaces with a wire brush to remove damaged spelter coating and repair in accordance with Subsection 501.4.2.9, Repair of Galvanizing.

606.4.3.2 Posts

1 Use the same type and shape of posts and blockouts throughout the project.

2 Establish line and grade between the end anchorage systems, and correct misalignment or sags in elevation. Set posts plumb. Install as follows:

1. **Post Placement by Excavation and Backfill.** Excavate postholes to a diameter of at least 18 in [450 mm]. Set posts on undisturbed or thoroughly compacted material. Backfill in 6-inch [150 mm] lifts and thoroughly compact without moving posts from the correct alignment.

2. **Post Placement by Driving.** Guide driven posts laterally and protect the tops to avoid battering. Posts may be driven using pilot holes formed with an auger or rock punch. Make pilot holes no less than the diameter of the post and extend the depth to within 6 in [150 mm] of the final grade. Drive posts the last 6 in [150 mm] to final elevation. If adverse or rocky soil conditions hinder driving, the depth of the pilot holes may be increased.

3 After placing posts, place material around each post to match the depth and type of existing surfacing material. Set the initial height of posts for corrugated beam guardrail to provide the specified rail mounting height with blockouts mounted in the lowest set of mounting holes.

606.4.3.3 Rail Elements

1 Erect rail elements to provide a smooth, continuous installation. Ensure that bolts in the finished rail are snug-tight and extend beyond the nuts.

2 Place reflective sheeting on both sides of the reflector tabs. Use white sheeting for shoulder installations and yellow for median installations.

3 The following apply when installing corrugated beam guardrail:

1. Use guardrail in lengths to the next 12.5-foot [3.81 m] increment.

2. Do not use washers between the head of the post bolt and rail element.

3. Place splice laps with the exposed edge away from adjacent traffic.

4. Do not use steel blockouts.

5. Orient reflector tabs with the bolt slot facing away from adjacent traffic.

606.4.3.4 End Anchorages

1 Use precast concrete end anchorage blocks or cast in place. Use class B concrete in accordance with Subsection 513.4.4, Mix Design. The engineer may approve a local commercial mix. Form, place, and cure concrete in accordance with applicable portions of Subsection 513.4, Construction.

2 When using precast blocks, install lifting devices to avoid damaging the anchor bolts during lifting or setting. Do not use anchor bolts for lifting. Do not place reflector tabs on end anchorages.

606.4.3.5 WYBET End Terminal

1 The department will allow intermediate spacers for WYBET end terminals to be painted with two coats of a zinc-rich paint in accordance with Subsection 501.4.2.9, Repair of Galvanizing, in lieu of galvanization.

2 Slide the inner rail inside the outer rail using only manual labor. Before completion of the installation, demonstrate to the engineer that the outer tube slides freely over the inner tube's entire length without binding.

3 Cover the impact plate with black and yellow reflective sheeting. Do not place reflector tabs on WYBET end terminals.

606.4.3.6 Bridge Rail and Concrete Barrier Connections

1 Construct corrugated beam and box beam transition sections and connections to bridge railing and concrete barrier as specified. Bridge rail connections include plates, sleeves, special end shoes, and associated hardware necessary to complete installation. If required, weld the connection sleeve or plate to the steel bridge railing in accordance with Subsection 501.4.2.5, Field Welding.

606.4.4 Reset/Upgrade Guardrail

1 Reset or upgrade existing guardrail installations in accordance with the following:

1. **Reset Guardrail.** Adjust or install posts and rail to the specified alignment and grade. If necessary, raise or lower posts in accordance with Subsection 606.4.3.2, Posts. Provide and install additional bolts, nuts, washers, post mounting brackets, and angles as necessary. Provide and install new reflective tabs for the length of the reset rail except on end terminals and end anchorages.

2. **Upgrade Guardrail.** Provide and install additional rail, posts, hardware, and other guardrail components, and modify removed salvaged components to provide the specified length. When the upgrade causes post spacing to vary more than 24 in [600 mm] from specified spacing, adjust posts, including those outside the upgrade section.

2 After post removal, backfill and compact holes in 8-inch [200 mm] lifts up to ground or shoulder surface. Backfill holes in plant mix with new plant mix up to the existing surface.

3 Cut rail, drill holes, and touch up exposed steel surfaces with two coats of zinc-rich paint in accordance with Subsection 501.4.2.9, Repair of Galvanizing, to accommodate required modifications in guardrail configuration.

606.4.5 Temporary Guardrail

1 When required, install temporary guardrail as specified. Obtain the engineer's approval before installing undamaged, used guardrail elements, posts, and hardware. Replace unsatisfactory materials at no additional cost to the department. Remove guardrail when it is no longer required.

2 When specified, modify existing bridge railing for connecting temporary guardrail. Before welding, remove galvanizing in areas to be welded. Field-weld a steel plate to the existing bridge rail end as specified and in accordance with Subsection 501.4.2.5, Field Welding. If the end terminal will be reused or remain in place, galvanize the steel plate and affected areas in accordance with Subsection 501.4.2.9, Repair of Galvanizing.

3 Bolt the W-beam terminal connector to the steel plate as specified. Make bolts snug-tight in accordance with Subsection 501.4.2.3.4.5, General Installation.

606.5 MEASUREMENT and PAYMENT

606.5.1 General

1 The engineer will measure as follows:

1. Box Beam Guardrail, Box Beam Med Barrier, Corr Beam Guardrail, Corr Beam Guardrail (Self-Oxidizing), and Corr Beam Med Barrier by the foot [meter].

2. Reset Corr Beam Guardrail, Reset Corr Beam Med Barrier, Reset Box Beam Guardrail and Reset Box Beam Med Barrier by the foot [meter], and will include the lengths of end anchorages and bridge rail connections in the measured length for resetting barrier or guardrail.

3. Upgrade Corr Beam Guardrail, Upgrade Corr Beam Med Barrier, Upgrade Box Beam Guardrail, and Upgrade Box Beam Med Barrier by the foot [meter].

4. Corr Beam Guardrail End Anch Type _____, Corr Beam Guardrail End Anch Type _____ (Self-Oxidizing), Corr Beam Med Barrier Term, Box Beam Guardrail End Anch Type _____, and Box Beam Med Barrier End Anch Type _____ by the each.

5. Box Beam End Term (WYBET), Box Beam End Term (WYBET) Mod, Box Beam Med Barrier End Term (WYBET), and Reset Box Beam End Term (WYBET) by the each.

6. Temporary Guardrail by the each, which includes the work at both sides of the bridge end.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Box Beam End Term (WYBET)	EA [Ea]	EA [Ea]	EA [Ea]
Box Beam End Term (WYBET) Mod	EA [Ea]	EA [Ea]	EA [Ea]
Box Beam Guardrail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Box Beam Guardrail End Anch Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Box Beam Med Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Box Beam Med Barrier End Anch Type _____	EA [Ea]	EA [Ea]	EA [Ea]

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Box Beam Med Barrier End Term (WYBET)	EA [Ea]	EA [Ea]	EA [Ea]
Corr Beam Guardrail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Corr Beam Guardrail (Self-Oxidizing)	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Corr Beam Guardrail End Anch Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Corr Beam Guardrail End Anch Type _____ (Self-Oxidizing)	EA [Ea]	EA [Ea]	EA [Ea]
Corr Beam Med Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Corr Beam Med Barrier Term	EA [Ea]	EA [Ea]	EA [Ea]
Reset Box Beam End Term (WYBET)	EA [Ea]	EA [Ea]	EA [Ea]
Reset Box Beam Guardrail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Reset Box Beam Med Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Reset Corr Beam Guardrail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Reset Corr Beam Med Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Temporary Guardrail	EA [Ea]	EA [Ea]	EA [Ea]
Upgrade Box Beam Guardrail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Upgrade Box Beam Med Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Upgrade Corr Beam Guardrail	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Upgrade Corr Beam Med Barrier	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

606.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for Removal of Guardrail in accordance with Section 202, Removal; however, when reset is specified, removal is incidental to resetting.

SECTION 607
Fences

607.1 DESCRIPTION

1 This section describes the requirements for the construction of fence and gates and the removal and resetting of gates.

607.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Admixtures	801.4
Aggregate for Concrete	803
Barbed Wire	812.1
Bolts, Nuts and Washers	815.6
Fasteners - Plastic Fence Posts	812.8.3.5
Fence Posts	812.8
Fly Ash	801.2
Industrial Fence	812.4
Paint	809
Plastic Fence Posts	812.8.3
Portland Cement	801.1
Structural Steel	815.1
Twisted Barbless Wire	812.2
Water	814.1
Woven Wire	812.3

2 Provide 3 ft [1 m] of galvanized gate chain with ¼-inch [6 mm] diameter welded links.

607.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	**Subsection**
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

607.4 CONSTRUCTION

607.4.1 General

1 Control livestock and unauthorized vehicle traffic in accordance with Section 107, Legal Relations and Responsibility to the Public. Clear and grub in accordance with Section 201, Clearing and Grubbing, as necessary to construct fence to the required grade and alignment.

2 Remove fence in accordance with Subsection 202.4.7, Removal of Fence, Snow Fence, and Signs.

3 Place fence 12 in [300 mm] inside the right-of-way lines except where topography prevents construction. When required at breaks in fencing or intersections with existing fences, make appropriate adjustments in post spacing to meet the requirements for the type of fence specified.

4 When imbedding posts, braces, or anchors in concrete, install temporary guys or braces as required to hold the posts in proper position until the concrete sets. Use class B concrete in accordance with Subsection 513.4.4, Mix Design. The engineer may approve a local commercial mix. Do not install materials on posts set in concrete or place stress on guys or bracing until at least seven calendar days after placing concrete.

607.4.2 Wire Fence

607.4.2.1 Posts

1 For fences with wooden or plastic posts, add metal posts between regular posts at intervals no greater than 500 ft [150 m]. Install one metal post in any length of fence with over 200 ft [60 m] between openings. Set posts firmly and plumb. Remove and replace damaged posts.

607.4.2.1.1 Wooden Posts

1 Drive or tamp posts. If posts are driven, orient the small end of the post in the ground. Orient tamped posts with large (butt) end in the ground.

607.4.2.1.2 Plastic Fence Posts

1 Before starting, give the engineer two copies of the manufacturer's recommendations for installation. Set recycled plastic fence posts by digging, auguring, or driving. Instead of staples and nails, use laydown post clips and predrilled $^{3}/_{16}$-inch [5 mm] pilot holes to attach wire fence.

607.4.2.2 End Panels and Brace Panels

1 Place end posts, corner posts and brace posts with the large end (butt) in the ground. Notch posts to provide a flat bearing surface for cross braces.

2 Use cross braces as specified for the type of panel used and nail to each post with at least three 40d spikes. Bevel diagonal cross braces to obtain adequate bearing against the brace posts.

3 Use type I, II, or III end panels. When conditions prevent installing the deadman required for type I, use a type II or III. End panels placed in a corner installation may share a common end post. Install end panels at each termination of a fence run, change in direction, gate location, and other locations specified by the engineer.

4 When fencing around curves, place a brace panel at the beginning, end, and center of the curve. Depending on the curves radius and length, place additional brace panels at locations along the curve as specified by the engineer.

607.4.2.3 Wire Installation

1 Attach wire to posts as follows:

1. **Tangent Sections.** Place on the landowner's side of the post.
2. **Curves.** Place on the outside of the curve.

2 If a strand of wire touches the ground, tie it to the next higher wire, or change wire spacing with the engineer's approval. Firmly attach wire or fencing to posts and braces as specified. Stretch wire taut and install at the required elevations.

607.4.2.4 Stays

1 Use wire stays for barbed wire fence. Place them at midspan between posts and extend 2 in [50 mm] below the bottom wire. For woven wire fence, place wire stays at midspan between posts and extend from the top barbed wire to 6 in [150 mm] below the top of the woven wire as specified.

2 When specified, use wood stays meeting requirements for gate sticks. Space equally and place with the bottom touching the ground. Staple each wire to the stay.

607.4.2.5 Gates

607.4.2.5.1 General

1 Provide gate chains for gates wider than 4.5 ft [1.4 m] on right-of-way fence along access control roadways. The department will provide padlocks required for locked gates.

607.4.2.5.2 Wire Gates

1 Provide wire gates at approaches, cattle guards, and at least one wing fence on each side of the roadway at structure locations and other locations specified or determined by the engineer. When the wing fence is 50 ft [15 m] long or longer, the engineer may require an additional brace or end panel to support the gate.

2 Use the same barbed wire number and spacing as specified for the fence. Use a 6-barbed wire gate with a combination woven and barbed wire fence. For gate hinges and gate supports, use a double loop of 9-gage, galvanized, smooth, twisted wire.

3 Install a gate tightener on all gates. The engineer may approve the use of tighteners other than those specified. Construct tighteners for metal posts the same way and of the same material as for wooden posts.

4 Provide wire gates in accordance with Table 607.4.2-1, Length of Wire Gates.

Table 607.4.2-1
Length of Wire Gates

Location	Length ft [m]	Gate Sticks (equally spaced)
Approaches	16.5 [5.0]	4
Gates used by large farm and ranch machinery	20 or 24 [6.0 or 7.2] (as specified)	5
Separation structures and wing fences	12.0 [3.6]	3
Pedestrian access	4.5 [1.4]	2

607.4.2.5.3 Rail Gates

1 Provide rail gates in 24-inch [600 mm] increments. For double installations provide two gates of equal length. Provide vertical stays in accordance with Table 607.4.2-2, Rail Gate Vertical Stay Requirements.

Table 607.4.2-2
Rail Gate Vertical Stay Requirements

Gate Length ft [m]	Vertical Stays (equally spaced)
6, 8, and 10 [1.8, 2.4, and 3.0]	1 pair
12 and 14 [3.6 and 4.2]	2 pair
16 [4.8]	3 pair

2 Paint rail gates using either system in accordance with Subsection 501.4.1.24, Painting. Apply all coats in the shop or dip paint as per the manufacturer's recommendations for color and process.

607.4.2.6 Deadman Installation

1 Install a deadman at each specified location to adequately support the fence and in accordance with the deadman details associated with a type I end panel. Use one of the following:

1. A timber post with a diameter of at least 6 in [150 mm] and a length of at least 24 in [600 mm].
2. A stone with a weight [mass] of at least 100 lb [45 kg].
3. Concrete with a weight [mass] of at least 100 lb [45 kg].

607.4.2.7 Floodgates

1 Fasten floodgates so that flood debris will rip out the floodgate rather than the main fence.

607.4.3 Wing Fence

1 Install wing fences in accordance with the applicable portions of Subsection 607.4.2, Wire Fence, and at structures with equivalent diameter of at least 72 in [1800 mm], including stockpasses, box culverts, bridges, and other locations, as specified or directed by the engineer.

2 Tie wing fences to the structure with at least four strands of barbed wire extending from the end panel corners to four eye bolts set in the wingwalls, slope paving, or pipe ends. If the engineer determines the fence can be anchored to the structure to maintain integrity, the engineer may elect to eliminate an end panel or substitute a brace panel for an end panel. The engineer may eliminate the requirement to tie the end or brace panel to the structure if it can be butted tight against the structure to prevent animal passage and the end or brace panel is stable.

3 When attaching or abutting the wing fence to the structure is not possible, extend wing fences up, over, and back down the other side of the structure to prevent passage of game and livestock.

4 Construct a detachable fence section across the opening of the structure between wing fences for controlled access highways, at other specified locations, or as determined by the engineer, unless the structure requires continuous access as a stockpass.

607.4.4 Temporary Fence

1 If placing fence will interfere with construction, place temporary fence. Use the temporary fence type and configuration specified, and leave it in place at the completion of the contract. Temporary fence placed for contractor convenience will be at no additional cost to the department.

2 Install temporary fence in accordance with the applicable portions of Subsection 607.4.2, Wire Fence. Standard brace panels may be used in lieu of end panels. The department does not require gate tighteners for temporary fence wire gates.

607.4.5 Resetting Fence

1 Salvage material, including hardware, posts, brace panels and gates; if insufficient to complete the fence, provide additional new materials at no additional cost to the department.

2 When specified, reset gates by removing, salvaging, and reusing existing gates and hardware. Provide new materials as required at no additional cost to the department.

607.4.6 Industrial Fence

1 Install industrial fence where, and to the height, specified. Install two end panels connected at right angles for each corner installation, two brace panels connected in line for each brace installation, and one end panel for each end installation.

607.4.7 Wire Acceptance

1 For wire products used not meeting the specification requirements for the type of wire specified, the engineer will do one of the following:

1. Reject and require removal of the out-of-specification material at no additional cost to the department;
2. Accept and leave the material in place with the contractor's cost of the wire product deducted; or
3. Accept the material at a reduced unit price in accordance with the Materials Program's *Schedule of Price Adjustment for Out-of-Specification Wire Products* in effect at the time of the contract award. Obtain a copy from the Materials Program.

607.5 MEASUREMENT and PAYMENT

607.5.1 General

1 The engineer will measure:

1. Brace Panels, Brace Panels (_____), End Panels, and End Panels (_____) by the each. The measured number will not be reduced when adjoining brace and end panels share a common post. Both End Panels will be measured at corners.

2. Fence Type _____, Fence Industrial _____ in [mm], Fence Industrial _____ in [mm] (BW Top), Fence _____, Fence-Wing _____, and Reset Fence by the foot [meter] from the outside to outside of end posts for each continuous run of fence and reset fence using surface measurement, with no deduction in length for end panels, brace panels, wire fence gates, or reset gates.

3. Gates Industrial _____, Gates Galv Stl _____ ft [m], Gates Rail _____ ft [m], and Gates _____ by the each for the size and type specified and will deduct the lengths from the linear fence measurement. A double installation of rail gates will be measured as two gates. A double swing gate installation of industrial gates will be measured as two gates, each half the length of the specified opening width.

4. Reset Gates by the each, when specified.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Brace Panels	EA [Ea]	EA [Ea]	EA [Ea]
Brace Panels (_____)	EA [Ea]	EA [Ea]	EA [Ea]
End Panels	EA [Ea]	EA [Ea]	EA [Ea]
End Panels (_____)	EA [Ea]	EA [Ea]	EA [Ea]
Fence _____	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Fence Industrial _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Fence Industrial _____ in [mm] (BW Top)	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Fence Type _____	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Fence-Wing _____	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Gates _____	EA [Ea]	EA [Ea]	EA [Ea]
Gates Galv Stl _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]
Gates Industrial _____	EA [Ea]	EA [Ea]	EA [Ea]
Gates Rail _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]
Reset Fence	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Reset Gates	EA [Ea]	EA [Ea]	EA [Ea]

607.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for Fence Removal in accordance with Section 202, Removal; however, when reset is specified, removal will be incidental to resetting.

607.5.3 Price Adjustment

1 If the engineer accepts fence constructed with out-of-specification wire, the unit price will be adjusted in accordance with the Materials Program's *Schedule of Price Adjustment for Out-of-Specification Wire Products* in effect at the time of the contract award. Obtain a copy from the Materials Program.

SECTION 608
Minor Concrete Paving

608.1 DESCRIPTION

1 This section describes the requirements for constructing sidewalks, bike paths, median paving, ditch paving, and other minor paving.

608.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Admixtures	801.4
Aggregate for Concrete	803
Bed Course Material	803
Curing Material	802.1
Fly Ash	801.2
Joint Materials	807
Joint Sealer	807.1
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

608.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	**Subsection**
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

2 Use a slip-form machine that places, spreads, consolidates, screeds, and finishes the concrete in one pass, providing a dense and homogeneous section with minimal hand finishing.

608.4 CONSTRUCTION

608.4.1 General

1 Construct the foundation to a depth and width allowing for the installation and bracing of forms or operation of a slip-form paver. Compact the foundation to the requirements of Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control, and shape to the section specified. Remove soft and yielding material and replace with approved material.

2 Place concrete at least 4 in [100 mm] thick.

3 When welded wire fabric is specified, positively support reinforcing to minimize vertical or lateral movement of the fabric and place in accordance with Subsection 514.4.5, Placing and Fastening.

608.4.1.1 Placing Concrete

1 Use class B concrete in accordance with Subsection 513.4.4, Mix Design. The engineer may approve a local commercial mix. The department does not require aggregate gradation tests or cement sample submission.

2 Form, place, and consolidate concrete in accordance with applicable portions of Subsection 513.4, Construction, and as follows for the method of placement used:

1. **Formed Method.** Extend forms for the full depth of the concrete so that they are straight, free from warp, and strong enough to resist the pressure of the concrete without springing. Brace and stake forms to maintain horizontal and vertical alignment until removed. Treat forms with a release agent compatible with the concrete and the form.

2. **Slip-Form Method.** A slip-form machine may be used if the finished concrete meets the specified lines and grades and has the specified surface texture. Use the machine to shape, vibrate, and extrude the concrete for the full width and depth of the placement section and with a continuous forward movement. Use concrete of a consistency capable of maintaining the section's shape without support.

3 Finish outside edges of slab and joints with a ¼-inch [6 mm] radius edging tool. Finish sidewalks and bike paths with a light broom texture.

608.4.1.2 Joints

1 Space joints to coincide with joints in adjoining concrete. Construct joints in new concrete paving as follows:

1. **Contraction Joints.** Divide paving into sections by contraction joints formed with a jointing tool. Extend contraction joints into the concrete to at least one-third of the concrete's depth. Ensure a joint width of ⅛ in [3 mm]. Space contraction joints at 10-foot [3 m] intervals or at a distance equal to the paving width, whichever is less. If the paving width exceeds 10 ft [3 m], place a longitudinal contraction joint at the width's midpoint. Do not space transverse joints farther apart than this same distance of half the paving width.

2. **Expansion Joints.** Install expansion joints of the dimensions specified, filled with a preformed expansion joint material, at the following locations:

    2.1. Radius points;

    2.2. Junctions with existing concrete;

    2.3. Around rigid structures;

    2.4. In line with expansion joints in adjacent concrete pavement;

    2.5. At intervals not to exceed 150 ft [45 m] in continuous runs of concrete paving; and

    2.6. Between back of curb and sidewalk, if the adjacent roadway pavement is concrete and there is lateral constraint other than soil on the opposite side of the sidewalk.

    Use preformed joint material, ½ in [12 mm] thick, that extends the depth of the section. Seal with silicone joint sealant.

608.4.1.3 Curing

1 Cure concrete in accordance with applicable portions of Section 513.4.13, Curing Concrete. Do not allow pedestrian and vehicular traffic on concrete during curing.

608.4.2 Sidewalk and Curb Ramps

1 Construct sidewalks to provide accessibility consistent with ADA standards, current at the time of award, unless otherwise approved by the engineer. Provide sidewalk curb ramps at street intersections and other specified locations. Do not install drainage structure grates or access covers in sidewalk curb ramps.

2 Construct type I or type I modified sidewalk curb ramps. If conditions do not allow adequate clear right-of-way, type II or III may be constructed depending on specified sidewalk width and the engineer's approval.

3 Install ramps as close to the intersection as possible, within pedestrian crossing markings when present, and perpendicular to the curb section. Color concrete with red pigment where specified. Do not use surface treatment to obtain red color of the concrete.

608.4.3 Surface Tolerance

1 For sidewalks and bike paths, leave the finished surface without variation greater than $^{3}/_{16}$ in [5 mm] every 10 ft [3 m] in any direction; correct excess variation by removal and replacement or grinding.

608.5 MEASUREMENT and PAYMENT

608.5.1 General

1 The engineer will measure:

1. Concrete, Sidewalk (Conc), Bike Path (Conc), Median Paving (Conc), and Ditch Paving (Conc) by the square foot [square meter] or square yard [square meter] of paved surface. Measurement will be parallel to the paved surface.

2. Curb ramps as Sidewalk (Conc), including curb returns and interior curbs.

3. Driveways and approaches as Sidewalk (Conc), if the same thickness as the adjacent sidewalk.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Bike Path (Conc)	SF, SY [m^2]	0.1 ft, 0.1 ft [0.05 m]	SF, 0.1 SY [0.1 m^2]
Concrete	SF, SY [m^2]	0.1 ft, 0.1 ft [0.05 m]	SF, 0.1 SY [0.1 m^2]
Ditch Paving (Conc)	SF, SY [m^2]	0.1 ft, 0.1 ft [0.05 m]	SF, 0.1 SY [0.1 m^2]
Median Paving (Conc)	SF, SY [m^2]	0.1 ft, 0.1 ft [0.05 m]	SF, 0.1 SY [0.1 m^2]
Sidewalk (Conc)	SF, SY [m^2]	0.1 ft, 0.1 ft [0.05 m]	SF, 0.1 SY [0.1 m^2]

608.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Bed Course Material in accordance with Section 301, Aggregate Materials. Measurement specified by the cubic yard [cubic meter] will be based on neat lines.

2. The area of curb ramps located on the street side of the back-of-curb line as Curb and Gutter in accordance with Section 609, Curb and Gutter.

3. Driveways and approaches, including the sidewalk within the boundary of the driveway, as Double Gutter in accordance with Section 609, Curb and Gutter, when a thicker section than the adjacent sidewalk is specified.

4. Unclassified Excavation in accordance with Section 203, Excavation and Embankment.

SECTION 609
Curb and Gutter

609.1 DESCRIPTION

1 This section describes the requirements for constructing curb and gutter.

609.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Curing Materials	802.1
Fly Ash	801.2
Joint Materials	807
Joint Sealer	807.1
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

609.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

2 Use a slip-form machine capable of placing, spreading, consolidating, screeding, and finishing concrete in one complete pass, providing a dense and homogeneous section with minimal hand finishing. Ensure that the forming tube portion of the extrusion machine can be readily adjusted vertically during forward motion to produce a variable curb height matching the predetermined curb grade.

609.4 CONSTRUCTION

609.4.1 General

1 Construct the foundation to a depth and width allowing the installation and bracing of forms or operation of a slip-form paver. Compact the foundation in accordance with Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control, and shape to the section specified. Remove soft and yielding material and replace with approved material.

2 When constructing gutter next to existing pavement, locate the top front edge of the gutter flush with the top of the surfacing. If the top lift is wearing course, locate the top front edge flush with the contact point between the plant mix pavement and the wearing course or ¾ in [19 mm] below the wearing course surface, whichever is lower.

609.4.2 Placing Concrete

609.4.2.1 General

1 Coordinate concrete mixing, delivery, and spreading to ensure uniform progress.

2 Use class B concrete in accordance with Subsection 513.4.4, Mix Design. Form and place concrete in accordance with applicable portions of Subsection 513.4, Construction, modified as follows. Place concrete with forms or a slip-form machine. When the radius of the curb and gutter section is less than or equal to 40 ft [12 m], square the section off as specified. When placing concrete curb over a slotted drain, cover the slot to keep out foreign material. Do not allow the slot to extend above the flow line of the gutter section.

609.4.2.2 Formed Method

1 Place forms the full depth of the concrete, straight, and free from warp and to enable the inspection of grade and alignment. Brace and secure forms to maintain alignment and grade during concrete placement.

2 Place and consolidate concrete without segregation. Screed with a straightedge float.

609.4.2.3 Slip-Form Method

1 Use the machine to shape, vibrate, and extrude the concrete for the full width and depth of the section placed and with a continuous forward movement. Use concrete of a consistency capable of maintaining the curb's shape without support.

2 Indicate the grade for the top of the curb by an offset guide line set from survey marks. Attach a grade-line gauge or pointer to the machine to enable a continual comparison between the curb placed and the grade indicated by the offset guide line. Alternatively, maintain curb grade by operating the machine on rails or forms set at uniform depth below the predetermined finished top of the curb grade.

3 When placing curb, gutter, and concrete pavement monolithically, match the depth of the curb and gutter section to the pavement depth, and delete the longitudinal curb-and-gutter joint if the overall concrete slab width does not exceed 14 ft [4.2 m].

609.4.3 Joints

609.4.3.1 General

1 Construct joints at right angles to curb lines. Except sawed cuts, tool joint edges before final finishing.

609.4.3.2 Expansion Joints

1 Install preformed expansion-joint material at the following locations:

1. Radius points;
2. Junctions with existing concrete;
3. Around rigid structures;
4. In line with expansion joints in existing adjacent concrete pavement and at both sides of driveways; and
5. At intervals of 150 feet [45 m] or less in continuous runs of curb, curb and gutter, and double gutter.

6. Between back of curb and sidewalk, if the adjacent roadway pavement is concrete and there is lateral constraint other than soil on the opposite side of the sidewalk.

2 Use preformed joint material that is ½ in [12 mm] thick, shaped to fit the template, and extends the full depth of the section. Make joints true and straight, and ensure a snug fit of joint material. After curing, check material in each joint for tightness of fit. Mortar loose material in place and cure. Seal with silicone joint sealant.

609.4.3.3 Contraction Joints

1 Make contraction joints ⅛ in [3 mm] wide and from one-quarter to three-quarters the depth of the section. Space joints to coincide with joints in adjoining concrete and at intervals from 4 ft [1.2 m] to 10 ft [3 m].

609.4.3.4 Construction Joints

1 Make construction joints between curb and gutter and concrete pavement that are:

1. **Type Y** when no lateral constraint exists behind the curb.
2. **Type B** when full lateral constraint exists behind the curb.

2 The department considers the pouring of concrete against a foundation or other fixed object full lateral constraint. Soil is not considered full lateral constraint.

3 Place reinforcing steel required for type Y joints perpendicular to the curb face as specified.

609.4.4 Finishing

1 When using forms, trowel exposed surfaces smooth and give a fine brush finish with brush strokes parallel to the curb line. After removing forms, fill surface blemishes that will be exposed with grout and finish.

2 When using the slip-form method, remove blemishes and give surfaces that will be exposed in the completed item a fine brush finish with brush strokes parallel to the line of the curb.

609.4.5 Curing

1 Immediately after finishing, cure the curb and gutter for five calendar days using impervious curing compound or the water method in accordance with Subsection 513.4.13, Curing Concrete.

609.4.6 Surface Tolerance

1 Ensure that the finished top and face of the curb are true and straight and that the top surfaces are of uniform width and free from irregularities. Do not leave the finished surface with variation greater than $^{3}/_{16}$ in [5 mm] every 10 ft [3 m] in any direction. Correct excess variation by removing and replacing the curb section.

609.5 MEASUREMENT and PAYMENT

609.5.1 General

1 The engineer will measure:

1. Double Gutter by the square foot [square meter] or square yard [square meter], parallel to the finished surface between neat edge lines, making no deduction for appurtenances with less than one square yard [one square meter] surface area.

2. Special Curb Type _____ and Curb and Gutter Type _____ by the foot [meter] along the face of the curb, making no reduction in length for drainage structures installed in the curb such as catch basins, drop inlets, etc.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Curb and Gutter Type _____	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Double Gutter	SF, SY [m^2]	0.1 ft, 0.1 ft [0.05 m]	SF, 0.1 SY [0.1 m^2]
Special Curb Type _____	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

609.5.2 Pay Adjustment

1 When the engineer requires an increased thickness for items paid for by area, the quantity for payment will be computed by multiplying the actual area by the relationship of the increased thickness to the specified thickness.

SECTION 610
Metal Drain Inlets

610.1 DESCRIPTION

1 This section describes the requirements for furnishing and constructing metal drain inlets.

610.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Bolts, Nuts and Washers	815.2.1
Corrugated Aluminum Alloy Culvert Pipe	808.6
Corrugated Metal Units	808.7
Corrugated Steel Pipe and Pipe Arches	808.5
Galvanized Coating	815.14
Rubber Gaskets	808.15

610.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

610.4 CONSTRUCTION

1 Install metal drain inlets in the completed embankment slope at specified locations or as staked by the engineer. Do not order pipe before the engineer checks pipe lengths and elbow angles in the field. Use pipe of any material specified above. Use metal inlet units.

2 Excavate a trench in the embankment slope of sufficient width for pipe and fixture installation. Install the metal drain inlet, elbows, drain pipe, and metal drain outlet and connect with coupling bands to provide a complete drainage unit. Make joints watertight by installing flat rubber gaskets at each joint.

3 After installing metal drain inlet, backfill the trench to the original slope line in accordance with Subsection 206.4.5, Backfilling. Compact backfill material to at least the density of the adjacent embankment.

4 When stilling basins are specified or required by the engineer, use erosion control concrete in accordance with Subsection 614.4, Construction.

610.5 MEASUREMENT and PAYMENT

610.5.1 General

1 The engineer will measure:

1. Metal Drain Pipe by the foot [meter] from end to end, in place. The pay length will not exceed the length staked.

2. Metal Drain Inlet units by the each.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Metal Drain Inlet	EA [Ea]	EA [Ea]	EA [Ea]
Metal Drain Pipe	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

610.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for Erosion Control Concrete in accordance with Section 614, Erosion Control Concrete.

SECTION 611
Highway Monuments

611.1 DESCRIPTION

1 This section describes the requirements for furnishing and installing highway monuments.

611.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Curing Materials	802.1
Fly Ash	801.2
Joint Materials	807
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

2 Provide highway monument posts of precast, reinforced concrete. Provide tablets meeting U.S. Army Corps of Engineers Type 1 disc with the classic 3-inch [75 mm] long split style tapered stem. Ensure the tablet is orbital-formed from solid, unleaded silicon-bronze bar and has a completely smooth top and polished appearance with no raised markings or visible surface defects.

3 Use class B concrete in accordance with Subsection 513.4.4, Mix Design, but with the substitution of type V portland cement.

4 Ensure right angles are fabricated with a ¾-inch [19 mm] chamfer.

611.3 EQUIPMENT—Vacant

611.4 CONSTRUCTION

611.4.1 General

1 Do not remove monuments until approved by the engineer. Removed monuments become the contractor’s property.

2 Accurately locate highway monuments within the engineer's staked reference points, and hold them in true position during placement. Set monuments plumb with the designated post length above ground and, with backfill, firmly tamp into place. Place polyethylene survey marker signs along side of the monuments as specified. The department will complete monument marking.

611.5 MEASUREMENT and PAYMENT

1 The engineer will measure Highway Monuments by the each.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Highway Monuments	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 612
Siphons

612.1 DESCRIPTION

1 This section describes the requirements for constructing inverted pipe siphons.

612.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Bolts, Nuts and Washers	815.6
Corrugated Metal Units	808.7
Corrugated Steel Pipe and Pipe-Arches	808.5
Corrugated Steel Siphon Pipe	808.10
Curing Materials	802.1
Fly Ash	801.2
Galvanized Coating	815.14
Joint Materials	807
Portland Cement	801.1
Reinforced Concrete Siphon Pipe	808.3
Reinforcing Steel	811.1
Rubber Gaskets	808.15
Structural Steel	815.1
Water	814
Welded Steel Siphon Pipe	808.11

2 For drain valves, provide solid wedge gate valves with flanged, iron bodies, bronze-mounted, nonrising stems with operating nuts, and a rating of at least 50 psi [345 kPa]. Provide a handle for valve operation.

612.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

612.4 CONSTRUCTION

612.4.1 Shop Drawings

1 Submit shop drawings for siphon pipe, including recommended installation procedures, to the State Bridge Engineer in accordance with Subsection 105.2, Working Drawings.

2 For reinforced-concrete pipe siphons, ensure that the siphon pipe fabricator calculates the allowable leakage value for acceptance testing in accordance with exfiltration requirements of ASTM C 969 [ASTM C 969M] and converts this value from gallons [liters] of water to a drop in water elevation below the outlet flowline. Include this value with the installation procedures.

612.4.2 Excavation

1 Excavate trenches in accordance with Subsection 206.4.1.1, Culvert Excavation.

612.4.3 Installation of Pipe

1 Prepare bedding in accordance with Subsection 603.4.4, Pipe Bed Preparation, for class C installation. Place bell ends of welded steel siphon pipe and plastic siphon pipe and outside circumferential laps of corrugated steel siphon pipe facing upstream. Place corrugated steel siphon pipe with longitudinal laps at the sides.

2 Install magnesium anodes at specified locations along welded steel pipe siphons to provide cathodic protection. Test for electrical continuity before backfilling.

3 Repair damage to the protective coating of the pipe by priming the areas with approved coal tar paint then applying hot coal tar enamel in accordance with AWWA C203. Do not field-coat damaged parts in air temperatures below 30 ºF [0 ºC] unless using an approved method of protection and heating.

4 Do not use damaged plastic siphon pipe; the engineer will reject it.

612.4.4 Couplings

1 Use "O-Ring" type couplings for welded steel pipe siphons. Protect field joints by applying primer and wrapping them with two thicknesses of 10-inch [250 mm] wide protective tape.

2 Join corrugated steel siphon pipe by placing concrete collars.

3 For reinforced concrete pipe siphons, use bell-and-spigot couplings with a rubber gasket. Form couplings entirely of concrete with a positive groove in the spigot to contain the gasket.

4 When specified, place concrete collars at each joint. Use class B concrete in accordance with Subsection 513.4.4, Mix Design. Form and place concrete in accordance with applicable portions of Subsection 513.4, Construction. Place reinforcing steel in accordance with Section 514, Reinforcing Steel.

612.4.5 Testing

1 Before backfilling over siphon pipe, test the entire installation as follows:

1. **Corrugated, Plastic, and Welded Steel Pipe**

    1.1. Fill siphon structure with water to the outlet flow line level.

    1.2. Repair evident leaks, refill to the flow line, and let stand for at least 24 hours.

    1.3. If there is no apparent water loss during the 24-hour test period, backfill the trench. If there is water loss, repair leaks and repeat the test.

    1.4. Where it is impractical to divert traffic around the full length of the siphon structure, construct, test using the same test head, and backfull a portion of the structure.

2. **Concrete Pipe**

    2.1. Fill the siphon structure with water to the outlet flow line level and let stand for 24 hours.

2.2. Refill to the outlet flow line and let stand for another 24 hours. If the water level is within the allowable leakage value shown on the shop drawings, backfill the trench.

2.3. If the water level is above the allowable water elevation value shown on the shop drawings, backfill the trench.

2.4. If the water level is below the allowable water elevation value as determined by the fabricator, repair the siphon and repeat the test.

2.5. Where it is impractical to divert traffic around the full length of the siphon structure, construct, test using the same test head, and backfill a portion of the structure. Obtain the maximum acceptable drop in water level for the tested portion from the pipe fabricator, determined in accordance with ASTM C 969 [ASTM C 969M], and have it approved by the State Bridge Engineer.

612.4.6 Inlet and Outlet Structures and Drain Boxes

1 When specified, use class B concrete for inlet and outlet structures and drain boxes in accordance with Subsection 513.4.4, Mix Design. Form, place, and cure concrete in accordance with applicable portions of Subsection 513.4, Construction. Place siphon pipe sections flush with the inside of the structure wall and projecting far enough outside to properly connect with the next pipe section.

2 Provide and place reinforcing steel in accordance with Subsection 514.4, Construction.

3 Construct drain boxes with a steel lid and ladder rungs, as specified, to access the drain valve.

4 Provide trash guards, drain box lids, ladder rungs, and other similar steel items in accordance with Subsection 501.4, Construction, and galvanized in accordance with Subsection 501.4.1.25, Galvanizing.

612.4.7 Backfill

1 Place and compact backfill in accordance with Subsection 206.4.5, Backfilling.

612.5 MEASUREMENT and PAYMENT

612.5.1 General

1 The engineer will measure:

1. Corr Stl Siphon Pipe _____ in [mm], Plastic Siphon Pipe _____ in [mm], RCP Siphon _____ in [mm], and Welded Stl Siphon Pipe _____ in [mm] by the foot [meter] along the invert from end to end of pipe.

2. Corr Stl Siphon FE Sect _____ in [mm] and RCP Siphon FE Sect _____ in [mm] by the each for each size specified.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Corr Stl Siphon Pipe _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Corr Stl Siphon FE Sect _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
Plastic Siphon Pipe _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
RCP Siphon _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
RCP Siphon FE Sect _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]
Welded Stl Siphon Pipe _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

612.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Class B Concrete required for constructing inlet and outlet structures and drain boxes in accordance with Section 513, Structural Concrete.
2. Reinforcing Steel required for constructing inlet and outlet structures and drain boxes in accordance with Section 514, Reinforcing Steel.
3. Drain box lids, ladder rungs, and similar steel items in accordance with the contract.
4. Trash Guards in accordance with Section 619, Trash Guards.

SECTION 613
Latex Emulsion Paint for Concrete

613.1 DESCRIPTION

1 This section describes the requirements for latex emulsion paint.

613.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Latex Emulsion Paint	809.8

613.3 EQUIPMENT—Vacant

613.4 CONSTRUCTION

613.4.1 Surface Preparation

1 Give concrete surfaces a rubbed finish in accordance with Subsection 513.4.12, Finishing Concrete Surfaces.

2 Clean surfaces before painting.

3 Where applicable, protect concrete surfaces that have been or will be painted with latex from structural steel paint overspray.

613.4.2 Application

1 Allow the paste from surface preparation to set at least 24 hours. Saturate the surface with water and paint while damp but not showing free water. Do not mix sand with paint. Apply at least two coats at a rate of approximately 350 ft^2/gal [9 m^2/L] for the first coat and from 400 ft^2/gal [10 m^2/L] to 500 ft^2/gal [12 m^2/L] for the second. Apply additional coats as necessary for uniform coverage and appearance. Paint when the air temperature is at least 50 ºF [10 ºC] and only with rollers or brushes.

613.5 MEASUREMENT and PAYMENT

613.5.1 General

1 The engineer will measure Ltx Emulsion Paint (Conc) as a complete unit in place.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Ltx Emulsion Paint (Conc)	LS	LS	LS

SECTION 614
Erosion Control Concrete

614.1 DESCRIPTION

1 This section describes the requirements for concrete invert paving and erosion control concrete.

614.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Asphalt Mastic for Field Coating	804.5
Curing Materials	802.1
Fly Ash	801.2
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

614.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

614.4 CONSTRUCTION

614.4.1 General

1 Perform minor grading required to place erosion control concrete in accordance with Subsection 203.4.1, Excavation and Embankment, Construction, General.

2 Use class B concrete in accordance with Subsection 513.4.4, Mix Design. The engineer may approve a local commercial mix. The department does not require a cement sample or aggregate gradation tests.

3 Mix, form, and place concrete in accordance with applicable portions of Section 513.4, Construction. Finish surfaces to a coarse texture.

614.4.2 Invert Paving

1 On a thoroughly cleaned surface, place and screed concrete to form a paved section of designated width. Ensure that the final surface of invert paving is parallel with the flow line and level or slightly-dished transversely with the pipe centerline. Coat aluminum pipe surfaces to be invert-paved with an asphalt mastic.

614.4.3 Chutes and Stilling Basins

1 Unless the ground can be graded to a neat section with uniform grades, use forms to construct chutes, stilling basins, or similar items. Excavate the trench or basin to necessary limits and grade to the specified shape. If required to reduce flow velocity, score the surface or otherwise leave a rough surface texture. Hand-tool contraction joints at intervals of 10 ft [3 m]. Ensure a joint depth equal to at least one-third of the thickness of concrete and a width of ⅛ in [3 mm].

614.4.4 Ditch Checks

1 When placing concrete in a trench, excavate to specified lines and grades with sides as vertical as practical. Form exposed edges above the finished grade to leave neat lines.

614.4.5 Curing

1 After finishing concrete, cure in accordance with Subsection 513.4.13, Curing Concrete. When using a curing compound, apply at a rate of 1 gal/150 ft² [1 L /3.5 m²].

614.5 MEASUREMENT and PAYMENT

1 The engineer will measure Erosion Control Concrete by the cubic yard [cubic meter] based on batch volumes ordered and placed.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Erosion Control Concrete	CY [m^3]	0.25 CY [0.25 m^3]	0.1 CY [0.1 m^3]

SECTION 615
Cattle Guards

615.1 DESCRIPTION

1 This section describes the requirements for constructing and resetting cattle guards and replacing cattle guard grill units.

615.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Bolts, Nuts and Washers	815.6
Curing Materials	802.1
Fence Posts	812.8
Fly Ash	801.2
Galvanized Coating	815.14
Joint Materials	807
Metal Delineator Posts	816.5
Paint	809
Portland Cement	801.1
Prefabricated Cattle Guard Units	812.6.1
Reinforcing Steel	811.1
Structural Steel	815.1
Water	814.1
Welded Grill Cattle Guard Units	812.6.2

615.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

615.4 CONSTRUCTION

615.4.1 General

1 Ensure that plants providing precast concrete foundations are certified in accordance with Subsection 502.4.1, Plant Certification.

2 Use galvanized bolts, fasteners, and associated hardware. Connect existing fences to new and reset cattle guards.

3 The department specifies minimum outside dimensions of cattle guard grill units. At no additional cost to the department, and with proper adjustments to the foundation dimensions, units with dimensions up to 6 in [150 mm] larger than the specified minimum may be provided.

615.4.2 Excavation

1 Excavate in accordance with Section 212, Structure Excavation and Backfill. Provide enough space for the proper installation of forms or precast sections. When specified, excavate the area under the unit to provide drainage through the end of the foundation opposite the gate.

2 When installing on new embankment, bring the fill to grade in accordance with Subsection 203.4.3, Embankment and Cut Areas with Moisture and Density Control, then excavate for the foundation unit.

615.4.3 Foundations

1 Use precast or cast-in-place foundations made with class B concrete or better, in accordance with Subsection 513.4.4, Mix Design. Form, mix, and place concrete in accordance with applicable sections of Subsection 513.4, Construction. Give exposed concrete an ordinary finish.

2 Construct foundations to match the roadway cross-slope. If necessary, and with the engineer’s approval, adjust the elevation of the end support seats and backwall. For a crowned roadway with an odd number of grill units specified, place the center grill level and slope outside units to match the roadway. Adjust foundation units accordingly.

3 Provide and place reinforcing steel in accordance with Section 514, Reinforcing Steel. Extend steel into the lateral supports when cast-in-place.

4 Place adjacent backfill in 8-inch [200-mm] layers and compact in accordance with Subsection 212.4.7, Backfill.

615.4.4 Grill Units and Wings

1 Fabricate grill units and wings in accordance with Subsection 501.4.1, Fabrication, with the exception that they may be fabricated at the site. The department does not require shop inspection or drawings.

2 Clean and paint grill units, wings and miscellaneous hardware in accordance with the applicable portions of Subsection 501.4.1.24, Painting, or Subsection 501.4.2.8, Field Painting. Required coats may be applied in the shop or field. Use brown for the final coat.

3 Install grill units and wings as specified. Leave no more than ⅜ in [10 mm] of vertical distortion between the grill unit and a plane parallel to the foundation surface. Fabricate and install cattle guard swing-wings as specified.

615.4.5 Resetting and Replacing Cattle Guards

1 When specified for resetting, dismantle and reset existing cattle guards. Provide new hardware for connectors as required. Replace or repair portions damaged during removal.

2 When specified, replace grill units by removing and replacing with a new unit of the same size and type. Modify foundations as required.

615.4.6 Delineation

1 Use type IV delineators to mark cattle guard corners. For two-way traffic, install delineators on all four corners. An approach is considered a two-way traffic condition. For one-way traffic, install two delineators on the side of on-coming traffic.

615.5 MEASUREMENT and PAYMENT

615.5.1 General

1 The engineer will measure Cattle Guard (Heavy Duty) _____ ft [m], Cattle Guard (Medium Duty) _____ ft [m], Reset Cattle Guard, Reset Cattle Guard (Heavy Duty) _____ ft [m], Replace Cattle Guard Grill (Heavy Duty) _____

ft [m], Reset Cattle Guard (Medium Duty) _____ ft [m], Replace Cattle Guard Grill (Medium Duty) _____ ft [m], and Cattle Guard Swing-Wing by the each as a complete unit.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Cattle Guard (Heavy Duty) _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]
Cattle Guard (Medium Duty) _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]
Cattle Guard Swing-Wing	EA [Ea]	EA [Ea]	EA [Ea]
Replace Cattle Guard Grill (Heavy Duty) _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]
Replace Cattle Guard Grill (Medium Duty) _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]
Reset Cattle Guard	EA [Ea]	EA [Ea]	EA [Ea]
Reset Cattle Guard (Heavy Duty) _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]
Reset Cattle Guard (Medium Duty) _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]

615.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for cattle guard removal in accordance with Section 202, Removal; however, when reset is specified, removal will be incidental to resetting.

SECTION 616
Snow Fence

616.1 DESCRIPTION

1 This section describes the requirements for constructing and resetting snow fence.

616.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Bolts and Fasteners	815.6
Line Posts	812.8
Reinforcing Steel	811.1
Timber and Lumber	817.1

2 Provide Lodgepole Pine, Ponderosa Pine, Engelmann Spruce, Douglas Fir, Hem-Fir, or Western Larch rough-dimension lumber. For 1-inch [25 mm] lumber, provide Western Wood Products Association (WWPA) No. 3 or better, treated or untreated. For 2-inch [50 mm] lumber, provide WWPA No. 2 or better, and when used for line posts and sill-and-frame assemblies, provide treated lumber. Use treated timber that is dried to a moisture content of 19 percent after treatment.

3 Provide anchor angles of structural carbon steel in accordance with ASTM A 36 [ASTM A 36M] requirements. Provide bolts with washers and nylon-insert locknuts. Use plated nails in accordance with ASTM B 633, SC3 or ASTM A 641 [ASTM A 641M], class I coating. Use grade 60 [400] reinforcing steel in the anchorage system.

4 Provide galvanized bolts and fasteners.

616.3 EQUIPMENT—Vacant

616.4 CONSTRUCTION

616.4.1 New Snow Fence

1 The department specifies the minimum number of washers. As required, provide additional washers, and adjust bolt lengths to provide a minimum of 1 thread

and a maximum of ½ in [13 mm] of thread exposed beyond the outside end of the nut when components are assembled clamp-tight. Do not crush wood fibers by over-tightening.

2 Place reinforcing steel anchors as specified and drive to prevent panels from sliding or overturning. Remove and replace anchors that are not tight against the anchor angle.

3 Where rock hinders the driving of anchor bars, anchor in the rock. Drill a 1-inch [25 mm] diameter hole at least 6 in [150 mm] deep into solid rock and remove dust and loose material. Install bars in holes using epoxy resin grout, as approved by the engineer and in accordance with the manufacturer's recommendations.

4 Fasten the rock anchor bars to the frame as specified; they may be perpendicular to the sill. Ensure that rock-anchored bars extend above ground to the same height as driven anchor bars. If driving anchors is not possible, install four rock anchors per panel with two rock anchors for each outer sill. Replace and compact soil removed for rock drilling.

5 Place line posts in holes excavated to specified dimensions. Backfill holes to finished ground in approximately 6-inch [150 mm] compacted layers. The engineer may approve the driving of posts.

6 Place panels to equally distribute weight [mass] to the uprights and with a continuous bearing surface under each sill. Grade to obtain proper bearing. Overlap panels to eliminate spaces.

616.4.2 Removing and Resetting Snow Fence

1 As specified, remove snow fence, including hardware, posts, and panels, and reset. Before resetting, inspect each panel for damage and repair as directed by the engineer. Repair damage incurred during resetting at no additional cost to the department. Panels removed but not reset become the property of the contractor.

616.5 MEASUREMENT and PAYMENT

616.5.1 General

1 The engineer will measure:

1. Reset Snow Fence and Snow Fence (Wood) _____ ft [m] by the each for each fence panel constructed or reset.

2. Snow Fence Repair for panels damaged prior to removal in accordance with Subsection 109.4, Extra and Force Account Work.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Reset Snow Fence	EA [Ea]	EA [Ea]	EA [Ea]
Snow Fence Repair	$$	0.01 $$	0.01 $$
Snow Fence (Wood) _____ ft [m]	EA [Ea]	EA [Ea]	EA [Ea]

616.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for Removal of Snow Fence Panels in accordance with Section 202, Removal; however, when reset is specified, removal will be incidental to resetting.

SECTION 617
Cut-Off Walls and Head Walls

617.1 DESCRIPTION

1 This section describes the requirements for constructing concrete cut-off walls and head walls.

617.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Bolts and Fasteners	815.6
Curing Materials	802.1
Fly Ash	801.2
Galvanized Coating	815.14
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

617.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

617.4 CONSTRUCTION

1 Use class B concrete or better in accordance with Subsection 513.4.4, Mix Design. Form, mix, place, and cure concrete in accordance with Subsection 513.4, Construction.

2 Construct head walls and cut-off walls perpendicular to the pipe. For corrugated metal pipe, install anchor bolts as specified and prior to concrete placement. Head walls may be poured monolithically or with the footing or cut-off portion and wall or slope paving poured independently. If poured independently, provide a key way as specified and in accordance with Subsection 513.4.11.3, Joints.

3 Provide and place reinforcing steel in accordance with Section 514, Reinforcing Steel. Field-cut vertical and horizontal steel to maintain a clearance of at least 2 in [50 mm] vertically and horizontally around the pipe.

4 Grade fill slopes to match head wall, cut-off wall, or both.

617.5 MEASUREMENT and PAYMENT

1 The engineer will measure Cut-Off Wall (Conc) and Head Wall (Conc) by the cubic yard [cubic meter], using the neat lines specified for the computed volume of concrete. Volumes occupied by reinforcing steel and anchor bolts will not be deducted from the concrete volume. The volume occupied by the pipe's outside diameter will be deducted.

2 When a head wall consists of a cut-off wall portion and slope paving, the entire installation will be measured as a Head Wall (Conc).

3 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Cut-Off Wall (Conc)	CY [m^3]	0.1 ft [0.05 m]	0.1 CY [0.1 m^3]
Head Wall (Conc)	CY [m^3]	0.1 ft [0.05 m]	0.1 CY [0.1 m^3]

SECTION 618
Precast Reinforced Concrete Stock Passes

618.1 DESCRIPTION

1 This section describes the requirements for constructing precast reinforced concrete stock passes.

618.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Bolts and Fasteners	815.6
Portland Cement	801.1
Curing Materials	802.1
Fly Ash	801.2
Galvanized Coating	815.14
Reinforced Concrete Stock Passes	808.2
Reinforcing Steel	811.1
Water	814.1

618.3 EQUIPMENT—Vacant

618.4 CONSTRUCTION

1 Provide precast reinforced concrete stock pass sections from plants certified in accordance with Subsection 502.4.1, Plant Certification. The department will not accept dry-cast precast members. Provide sections that vary from specifications no more than:

1. 1 percent for internal dimensions;
2. ¼ in [6 mm] for haunch dimensions;
3. 5 percent less for slab and wall thicknesses; and
4. ¾ in [19 mm] for lengths of two opposite surfaces of the box section, except where bevel ends are specified.

2 Before shipping, shop-assemble at least three sections to verify that joint fit meets the requirements specified for final assembly.

3 Excavate for stock passes in accordance with Subsection 206.4.1.1, Culvert Excavation. Shape and uniformly compact the trench bottom to support the length and width of the stock pass and flared end sections at the established line and grade.

4 Install stock pass and end sections with joints tightly closed. When specified, use galvanized tie bolts and fasteners to join flared end sections to end culvert sections.

5 When assembled in their final positions, do not allow a gap between sections or a misalignment of walls, top slabs, and bottom slabs greater than ½ in [12 mm] for more than 6 in [150 mm] at one location or 12 in [300 mm] total for multiple locations. Measure misalignment perpendicular to slabs and walls.

6 Backfill the stock pass in accordance with Subsection 206.4.5, Backfilling.

618.5 MEASUREMENT and PAYMENT

1 The engineer will measure:

1. RC Stock Pass _____ × _____ in [mm] by the foot [meter] along the invert centerline, not including flared end sections. The measured length will not exceed the length staked.

2. RC Stock Pass FE Sect _____ × _____ in [mm] by the each installed, per end, regardless of the number of sections required to complete a flared end assembly.

2 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
RC Stock Pass _____ × _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
RC Stock Pass FE Sect _____ × _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 619
Trash Guards

619.1 DESCRIPTION

1 This section describes the requirements for furnishing and installing trash guards.

619.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Bolts and Fasteners	815.6
Structural Steel	815.1
Paint	809

619.3 EQUIPMENT—Vacant

619.4 CONSTRUCTION

1 Fabricate in accordance with Section 501, Structural Steel, with the exception that they may be fabricated at the site. The department does not require shop inspection or drawings.

2 Clean and paint trash guards and brackets in accordance with the relevant portions of Subsection 501.4.1.24, Painting, or Subsection 501.4.2.8, Field Painting. Required coats may be applied in the shop or field. Use brown for the final coat.

3 Fasten trash guards to the pipe as specified. When required, the department will provide padlocks for the locking bar.

619.5 MEASUREMENT and PAYMENT

1 The engineer will measure Trash Guard _____ by the each, for each type installed.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Trash Guard _____	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 620
Adjustment of Valve Boxes and Fire Hydrants

620.1 DESCRIPTION

1 This section describes the requirements for adjusting valve boxes, fire hydrants, and associated waterlines.

620.2 MATERIALS

1 Provide materials in accordance with the following:

Material	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Aggregate for Flowable Backfill	803
Bed Course Material	803
Curing Materials	802.1
Ductile Iron Water Pipe	808.12
Fly Ash	801.2
Portland Cement	801.1
Water	814.1

2 Provide polyvinyl chloride pressure pipe and associated fittings that meet the requirements of AWWA C900, AWWA C905, or AWWA 907 as appropriate.

620.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

620.4 CONSTRUCTION

620.4.1 General

1 Adjust valve boxes and fire hydrants in accordance with the installation and material standards of the current *Wyoming Public Works Standard Specifications* and the owner.

2 Lay waterlines associated with adjustments on undisturbed material in trenches wide enough for proper installation and testing. Excavate in accordance with Subsection 206.4.1, Excavation. When excavating below grade, place, shape, and compact bed course material as specified.

3 Before starting work, give the engineer and owner 24-hour notice. Do not start without the owner's approval. Give notification for connections, service interruptions, line cleaning, pressure testing, and system disinfection. Minimize service interruptions, and notify users two hours or more before interrupting service. Unless otherwise required by the owner, notify fire departments 24 hours before interrupting service to hydrants.

4 Handle pipe, valves, and fixtures without causing damage; keep clean and store to prevent damage and excessive handling. Remove damaged or unsuitable material from the project.

5 Inspect each pipe joint or fixture and clean the inside before lowering into the trench. Prevent contaminants from entering during installation. Drain or pump water encountered during laying so that it does not enter the pipe.

6 Center each joint, fit tightly, and fasten in accordance with manufacturer's recommendations.

620.4.2 Adjustments of Waterlines, Valves, Valve Boxes, and Fire Hydrants

1 When specified, adjust existing waterlines, valves, and hydrants for grades, locations, and street elevations. Remove and adjust items carefully to enable reuse. When salvaged items cannot be reused, install new items that meet specified requirements and the waterline owner's specifications and standards. Place a concrete collar around valve boxes in accordance with the applicable sections of the current edition of *Wyoming Public Works Standard Specifications*.

620.4.3 Testing and Disinfecting Lines

1 Test and disinfect lines before backfilling in accordance with applicable municipal requirements or as specified.

620.4.4 Thrust Blocks

1 Brace fixtures that could blow off the line under pressure with a cast-in-place wedge block of class B concrete in accordance with Subsection 513.4.4, Mix Design. Mix and place in accordance with applicable portions of Subsection 513.4, Construction. Cast the block between the fixture and undisturbed vertical trench wall in accordance with municipal requirements or as specified.

620.4.5 Backfilling

1 Do not place backfill containing rock or hard lumps larger than 2 in [50 mm] alongside or within 12 in [300 mm] of the pipe's top. Place and compact backfill in accordance with Subsection 206.4.5, Backfilling, or, if the waterline is not located in the roadway, to at least the density of the adjacent material. When specified, use flowable backfill in accordance with Subsection 206.4.5.2, Flowable Backfill. During backfilling, brace hydrants, valve boxes, or other vertical fixtures and adjust the fixture's top to correspond with the fixture's established elevation.

620.5 MEASUREMENT and PAYMENT

1 The engineer will measure Valve Boxes _____ in [mm]; Fire Hydrant; Adjustments, Fire Hydrants; Adjustments, Valve Boxes; and Thrust Blocks by the each.

2 The department will measure and pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Adjustments, Fire Hydrants	EA [Ea]	EA [Ea]	EA [Ea]
Adjustments, Valve Boxes	EA [Ea]	EA [Ea]	EA [Ea]
Fire Hydrant	EA [Ea]	EA [Ea]	EA [Ea]
Thrust Blocks	EA [Ea]	EA [Ea]	EA [Ea]
Valve Boxes _____ in [mm]	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 621
Vacant

SECTION 622
Structural Plate Pipe

622.1 DESCRIPTION

1 This section describes the requirements for constructing structural plate pipe, pipe arches, stock passes, and underpasses.

622.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	**Subsection**
Aluminum Alloy Structural Plate Pipe	808.9
Asphalt Mastic for Field Coating	804.5
Class B Bedding	803
Galvanized Coating	815.14
High-Strength Bolts and Fasteners	815.2
Structural Plate Pipe	808.8

622.3 EQUIPMENT

1 For applying asphalt mastic, provide equipment that uses a high-pressure spray.

622.4 CONSTRUCTION

622.4.1 General

1 Use galvanized bolts, washers, and nuts. Use bolts long enough to engage the full length of the nut.

2 Cover pipes to prevent damage during construction.

622.4.2 Size and Thickness Designations

1 The department specifies sizes based on steel plate structures and will accept aluminum alloy structural plate pipe structures as an alternate. Determine aluminum alloy structure size from the specified Equivalent Size Table. For steel or aluminum, determine the plate thickness by the fill heights, or provide thicker-gage metal at no additional cost to the department.

2 Use equally thick plates within a structure. In elliptical structures, use a bottom plate or plates wide enough to provide at least 10 percent of the structure periphery with the heaviest thickness specified. For pipe-arches, stock passes, and underpasses, use bottom plates (including corner plates) of the heaviest thickness specified.

3 Fourteen calendar days before fabrication, submit four sets of installation drawings to the engineer. Show proposed details for structural plates, the locations of bolt holes, and the type, size, thickness, and number of plates, bolts, and washers. Match mark plates that are not standard. Show match marks on the installation drawings.

4 Obtain fill heights and pipe lengths from the engineer before ordering.

622.4.3 Excavation and Bed Preparation

1 Excavate in accordance with Subsection 206.4, Excavation. Place the structure on an earth foundation of uniform density.

2 For structures with a specified corner pressure of 3 ton/ft^2 [300 kPa], prepare bedding in accordance with a class B installation in Subsection 603.4.4, Pipe Bed Preparation. Prepare as class C bedding for other installations.

622.4.4 Assembly of Plates

1 Assemble plates and tighten bolts in accordance with the manufacturer's recommendations for the type of structure. Torque bolts from 100 ft•lbs [135 N•m] to 300 ft•lbs [405 N•m].

2 Before extending an existing structural plate pipe with a beveled end section, remove individual plates to obtain a near-vertical end.

622.4.5 Field Coating

1 When specified, field-coat structural plate pipe with asphalt mastic; coat interior and exterior pipe faces and steel mitered ends. Before coating, remove foreign matter from surfaces. Apply uniformly to obtain a thickness of at least 0.05 in [1300μm], measured on corrugation crests. Apply with high-pressure spraying equipment. Brush or trowel in small areas where spraying is impractical. The underside of bottom plates may be coated during assembly.

622.4.6 Backfilling

1 Place and compact in accordance with Subsection 206.4.5, Backfilling. Completely backfill and compact below corner plates.

622.5 MEASUREMENT and PAYMENT

622.5.1 General

1 The engineer will measure Structural Plate Pipe _____ in [mm], Structural Plate Pipe-Arch _____ × _____ in [mm], and Structural Plate Stock Pass _____ × _____ in [mm] by the foot [meter] along the invert centerline from end to end. The length for payment will not exceed the length staked.

2 The engineer will measure structural plate pipe extensions after removal of the existing beveled end section, if applicable, from the end of the existing pipe along the invert to the end of the new pipe.

3 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Structural Plate Pipe _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Structural Plate Pipe-Arch _____ × _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]
Structural Plate Stock Pass _____ × _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

SECTION 623
Vacant

SECTION 624
Vacant

SECTION 625
Manholes, Inlets, Catch Basins, and Diversion Boxes

625.1 DESCRIPTION

1 This section describes the requirements for constructing manholes, inlets, catch basins, and diversion boxes.

625.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Asphalt Mastic for Field Coating	804.5
Curing Materials	802.1
Fly Ash	801.2
Frames, Grates, and Covers	815.20
Galvanized Coating	815.14
Joint Material	807
Paint	809
Pipe Joint Mortar	808.14
Portland Cement	801.1
Manhole Risers and Tops	808.1
Reinforcing Steel	811.1
Slide Gates	808.17
Structural Steel	815.1
Structural Timber and Lumber	817.1
Water	814.1

2 Provide Douglas Fir timber for stop gates.

625.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	Subsection
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

625.4 CONSTRUCTION

625.4.1 General

1 Provide precast manholes, inlets, catch basins, and diversion boxes from plants certified in accordance with Subsection 502.4.1, Plant Certification.

2 Do not place street drainage structures, gratings, or access covers in sidewalk curb ramps or pedestrian paths.

3 Excavate and backfill in accordance with Section 206, Excavation and Backfill for Culverts.

4 Provide and place reinforcing steel in accordance with Section 514, Reinforcing Steel.

5 The department will allow an ⅛-inch per foot [10 mm per meter] taper in walls to ease form removal.

6 Use class B concrete in accordance with Subsection 513.4.4, Mix Design. Form, mix, and place concrete in accordance with applicable sections of Subsection 513.4, Construction. Cure exposed concrete with wet burlap or curing membrane, applied in accordance with Subsection 513.4.13, Curing Concrete, for at least 72 hours.

7 Place pipes in the inlet box or riser as specified. Preform holes for precast barrels and grout outlet pipes with grout approved by the engineer. Grout connections and broken areas smoothly to form a watertight inlet or manhole. Place pipe sections flush on the inside of the structure wall and projecting far enough outside to properly connect with the next pipe section.

8 Form or hand trowel inverts and slope to facilitate water movement in the direction of flow. Slope shelves 1V:12H or steeper.

9 Set metal frames in a full-mortar bed.

625.4.2 Inlets

1 Provide precast concrete inlet structures or cast-in-place.

625.4.2.1 Median Drains

1 When the inlet box joins two or more pipes, provide a drop of at least 3 in [75 mm] between inverts of the inlet and outlet pipes. Use only one of the three grate types specified.

625.4.2.2 Curb Inlets

1 For a type A inlet, the department will allow substitution of a type B or C. For inlet frames and grates, use cast or fabricated structural steel. Fabricate in accordance with Section 501, Structural Steel. The department does not require shop inspection or drawings. When using precast inlet lids, warp curb sections and road surfaces to match the lid.

625.4.3 Manholes

1 Use precast concrete cones, riser sections, and slab covers. Use precast or cast-in-place concrete bases for manhole types A, B, C, and D; cast bases in place for type E manholes. Use manhole sleeves with connecting pipes on sanitary sewers to ensure water-tightness. Finish joints inside and out with asphaltic waterproof mortar or mastic. Use mortar within 30 minutes after it's preparation. Seal joints outside with asphaltic waterproofing compound or other methods approved by the engineer. Construct reinforced concrete collars around the manhole ring for all manhole types.

625.4.4 Catch Basins and Diversion Boxes

1 Construct catch basins and diversion boxes to the dimensions and grades specified. Locate flow gates for diversion boxes as specified and place as follows:

1. **Stop Gate.** As specified, construct using stop timbers stacked on top of each other.

2. **Steel Slide Gate.** Install over the pipe end as recommended by the manufacturer.

625.4.5 Cleaning and Painting

1 Paint miscellaneous structural steel pieces or provide as galvanized. Do not paint galvanized pieces. Clean and paint structural steel in accordance with the applicable portions of Subsection 501.4.1.24, Painting, or Subsection 501.4.2.8, Field Painting. Required coats may be applied in the shop or field. Use brown for the final coat. Galvanize in accordance with Subsection 501.4.1.25, Galvanizing. The department does not require the painting of castings or wrought iron items.

625.4.6 Adjusting Manholes and Inlets

1 When specified, adjust the grade of existing structures by removing frames, covers, and grates and reconstructing walls as required. Reset cleaned frames at the required elevation. After resetting, clean the structure of any foreign matter and keep clean until approval.

625.5 MEASUREMENT and PAYMENT

1 The engineer will measure Inlet Type _____, Manhole Type _____, Catch Basin Type _____, Diversion Box Type _____, Inlet Adjustment, Manhole Adjustment, and Slide Gate _____ by the each.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Catch Basin Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Diversion Box Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Inlet Adjustment	EA [Ea]	EA [Ea]	EA [Ea]
Inlet Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Manhole Adjustment	EA [Ea]	EA [Ea]	EA [Ea]
Manhole Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Slide Gate _____	EA [Ea]	EA [Ea]	EA [Ea]

SECTION 626
Vacant

SECTION 627
Epoxy Resin Injection

627.1 DESCRIPTION

1 This section describes the requirements for furnishing and injecting epoxy resin for repairing cracks, delaminations, and voids in portland cement concrete.

627.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	Subsection
Epoxy Resin	810.6

627.3 EQUIPMENT

1 Use a handgun or pressure pot for injection. With the engineer's approval, a machine capable of metering and mixing components to within 1 percent of specified properties and injecting resin may be used. Provide instruments to periodically check nozzle pressure.

627.4 CONSTRUCTION

1 Work in accordance with and give the engineer a copy of the epoxy resin manufacturer's recommendations.

2 During injection, maintain a nozzle pressure of from 10 psi to 25 psi [70 kPa to 170 kPa].

3 Clean repair surfaces of deposits detrimental to adhesion.

4 Alter void areas at the surface as necessary to allow installation of injection ports or tees. Space ports or tees to completely and efficiently fill voids. Once in place, seal the void surface with a fast-setting cement paste mixture or epoxy mortar.

5 After the resin obtains its initial cure, remove ports, tees, and seal without marring the concrete surface. Clean adjacent areas.

627.5 MEASUREMENT and PAYMENT

1 The engineer will measure Epoxy Resin Injection as a complete unit, by the gallon [liter], or by the foot [meter]. Measurement by the foot [meter] will be along the surface of the crack, delamination, or void.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Epoxy Resin Injection	GAL, FT, LS [L, m, LS]	gal, 0.1 ft, LS [L, 0.05 m, LS]	GAL, FT, LS [L, 0.5 m, LS]

SECTION 628
Vacant

SECTION 629
Vacant

SECTION 630
Vacant

SECTION 631
Slotted Drains

631.1 DESCRIPTION

1 This section describes the requirements for installing slotted drains.

631.2 MATERIALS

1 Provide materials in accordance with the following:

Material	**Subsection**
Admixtures	801.4
Aggregate for Concrete	803
Class B Bedding	803
Corrugated Steel Pipe and Pipe Arches	808.5
Curing Materials	802.1
Fly Ash	801.2
Galvanized Coating	815.14
Portland Cement	801.1
Reinforcing Steel	811.1
Rubber Gaskets	808.15
Structural Steel	815.1
Water	814.1

631.3 EQUIPMENT

1 Ensure that equipment meets the following:

Equipment	**Subsection**
Batch Plant	513.3.1
Mixers	513.3.2
Placing Equipment	513.3.3

631.4 CONSTRUCTION

631.4.1 Fabrication

1 Fabricate slotted drains from galvanized, 14 gage [2 mm] thick steel pipe. Use a close-riveted and soldered annular pipe or a continuously-welded helical pipe. Use 14 gage [2 mm] galvanized metal end caps and coupling bands.

2 Fabricate the grate assembly from structural steel in accordance with Section 501, Structural Steel. The department does not require shop inspection or drawings. Galvanize the grate in accordance with Subsection 501.4.1.25, Galvanizing.

631.4.2 Installation

1 Do not install slotted drains in sidewalk curb ramps or pedestrian paths. Excavate in accordance with Subsection 206.4.1, Excavation.

2 Use watertight pipe coupling bands and end plugs. Use rubber gaskets with the coupling bands to ensure water-tightness. Use a metal or concrete end plug that matches the pipe corrugations.

3 For end plugs and for concrete used as backfill around slotted drains, use class B concrete in accordance with Subsection 513.4.4, Mix Design. The engineer may approve a local commercial mix. The department does not require a cement sample or aggregate gradation tests.

4 Use class B bedding material or concrete for the pipe bed. Use concrete for the top portion of the trench immediately above the bedding, as specified. When constructing a concrete pipe bed, prevent floating of the pipe.

5 When placing curb or paving material over slotted drains, cover the opening to keep out foreign material. Do not extend the slot above the paving material or gutter section.

631.4.3 Repair of Damaged Coating

1 Repair damage to spelter coatings in accordance with Subsection 501.4.2.9, Repair of Galvanizing. Do not backfill the pipe before inspection and approval of repairs by the engineer.

631.5 MEASUREMENT and PAYMENT

1 The engineer will measure Slotted Drain _____ in [mm] by the foot [meter] of pipe.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Slotted Drain _____ in [mm]	FT [m]	0.1 ft [0.05 m]	FT [0.5 m]

DIVISION 700

Traffic Control
and
Roadway Lighting

SECTION 701
Electrical Devices

701.1 DESCRIPTION

1 This section describes the requirements for providing and installing materials and equipment for traffic signals, roadway lighting, and other electrical systems and for modifying existing systems.

701.2 MATERIALS and EQUIPMENT

1 Provide new equipment and materials approved by the National Electrical Code (NEC) and Underwriter's Laboratories (UL) and in accordance with the following:

Materials	Subsection
Admixtures	801.4
Aggregate for Concrete	803
Anchor Bolts	815.6
Fly Ash	801.2
Galvanized Coating	815.14
Gravel for Drains	803
Grout	819.1
Joint Materials	807
Portland Cement	801.1
Reinforcing Steel	811.1
Water	814.1

2 Use nonmetallic additive with nonshrink grout. Ensure that the concrete batch plant and mixers meet the requirements of Subsection 513.3, Equipment. Provide and use an air compressor that produces clean, oil-free compressed air.

701.2.1 Conduits

1 Provide rigid galvanized steel conduit in accordance with UL Publication UL-6, ANSI C80.1 or federal specification WW-C-581.

2 Provide schedule 40 and schedule 80 polyvinyl chloride (PVC) rigid nonmetallic conduit in accordance with National Electrical Manufacturer's Association (NEMA) Standard TC-2.

3 Provide schedule 40 high-density polyethylene (HDPE) smooth-wall coilable electrical plastic duct in accordance with NEMA Standard TC-2. Ensure the duct is marked at intervals no greater than 24 in [600 mm] to show the UL listing, vendor name, duct size, sequential footage [meter] marking, and duct striping.

4 For liquid-tight flexible metal conduit, provide a product that is UL-listed for use as a grounding conductor and consists of a liquid-tight, nonmetallic, sunlight-resistant jacket over a flexible inner metal core.

5 For intermediate steel conduit, provide a product in accordance with UL Publication 1242 for Intermediate Metallic Conduit.

701.2.2 Conduit Hardware

1 For conduit hardware, provide products in accordance with applicable sections of the NEC, UL, ANSI, and NEMA standards. Provide steel hardware that is galvanized, cadmium-plated, or stainless steel.

701.2.3 Pull Box

1 For pull boxes and covers in open ground or sidewalk installations, provide as follows (dimensions are width × length × depth):

1. **Type A Pull Box.** Measuring approximately 13 in × 24 in × 18 in [325 mm × 600 mm × 450 mm] and designated type A1324.

2. **Type B Pull Box.** Measuring approximately 17 in × 30 in × 18 in [425 mm × 750 mm × 450 mm] and designated type B1730.

3. **Type RB Pull Box.** Measuring approximately 24 in × 36 in × 24 in [600 mm × 900 mm × 600 mm] and designated type RB2436.

4. **Type S Pull Box.** Measuring approximately 12 in × 12 in × 12 in [300 mm × 300 mm × 300 mm] and designated type S1212.

2 Provide pull boxes made from reinforced-polymer concrete or molded high-density polyethylene. Provide pull box covers made from reinforced polymer concrete, marked “WYDOT,” with a nonskid surface, and equipped with two recessed hex-head bolt lock downs and two lift slots. Ensure that boxes and covers are gray in color and meet or exceed H-20 load specifications.

701.2.4 Service Points

701.2.4.1 Service Point Equipment and Materials

1 On service points, provide UL-listed, bonded, and grounded equipment as follows:

1. **Weatherproof Enclosure.** Ensure a weatherproof enclosure with a lighting contactor meeting all the following requirements:

    1.1. Contactor case installed on the service point.

    1.2. Contacts of fine silver, silver-alloy, or other superior low contact resistance material.

    1.3. For each outdoor lighting contactor, a built-in manual/off/auto select switch mounted on the enclosure and featuring snap action, positive-on positive-off operation and a listing for the application.

    1.4. A hinged, lockable, NEMA 3R-type enclosure.

    1.5. A valve-type 0-550 volt lighting arrester.

2. **Photoelectric Control.** Provide a photoelectric control that:

    2.1. Features fail-safe operation. If the photo control components become inoperative, ensure that the lamp or lamps remain energized.

    2.2. Mounts in all locking-type receptacles that meet EEI-NEMA specifications.

    2.3. Is rated for a maximum load of 1000 watts (incandescent) or 1800 volt-amperes (high-intensity discharge).

3. **Load Center or Enclosure with Circuit Breakers.** Provide circuit breakers appropriately rated to protect the equipment and conductors against overcurrent in a lockable, SE-rated, NEMA 3R-type enclosure and with permanent markings indicating the electrical device they are protecting.

4. **Wooden Posts.** For service points, provide new, treated structural timber in accordance with Subsection 817.1, Structural Timber and Lumber.

701.2.4.2 Service Point Types

1. **Overhead Service Points.** For overhead service points, provide a new service pole, 30 ft [9 m] long, of class 5 or better wood in accordance with the current edition of ANSI 05.1, *Specifications and Dimensions for Wood Poles*, a load center, lighting contactor, rigid steel conduit, PVC conduit, weather head, ground wire, cables, and all other materials necessary for installation.

2. **Underground Service Points.** For underground service points, provide a dimensioned, 10-foot [3 m] wooden post, a load center, lighting contactor, rigid steel conduit, PVC conduit, ground wire, cables, and all other materials necessary for installation.

3. **Solar Service Points.** For solar service points, provide the specified size and type, and include all necessary materials and equipment.

701.2.5 Ground Rod, Grounding, and Bonding

1 For bonding and grounding jumpers, provide copper wire or copper braid as specified. Ensure that equipment grounding conductors are color-coded to NEC requirements.

701.2.6 Traffic Signal/Roadway Lighting Poles

1 Provide poles and mast arms of materials in accordance with the current edition of AASHTO *Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals* and designed for a wind loading from a 90 mph [140 km/h] fastest-mile wind speed. Ensure that complete shop drawings meet department standards and show the steel designation, minimum yield strength, and design yield strength. Submit plans and working drawings to the Bridge Program for approval in accordance with Subsection 105.2, Working Drawings. Obtain the State Bridge Engineer's approval of the drawings before ordering steel poles and mast arms.

701.2.6.1 Requirements

1 When measured at the midpoint of the pole, do not allow a greater variation from straight than shown in Table 701.2.6-1, Pole Straightness Requirements:

Table 701.2.6-1
Pole Straightness Requirements

Pole Height (ft [m])	Permissible Variation (in [mm])
7 to 28 [2.1 to 8.5]	¾ [19]
28.1 to 35.5 [8.5 to 10.8]	1 [25]

2 Provide open ends of shafts or arms with removable caps. For poles without pedestal bases, provide with hand holes reinforced with a frame. Make provisions in poles for grounding. Configure geometrically and load poles and mast arms as specified.

701.2.6.2 Classification

1. **Type I Poles.** May be steel or aluminum and mount on a pedestal base. Use for sign installations, flashing beacon installations, and post-top mounting of traffic signal indications or traffic signal controller cabinets. Provide steel poles as one continuous piece of schedule 40, galvanized steel pipe in accordance with ASTM A 53 [ASTM A 53M].

2. **Type II Steel Poles.** Design to accommodate side-mount traffic signal indications, to provide a luminaire mounting height of 30 ft [9 m], and to accept installation of a traffic signal mast arm with signal indications, a luminaire extension, and luminaire mast arm.

3. **Type III Steel Poles.** Provide with a luminaire mast arm, providing a luminaire mounting height of 30 ft [9 m], and designed to accept installation of a traffic signal mast arm with signal indications and side-mount traffic signal indications.

4. **Type IV Steel Poles.** Provide with a traffic signal mast arm and a pole top cover held by set screws, without a flange for lighting extension attachment.

5. **Type V Steel Poles.** Provide with a traffic signal mast arm and luminaire mast arm providing a luminaire mounting height of 30 ft [9 m].

6. **Type VI Poles.** Provide steel or fiberglass poles, designed for post-mounted luminaires and providing specified mounting heights.

7. **Type VII Poles.** Provide steel or fiberglass poles, designed for single or twin mast arm mounting of luminaires and providing specified mounting heights.

8. **Type VIII Steel Poles.** Provide for road-closure drop gate installations and with a luminaire mounting height of 30 ft [9 m].

701.2.6.3 Pedestal Base

1 Provide the pedestal base to mount on a concrete foundation using four internal anchor bolts sized ¾ in × 18 in [19 mm × 450 mm] and with a threaded top to accept threaded galvanized pipe with an outside diameter of 4½ in [113 mm].

2 Provide an 8½-inch [213 mm] square hand hole and cover to access the interior of the base for splicing cable and attaching anchor bolts. Secure the cover to the base by ¼-inch [6 mm] bolt(s).

701.2.6.4 Steel Poles and Mast Arms

1 Provide galvanized poles, mast arms, and anchor bolts in accordance with Subsection 501.4.1.25, Galvanizing.

2 Provide steel poles and mast arms with a circular cross-section, fabricated from sheet steel in accordance with ASTM A 709 [ASTM A 709M] grade 50, ASTM A 570 [ASTM A 570M], ASTM A 595, or from weldable-grade sheet steel with a minimum yield strength of 40,000 psi [275 MPa] after fabrication. For steel requiring cold-working to obtain final properties, use 48,000 psi [330 MPa] as the maximum yield strength in the design review.

3 Give the Bridge Program and engineer certified test reports verifying the minimum yield strength and yield strength used for design. Use the mill test reports for as-received steel, or when the as-received steel has a lower yield strength than required or designed for, provide test data (including steel tensile properties after cold-forming for specific heats and thicknesses) showing that your method of cold-forming consistently increases steel tensile properties to meet the specified minimum yield strength and yield strength used for design.

4 Provide poles and mast arms fabricated from full-length sheets or shorter lengths, with each section fabricated from no more than two pieces of sheet steel. When using two pieces, ensure that the longitudinal welded seams are located directly opposite one another. When butt-welding sections together, place longitudinal welded seams on adjacent sections to form continuous straight seams from base to end.

5 Strengthen butt-welded transverse joints by inserting, at each joint, a minimum No. 10 U.S. standard-gage metal sleeve that is at least 1 in [25 mm] long, centered at the joint, with the same taper and chemical composition as the pole or mast arm, and with the entire outside surface of the sleeve in full contact with the inside of the pole or mast arm. Make continuous welds and extend weld metal at the transverse butt joint to the sleeve, making the sleeve an integral part of the joint. Grind exposed longitudinal seam welds and transverse butt welds flush with the base metal.

6 Weld in accordance with the current edition of AASHTO *Standard Specifications For Structural Supports of Highway Signs, Luminaires and Traffic Signals*. The engineer may inspect poles in the shop or field; this does not preclude rejection of any material or finished member later found to be defective. Before fabrication, give the engineer two complete copies of chemical and physical tests.

701.2.6.5 Fiberglass Poles

1 Provide poles with a smooth finished surface, constructed by the filament winding process using fiberglass and thermosetting ultraviolet polyester resin with no clay fillers. Ensure that the filament is wound continuously with uniform tension and placed helically at low angles for axial strength, with additional windings placed in a circular manner for compressive strength. Design poles for direct burial installation.

2 Pigment the resin the same color as the final coating with pole color uniform throughout Ensure a final coating of weather-resistant, pigmented-polyurethane is applied.

3 Provide luminaire mounting configurations that:

1. Are predrilled for mast arm attachments and supplied with mast arms or
2. Have hot-dip galvanized tenons epoxy-bonded to the fiberglass shaft.

4 Provide each pole with a 4-inch × 6-inch [100 mm × 150 mm] hand hole and aluminum hand hole cover. Secure the cover with stainless steel screws or bolts as specified by the manufacturer.

5 Provide each pole with a conductor-entrance hole located 30 in [750 mm] above the pole base and capable of accommodating a 1½-inch [38 mm] conduit. Include a rubber grommet to seal the entrance.

6 For protection during shipping and storage, double spiral-wrap each pole individually with cushioned paper. Incorporate a full-length zip string in the wrapping to ease removal.

701.2.6.6 Identifying Plates

1 Provide traffic signal and roadway lighting poles with an identifying plate or tag sized 1¼ in × 2½ in [32 mm × 65 mm] from the pole manufacturer and permanently attached to the pole 12 in [300 mm] above the pole base plate. Do not attach the plate to the hand-hole cover.

701.2.7 Traffic Signal/Roadway Lighting Pole Foundation

1 Provide each anchor bolt with two nuts and two washers.

701.2.8 Cable and Conductors

1 Provide wire with the Underwriters' Laboratories (UL) label on each reel, coil, or container.

2 Provide stranded copper conductors in accordance with NEC requirements.

3 The department will specify conductor insulation types by the letter designations used in article 310 of the NEC.

4 Ensure that conductor insulation types specified meet NEC requirements.

701.2.9 Wiring General Requirements

1 Use only conductor insulation for color coding. Do not use color tape for identification on conductors No. 4 AWG and smaller.

701.2.10 Lighting Cable

1 Provide in accordance with International Municipal Signal Association (IMSA) specification 20-1.

701.2.11 Multi-Conductor Traffic Signal Cable

1 Provide in accordance with IMSA specification 20-1.

701.2.12 Loop Detector Wire

1 Provide in accordance with IMSA specification 51-5.

701.2.13 Vehicle Detector Shielded Lead-In Cable

1. **Loop Detector.** For multi-strand, shielded, insulated cable used as a lead-in cable from the pull box where detector cables enter from the pavement to the amplifier in the controller cabinet, provide a 4-conductor, No. 18 AWG stranded, polyethylene-jacketed, foil-shielded cable filled with water-blocking material or a 2-conductor, No. 16 AWG stranded, foil-shielded, polyethylene-insulated and jacketed cable in accordance with IMSA specification 50-2.

2. **Video Detector.** For video detector shielded lead-in cable, provide one of the following conductors enclosed in one external insulating jacket:

    2.1. A 3-conductor jacketed cable (for individual conductors, provide No. 16 AWG or No. 14 AWG, as specified by the video detector manufacturer) or

    2.2. An RG-59/U No. 20 AWG Belden 8281.

701.2.14 Splicing Kit

1 Before installing, obtain the State Traffic Engineer's approval of splicing kits. Provide kits for various conductor sizes as follows:

1. **No. 6 AWG or Larger.** Provide connectors rated for 600 VAC and consisting of an insulated bus and sealing sleeves. Ensure the bus is designed for submersible use or direct burial and the sleeves are constructed of high-temperature rubber to provide independent, reliable seals.

2. **No. 8 AWG or Smaller.** Provide insulated, spring-type connectors encased in an insulating sealing compound.

701.2.15 Connector Kit—Fused and Unfused

1 Provide UL-listed connector kits rated for 600 VAC and 30 A operation, intended for the application and designed for breakaway operation allowing separation without breaking or stretching conductors. Provide kits designed to eliminate the possibility of electrical shock when the kit is opened by placing exposed current-carrying components in the harmless load side connection. Identify the hot side of the kit with a permanent red marking. Permanently mark the load-side housing "load side." Provide each kit with sufficient silicone compound to lubricate the metal parts and rubber housing for easy assembly.

2 Size each Y- or I-connector kit individually to accommodate the conductor size and insulation thickness specified. Ensure that each fused connector kit accepts a fuse with the specified ampere rating. For the fused legs of 120/240 VAC circuits, provide two-pole fused connector kits. For the fused leg of 120 VAC circuits, provide single-pole fused connector kits.

3 Positively join the through electrical legs in a manner that allows disassembly from each other without damage. Adapt the load-side contact to the load-side cable, and keep it in proper position with a rubber load-side housing. Fasten the line-side contact to the line-side cable(s) with a bolt and steel lock nut with a nylon insert and keep in proper position with a rubber line-side housing.

4 For fused Y- or I-connector kits, provide a product made of water-resisting synthetic rubber, that can be buried or installed in sunlight, and with a waterleaf around the load- and line-side cables and around both parts of the body at the point of disconnection.

5 For unfused Y- or I-connector kits, provide a pin contact attached to the load-side housing instead of a fuse.

701.2.16 Road Closure Drop and Swing Gates

1 Provide road closure drop and swing gate assemblies as specified, including all appurtenances required for installation.

701.2.17 Solid-State Time Clock

1 For solid-state time clocks, provide a product in accordance with applicable sections of the NEMA standards publication *Traffic Control Systems* for equipment construction and environmental and operating standards.

701.2.18 Vehicle Traffic Signal Indication

1. **Vehicle Traffic Signal Indication Housing.** Provide vehicle traffic signal indications in accordance with the Institute of Transportation Engineers (ITE) *Vehicle Traffic Control Signal Heads* and the MUTCD and manufactured or equipped with all the following:

    1.1. Cast aluminum signal sections.

    1.2. Blanked tunnel visors 8 in [200 mm] or longer that are formed from corrosion-resistant aluminum alloy sheet with twist-on attaching ears to facilitate installation.

    1.3. A final coat of factory-applied synthetic resin black enamel on the housing, door, and outside of the tunnel visors.

    1.4. Factory-applied alkyd black synthetic baking enamel with minimum gloss reflectance inside tunnel visors.

2. **Vehicle Traffic Signal Indication, Incandescent.** Provide a one-piece modified parabolic specular alzak aluminum reflector and lamps with at least 8000 hours rated life and that meet ITE *Traffic Signal Lamps Standards*.

3. **Vehicle Traffic Signal Indication, LED.** Provide in accordance with ITE *Vehicle Traffic Control Signal Heads* and the MUTCD.

701.2.19 Pedestrian Traffic Signal Indication

1. **Pedestrian Traffic Signal Indication Housing.** Provide pedestrian traffic signal indication in accordance with ITE *Pedestrian Traffic Control Signal Indications* and the MUTCD and manufactured or equipped with all the following:

    1.1. A dust-proof, weatherproof housing consisting of a one-piece, corrosion-resistant aluminum alloy die-casting, suitable for post-top or bracket mounting.

    1.2. A hinged housing door, held securely to the housing body by a corrosion-resistant locking device.

    1.3. A housing design and clamshell-type mounting hardware that allow complete interchangeability among manufacturers.

    1.4. A final coat of factory-applied synthetic resin black enamel on the housing and door.

2. **Pedestrian Traffic Signal Indication, Incandescent.** For incandescent pedestrian traffic signal indications, provide optical units consisting of a "Walking Person-Hand" symbol message and equipped with all the following:

    2.1. An eggcrate-type visor designed to eliminate sun phantom, installed parallel to the face of the message and held in place with stainless steel screws.

    2.2. A reflector assembly consisting of a single-piece, double-parabolic reflector formed from polycarbonate plastic sheet, at least 0.25 in [6 mm] thick and textured on the lamp side.

    2.3. Two incandescent lampholders.

    2.4. Signal lamps in accordance with ITE *Traffic Signal Lamps Standards*.

3. **Pedestrian Traffic Signal Indication, LED.** Provide in accordance with ITE *Pedestrian Traffic Control Signal Indications* and the MUTCD.

701.2.20 Louvered Back Plates

1 Provide back plates made of 3003-H14 aluminum alloy sheet at least 0.051 in [1.25 mm] thick and factory-painted with alkyd black synthetic baking enamel with minimum gloss reflectance and that properly fit the specified indications.

701.2.21 Traffic Signal Indication Mounting Hardware

1 For mounting signal indications, provide watertight assemblies consisting of single-piece 1½-inch [38 mm] steel pipes and necessary fittings, slip-fitters, and terminal compartments made of cast bronze or ductile iron. Ensure that steel mounting hardware has a factory-applied final coat of synthetic resin black enamel.

2 Provide mounting assembly members of the specified dimensions, as measured between the axis through the center of the terminal compartment or slip-fitter. Ensure there are no sharp edges or protrusions that might damage conductor insulation. Equip with positive-locking serrated fittings that allow fastening at increments up to 7 degrees and that prevent rotation when mated with similar fittings on the indications.

3 For each side-of-pole signal mounting, provide a terminal compartment with a rain-tight cover, fitted with a terminal block containing 12 terminal positions, each with two screw-type terminals. Ensure each terminal position will accommodate at least five No. 14 AWG conductors. When used to bracket mount signals, provide a compartment designed to bolt securely to the pole.

4 For post-top signal mounting, provide a slip-fitter, with cadmium-plated set screws, that fits over a tapered end or 4½-inch [113 mm] outside-diameter pipe. For slip-fitters used to post-top mount signals with brackets, provide with an integral terminal compartment.

5 For mast-arm mounting of traffic signal indications, provide an adjustable mounting system constructed of high-strength, lightweight aluminum. Ensure a universal configuration for mounting signal heads on poles and mast arms that is completely adjustable to accommodate any size or shape of traffic signal indication and provides complete horizontal and vertical alignment of traffic signal indications.

701.2.22 In-Pavement Vehicle Detectors

1. **Saw Cut Loop Detector.** For loop detector conductors, provide a No.14 AWG stranded conductor with a tube jacket in accordance with IMSA specification 51-5.

2. **Prefab Loop Detector.** For loop detector conductors, provide a No.14 AWG stranded conductor in accordance with IMSA specification 51-1 or 51-3.

3. **Microloop Detector.** Provide a microloop detector consisting of one probe and a corresponding polyurethane-jacketed connecting cable made of four No. 22 AWG, color-coded conductors. Ensure the conductors are bundled together by means of from 4 to 6 twists per foot [13 to 20 twists per meter] of cable. Seal the probe and cable against moisture, and ensure that the probe produces an inductance change compatible with the operating requirements of the vehicle loop detector amplifier when a vehicle passes.

   Ensure that the detector operates as designed in temperatures from -35 ºF to 165 ºF [-37 ºC to 74 ºC] and in relative humidity from 6 percent to 100 percent. Ensure a nominal inductance of 25 microhenries and that the connecting-cable's inductance does not exceed 21 microhenries per 100 ft [21 microhenries per 30.5 m].

701.2.23 Out-of-Pavement Vehicle Detectors

1 Provide a microwave detector unit that produces a low-power microwave beam to detect vehicles as they pass. Ensure the detector operates as designed in temperatures from -35 ºF to 165 ºF [-37 ºC to 74 ºC], in the department's 170 controller configuration, and that inputs and outputs are compatible with operational requirements of the vehicle detector amplifier. Provide a mounting bracket and associated wiring, and ensure the detector is sealed against moisture.

701.2.24 Loop Detector Sealant

1 Provide loop detector sealant that:

1. Is moisture-curing and self-leveling, cures without heat, and remains flexible after curing to withstand normal pavement movement.

2. Allows vehicular traffic over the filled saw cut immediately after installation without tracking or stringing.

3. Has a minimum shelf life of nine months and is designed for installation on roadways with surface temperatures from 40 ºF to 140 ºF [4.4 ºC to 60 ºC].

4. Is temperature-stable and maintains the integrity of the loop detector from -40 ºF to 200 ºF [-40 ºC to 93 ºC].

5. Exhibits minimal shrinkage during and after installation and resists the effects of weather, vehicular fluids, deicing chemicals, and salt without affecting detector operation.

701.2.25 Pedestrian Detectors

1 Provide pedestrian detectors with precision, push button or piezoelectric switches with screw terminals. Ensure that pedestrian detectors are raised or flush with the housing, meet ADA requirements, have dimensions no smaller than 2 in [50 mm], and activate with less than 5 lb [2.26 kg] of force. Ensure that the pedestrian detectors assembly is waterproof and constructed so that it is impossible to receive electrical shock under any weather condition. Detectors shall be factory painted with synthetic resin black enamel.

701.2.26 Roadway Lighting Luminaire

1 Provide with a multi-tap ballast and the optical configuration specified. Provide lamps in accordance with the following:

1. **250-watt, High-pressure Sodium, Clear.** ANSI code number S-50.

2. **250-watt, Metal-halide, Clear.** ANSI code number M-58.

3. **400-watt, High-pressure Sodium, Clear.** ANSI code number S-51.

4. **400-watt, Metal-halide, Clear.** ANSI code number M-59.

5. **1000-watt, High-pressure Sodium, Clear.** ANSI code number S-52.

701.2.27 Rest Area Lighting Luminaire

1 Provide with a multi-tap ballast, lamp, and the optical configuration specified.

701.2.28 Overhead Sign Lighting Luminaire

1 Provide with a multi-tap, peak-lead, auto-transformer ballast and a 175-watt, metal-halide, clear, ANSI code number M-57 lamp.

701.2.29 Underpass Lighting Luminaire

1 When specified, supply with a galvanized or stainless-steel wire guard over the luminaire refractor, and attach it to the luminaire housing by external galvanized bolts.

701.3 EQUIPMENT—Vacant

701.4 CONSTRUCTION

701.4.1 General

1 Follow local ordinances. When the contract complies with but is more restrictive than local or national standards or requirements, use the contract requirements. Use an electrical contractor and electricians licensed by the State of Wyoming. Use standards or methods set forth by the supplier or manufacturer, unless otherwise directed by the engineer.

2 Install materials and equipment in accordance with NEC provisions and manufacturers' requirements. Use installation procedures and wiring in accordance with the Edison Electric Institute (EEI), NEMA, UL, Electronic Industries Alliance (EIA), ASTM, Insulated Power Cable Engineers Association (IPCEA), ANSI, and applicable local ordinances.

3 When replacing existing systems, conduct work to leave existing systems operational until the new system is in place and operational, unless otherwise approved by the engineer.

4 Cut roadway lighting poles, traffic signal poles, and mast arms that are removed and not reinstalled into three pieces and dispose of or salvage as approved by the engineer.

701.4.2 Product Submittals

1 Submit five copies of product submittals for lighting, signal, and electrical equipment to the State Traffic Engineer. For each item, include manufacturer names, sizes, electrical ratings, and identifying numbers. For nonstandard or special equipment, include detailed scale drawings and wiring diagrams. Indicate the project number, road route, stations, and county on each submittal, and forward a copy of the letter of transmittal to the engineer as notification.

2 The State Traffic Engineer will mark submittals "Approved," "Approved as Corrected," or "Not Approved" and distribute as follows:

1. Original copy to the engineer.
2. One copy to the Traffic Program.
3. One copy to the District Traffic Engineer.
4. Remaining copies to the contractor.

3 Approval will take 15 working days. The department is not responsible for materials purchased or supplied or labor performed before approval of product submittals. For items "Not Approved," determine the proper material or equipment and resubmit for approval.

701.4.3 Shop Drawings

1 Submit shop drawings for roadway lighting poles and traffic signal poles including grouting procedures to the State Bridge Engineer in accordance with Subsection 105.2, Working Drawings.

701.4.4 Excavation and Backfill

1 Do not excavate or drill for the installation of conduit, foundations, or other appurtenances before locating all underground and overhead utilities. Excavate immediately before installing conduit and other appurtenances and no more than necessary for installation. Minimize damage to streets, sidewalks, landscaping, and other improvements. Place excavated material in a position that does not cause damage or obstruct surface drainage or vehicular and pedestrian traffic.

2 After backfilling, keep excavations smooth and well-drained until permanent repairs are made. Backfill excavations and restore sidewalks, pavement, and landscaping at each location before excavating elsewhere.

701.4.5 Traffic Signal/Roadway Lighting Pole Foundation

1 Use drilled shaft foundations placed monolithically in accordance with Section 506, Drilled Shaft Foundations.

2 When placing foundations in sidewalks, provide an expansion joint between the foundation and abutting sidewalk.

3 Place foundations in firm material; extend the specified length if additional depth is necessary. When obstructions prevent construction of a proposed foundation, relocate the foundation as approved by the engineer.

4 In urban areas, form exposed foundation tops and finish to curb or sidewalk grade. In all areas, finish to present a neat appearance. In rural areas or areas with no curb or sidewalk, do not extend any portion of the foundation section above finished grade more than 2 in [50 mm]. For poles with breakaway devices, install the foundation to allow for proper operation of the device. Hold conduit ends and anchor bolts in place with a template until the concrete sets. Use forms that are true to line and grade.

5 When they will not be reused and do not obstruct other work, break down existing foundations 6 in [150 mm] below ground level. Remove and dispose of existing foundations before installing a new foundation at the same location.

701.4.6 Traffic Signal/Roadway Lighting Poles

1 Do not erect poles within 72 hours of placing drilled shaft foundations or until the foundation obtains 80 percent of its ultimate design strength (f′c).

2 Plumb standards by adjusting anchor bolt nuts before placing grout. Use shims to plumb standards with transformer bases; the department does not require an additional nut and washer for leveling.

3 Set traffic signal poles and transformer bases on foundations and seal with grout, as approved by the State Bridge Engineer. After the pole is in proper position, place nonshrink grout under the base plate, and finish to provide a neat appearance.

701.4.7 Cable and Conductors

1 Use stranded copper conductors throughout all systems except for the grounding electrode conductor. Ensure that conductor color coding is continuous throughout the installation. Cable together conductors within fixtures or cabinets using self-clinching nylon cable ties or other approved methods. Arrange wiring within controller cabinets neatly and lace or enclose in plastic tubing or a raceway. Tape and neatly stow spare roadway lighting and traffic signal conductors.

2 Inside traffic signal and roadway lighting poles, use lighting cable between the top of connector kits and luminaire heads. Use multi-conductor signal cable for signal systems in underground conduit and as an aerial cable supported by a messenger. Install the exact number of conductors specified.

3 Use approved methods to install cables in conduit without injuring the jacket, insulation, or conductors. Place cables within a single conduit at the same time. If necessary to ease pulling, use a lubricant that meets the manufacturer's recommendations and does not injure cables. When pulling multi-conductor cables into a conduit, tape cable ends to exclude moisture, and keep them taped until splices are made or terminal appliances are attached.

4 Place cable in trenches without dragging or stretching.

5 Pull cables through wire inlets without damaging the cable. Place a firm rubber pad or other suitable material around the inlet's bottom opening to separate the cable from rough edges and the protruding tab for fastening the cover.

6 Join conductors by methods as specified or as approved by the engineer. Ensure that finished connections and terminals meet cable manufacturers' recommendations.

7 When installed in screw terminals, terminate stranded conductors smaller than No. 10 AWG in crimp-style terminal lugs. Do not use crimp-style terminals for solid wire.

8 Splice roadway lighting and overhead sign lighting cables in pull boxes, hand holes, and junction and terminal boxes where readily accessible. Splice traffic signal light conductors in pull boxes, terminal boards in controller cabinets, or terminal boards in the terminal compartment of bracket-mounted signals on signal poles.

9 Splice active current-carrying conductors in pull boxes using weatherproof-type splice kits. Splice neutral conductors and equipment-grounding conductors using approved connectors and insulate with material in accordance with NEC requirements for waterproof installation.

10 Provide at least 3 ft [1 m] of slack for wiring and cables inside each traffic signal or roadway lighting pole. Provide at least 5 ft [1.5 m] of slack at each pull box and at the ends of each run at all other locations.

11 When specified, install small, permanent identification bands on traffic signal cables and roadway lighting conductors for cable identification. Attach the bands securely to each end of each conductor in each pull box and near the end of each conductor where conductors are terminated. Bands may be omitted where insulation color clearly indicates circuit and phase.

12 Do not use bands as a substitute for insulation color identification.

701.4.8 Vehicle Detector Shielded Lead-In Cable

1 Make each run of shielded lead-in cable for vehicle detectors continuous, without splices, from the controller cabinet to the camera attachment point, with 10 ft [3 m] of slack at each end of the run.

701.4.9 Connector Kit—Fused and Unfused

1 Use fused and unfused Y- or I-connector kits as specified to make continuous electrical connections for multiple electrical equipment in pole bases and at other specified locations.

2 Join the through electrical legs in a manner that allows for disassembly without damage. Adapt the load side contact to the load side cable and retain securely in the proper position within a rubber load side housing. Fasten the line side contact to the line side cable(s) with a bolt and steel lock nut with a nylon insert, and retain it securely in the proper position with a rubber line side housing. Permanently mark the load side housing with a plate or tag designating the "load side."

701.4.10 Vehicle Traffic/Pedestrian Signal Indication

701.4.10.1 Traffic Signal Indication Mounting Hardware

1 Plumb or level mounting assembly members, arrange symmetrically, and assemble securely. Orient each side of pole-mounting hardware assemblies to provide maximum horizontal clearance to the side street or adjacent roadway. Conceal conductors.

701.4.10.2 Vehicle Traffic Signal Indication

1 Mount vehicle traffic signal indications plumb as specified by the manufacturer, and aim them in accordance with the MUTCD and as approved by the engineer. Direct indications away from traffic or cover until ready for operation.

701.4.10.3 Pedestrian Traffic Signal Indication

1 Mount pedestrian traffic signal indications plumb as specified by the manufacturer, and aim them as approved by the engineer. Direct indications away from traffic and pedestrians or cover until the traffic signal is ready for operation.

701.4.10.4 Louvered Back Plates

1 Attach louvered back plates to signal indications to provide a dark background with no light showing between the backplate and signal indication or between sections. Fasten back plates consisting of two or more sections using rivets or aluminum bolts and peen after assembly to prevent loosening.

701.4.11 In-Pavement Vehicle Detectors

1. **Saw-Cut Loop Detector.** The department considers the term “saw-cut loop detector” to refer to the complete installation, including saw cut, loop detector wire, and sealant. The engineer will determine locations of loop detectors.

   Wash, blow out, and dry saw cuts before installing conductors. After installing them, fill slots with sealant. For each detector, use a continuous, unspliced copper conductor ending in the pull box next to the loop. In the pull box, seal tube jacket ends against moisture by following the loop detector manufacturer's recommendations. Wire the detectors to the lead-in cable and ensure that they provide detection as specified.

2. **Prefab Loop Detector.** The department considers the term "prefab loop detector" to refer to the complete installation, before pavement placement, of a preformed loop detector, consisting of loop detector wire installed in sealed PVC conduit with a diameter no greater than 1 in [25 mm]. For each detector, use continuous, unspliced conductors ending in the pull box next to the loop.

701.4.12 Loop Detector Sealant

1 Submit the sealant manufacturer's installation recommendations, including any shelf life requirements to the engineer seven calendar days before installing. When manufacturer's recommendations are more restrictive than those specified here, follow the manufacturer's recommendations.

2 Before installing loop detector wiring or sealant, clean and dry saw cuts with compressed, oil-free air. When required by the manufacturer, stir sealant thoroughly before installation. Do not apply in rain or any weather condition that hinders sealant curing. Store sealant in accordance with manufacturer's recommendations. Do not exceed storage shelf life.

701.4.13 Pedestrian Detectors

1 Install pedestrian detectors and pedestrian instruction signs on the crosswalk side of the pole. Ensure that arrows on pedestrian instruction signs point in the same direction as the corresponding crosswalks.

701.4.14 Electrical Traffic Device Tests

1 Before final acceptance in accordance with Subsection 113.4, Final Acceptance, perform a functional test to demonstrate that every system part works as specified. A shutdown of electrical systems during functional tests caused by damage from public traffic, a power interruption, or unsatisfactory performance of department-furnished materials does not constitute discontinuity of the system test.

1. **Traffic-Signal System Tests.** Begin turn-on and functional tests between 9:00 a.m. and 2:00 p.m. on any working day, Monday through Thursday, not preceding a legal holiday. Before turning on, install specified equipment, signs, and pavement markings, and verify its operability. Direct louvers, visors, and signal heads to provide maximum visibility.

   Test all traffic-signal circuits thoroughly before turning on new or modified traffic signal systems. Be available to correct field wiring problems when new or modified traffic-signal systems are put into operation.

   The functional test for each new or modified traffic signal or traffic signal system consists of at least 14 calendar days of continuous, satisfactory operation. Correct malfunctions resulting from the contractor's work at no additional cost to the department, and repeat the test until this requirement is met.

2. **Lighting System Tests.** The functional test for each lighting system and sign illumination system consist of at least 14 calendar days of continuous, satisfactory operation in accordance with the regular lighting schedule. Correct malfunctions resulting from the contractor's work at no additional cost to the department, and repeat the test until obtaining five calendar days of continuous, satisfactory operation.

   Direct the photoelectric control northward and check to determine if light sources other than sunlight interfere with normal operation of the light-sensitive cell.

3. **Flashing Beacon System Tests.** Begin turn-on and functional tests between 9:00 a.m. and 2:00 p.m. on any working day, Monday through Thursday, not preceding a legal holiday.

   The functional test for each new or modified flashing beacon consists of at least 14 calendar days of continuous, satisfactory operation. Correct malfunctions resulting from the contractor's work at no additional cost to the department, and repeat the test until this requirement is met.

4. **Road Closure System Tests.** Conduct the test under the engineer's supervision and in a manner to not confuse traffic. Correct malfunctions resulting from the contractor's work, at no additional cost to the department.

701.4.15 Conduits

701.4.15.1 General

1 Install conduit system wiring as specified and in accordance with the requirements of the utility company or agency for which the system is being installed. Larger-than-specified conduit may be used, at no additional cost to the department, provided it extends the entire length of the run from outlet to outlet; do not use reducing couplings.

2 Extend conduit ending in standards or pedestals no more than 3 in [75 mm] above the foundation and slope towards the hand hole opening. To leave the greatest space clear, locate conduit entering through the bottom of pull boxes near the end walls. At outlets, align the conduit entrance with the direction of the run. Extend conduit that ends in pull boxes to the specified minimum distance above the crushed rock. Use grounding bushings for metal conduit terminations inside pull boxes or pole bases to bond the entire conduit system; install a separate grounding conductor for path-to-ground faults.

3 In new construction, install specified conduits before placing the finished roadway surface. Lay conduit at least 18 in [450 mm] below grade in sidewalk and curbed paved median areas and 30 in [750 mm] below finished grade elsewhere.

4 When conditions preclude trenching, install rigid conduit using approved jacking or boring methods without disturbing pavement. With the engineer's approval and at no additional cost to the department, small test holes may be cut in the pavement to locate obstructions. Construct required jacking or boring pits at least 24 in [600 mm] clear of pavement edges on urban projects and at least 8 ft [2.4 m] from shoulder edges on rural projects. Do not undermine pavement or soften subgrade with excessive water.

5 Clean existing underground conduit incorporated into a new system with a mandrel or cylindrical wire brush and blow out with oil free compressed air.

6 Replace disturbed sod, concrete, and asphaltic material as approved by the engineer.

7 The department specifies the locations of conduit runs for general purposes only; determine exact locations on-site to avoid underground obstructions or utilities. Run conduit that parallels curbs next to the back of the curb; where this conflicts with existing facilities, place as approved by the engineer.

8 When installing new conduit without wiring or cables, install a No.10 AWG green bonding conductor in the conduit, and cap each conduit end.

9 Install polyethylene duct in accordance with the manufacturer's recommendations. Replace duct that has been damaged or contains dirt or debris.

701.4.15.2 Couplings

1 Make cuts square and true so that ends butt together for their full circumference. Ream conduit ends to remove burrs and rough edges. Do not use slip joints or running threads to couple conduit. When bending conduit outside the factory, form a radius as large as practical and at least six times the conduit's inside diameter; do not crimp or flatten.

1. **Metal Conduit.** Use a threaded union coupling when a standard through coupling cannot be used. Tighten couplings until conduit ends are brought together, providing a good electrical connection for the entire length. Thread the ends of metal conduit and cap with pipe caps. When wiring begins, remove caps and provide the threaded ends with conduit bushings. Paint threads and damaged coating on ferrous metal conduit with rust-preventive paint.

2. **Nonmetallic Conduit.** Cut with approved tools and use solvent-weld connections. Cap conduit ends until wiring begins.

701.4.16 Pull Boxes

1 The department specifies the minimum number of pull boxes required. At no additional cost to the department, and with the engineer's approval, additional pull boxes may be installed for convenience. The engineer will determine final locations and elevations for pull boxes.

2 Use type S pull boxes with 1-inch [25 mm] or smaller conduit and No.10 AWG or smaller wire.

3 Fill the bottom of pull boxes with gravel in accordance with Subsection 803.12, Gravel for Drains, and install with covers level with the finished sidewalk surface. Where no sidewalk is present, install with covers slightly higher than the surrounding ground and grade the area to provide drainage away from the pull box. On rural lighting projects, mark and identify pull box locations as specified.

701.4.17 Service Points

1 Use bonded and grounded UL-listed equipment on service points. Install and construct service points at the locations determined by the serving utility, the engineer, or both. Serving utilities will determine the position of service equipment when a service is installed on a utility-owned pole. Provide ground rods, grounding devices, and connections in accordance with the applicable NEC requirements. Ensure ground-rod-to-ground-resistance meets the applicable NEC requirements. Ground metal conduit and enclosures on service poles.

2 On service-pole conduit for overhead services, terminate with a weather head or seal against water, as approved by the utility company. Install surface-mounted conduits straight and true.

3 Arrange with the utility company for electrical power, and contact the local jurisdiction for home rule requirements for service installations. Complete service connections and pay permit fees in accordance with Subsection 107.2, Permits, Licenses, and Taxes.

701.4.18 Ground Rod, Grounding, and Bonding

1 Ensure that metallic cable sheaths, metal pull box covers, metal conduit, equipment-grounding conductors, ballast and transformer cases, service equipment, sign switches, and metal poles and pedestals are mechanically and electrically secure and form a continuous grounded system. Provide and use a copper-weld ground rod of the length and diameter specified. Use ground-rod clamps sized to accommodate the ground rod and approved for the application.

2 Ground one side of the secondary circuit of series-multiple and step-down transformers. Provide and install a ground electrode at each service point; bond to service equipment as specified. Ground all metallic equipment on wooden poles.

3 Bond standards and pedestals with a bonding wire or braid attached to the bolt installed in the lower shaft portion. Do not allow the grounding jumper to

enter the slip plane when installing slip-base standards or inserts; bond with a bonding strap attached to the bolt installed directly across from the hand hole.

4 In nonmetallic conduit, run a bonding conductor continuously in all circuits. Where nonmetallic conduit is installed for future use, the conductor may be omitted. To bond metallic conduit in concrete or plastic pull boxes, use galvanized grounding bushings and bonding jumpers. For metallic conduit in steel pull boxes, bond with locknuts.

701.5 MEASUREMENT and PAYMENT

701.5.1 General

1 The engineer will measure:

1. The following systems as complete units:

    1.1. Bridge Lighting System.

    1.2. Conduit System-______.

    1.3. Electrical System.

    1.4. Flashing Beacon System.

    1.5. Overhead Sign Lighting System.

    1.6. Road Closure System.

    1.7. Roadway Lighting System.

    1.8. Remove Conduit System.

    1.9. Rest Area Lighting System.

    1.10. Traffic Signal System.

    1.11. Tunnel Lighting System.

    1.12. Underpass Lighting System.

2. When specified, the engineer will measure:

   2.1. Conduit Boring, Conduit Hardware, Conduit-Flexible Metal ____ in [mm], Conduit-Rigid PVC ____ in [mm], Conduit-Rigid Stl ____ in [mm], Remove Conduit, and Trenching and Backfilling as a complete unit or by the foot [meter].

   2.2. Electrical Conductors by the complete unit.

   2.3. Pull Box Type ____, Remove Pull Box, and Reset Pull Box by the each.

   2.4. Service Point Lighting, Service Point Signal, Service Point Solar, Ground Rod, Remove Service Point, and Modify Service Point by the each. The pull box and ground rod near the base of an overhead service point are incidental to the service point installation.

   2.5. Stl Pole Type ____, Conc Pole Type ____, Install Lighting Pole, Remove Lighting Pole, Reset Lighting Pole, Modify Lighting Pole, Remove Pole Foundation, and Safety Cover by the each.

   2.6. Single Conductor Wire #____AWG, Remove Single Conductor Wire, Signal Cable __ Conductor # __ AWG, Lighting Cable __Conductor # __ AWG, Loop Detector Wire, and Loop Detector Shielded Lead-In Cable by the foot [meter].

   2.7. Splicing Kit, Connector Kit-Fused ___, Connector Kit-Unfused ___ by the each.

   2.8. Signal Controller, Remove Signal Controller, Reset Signal Controller, Signal Controller Cabinet, Remove Signal Controller Cabinet, Reset Signal Controller Cabinet, and Modify Signal Controller Cabinet by the each.

   2.9. Signal Controller Aux Eqp, Remove Signal Controller Aux Eqp, and Reset Signal Controller Aux Eqp by the complete unit.

   2.10. Time Clock, Remove Time Clock, and Reset Time Clock by the each.

2.11. Signal Indication ___, Remove Signal Indication, and Reset Signal Indication by the each.

2.12. Ped Signal Indication, Remove Ped Signal Indication, Reset Ped Signal Indication, and Ped Instruction Sign ____, and Ped Detector by the each.

2.13. Louvered Backplate ___ by the each.

2.14. Mast Arm Framework, Post Top Framework, Side Bracket Framework, Remove Framework, and Reset Framework by the each.

2.15. ___ Luminaire, Remove ___ Luminaire, and Reset ___ Luminaire by the each.

2.16. Microloop Detector complete-in-place and including complete installation of each individual microloop-detector probe (consisting of a drilled core, sawed slot, connecting cable, and sealant) by the each.

2.17. Saw-Cut Loop Detector, Prefab Loop Detector, and Microwave Detector by the each.

2.18. Loop Detector Sealant by the gallon [liter].

2 The engineer will consider rigid steel conduit or rigid nonmetallic polyvinyl chloride conduit contained within drilled shaft foundations and pull boxes and stubbed or noncontinuous conduit incidental to other contract pay items and will not measure or pay for such conduit directly.

3 The department will pay as follows:

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Bridge Lighting System	LS	LS	LS
Conduit System— _____	LS	LS	LS
Electrical System	LS	LS	LS
Flashing Beacon System	LS	LS	LS

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Overhead Sign Lighting System	LS	LS	LS
Road Closure System	LS	LS	LS
Roadway Lighting System	LS	LS	LS
Remove Conduit System	LS	LS	LS
Rest Area Lighting System	LS	LS	LS
Traffic Signal System	LS	LS	LS
Tunnel Lighting System	LS	LS	LS
Underpass Lighting System	LS	LS	LS
Conduit Boring	LS, FT [LS, m]	LS, ft [LS, m]	LS, FT [LS, m]
Conduit Hardware	LS	LS	LS
Conduit-Flexible Metal _____ in [mm]	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, m]
Conduit-Rigid PVC _____ in [mm]	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, m]
Conduit-Rigid Stl _____ in [mm]	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, m]
Remove Conduit	LS, FT [LS, m]	LS, ft [LS, m]	LS, FT [LS, m]
Trenching and Backfillling	LS, FT [LS, m]	LS, ft [LS, m]	LS, FT [LS, m]
Electrical Conductors	LS	LS	LS

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Pull Box Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Remove Pull Box	EA [Ea]	EA [Ea]	EA [Ea]
Reset Pull Box	EA [Ea]	EA [Ea]	EA [Ea]
Service Point Lighting	EA [Ea]	EA [Ea]	EA [Ea]
Service Point Signal	EA [Ea]	EA [Ea]	EA [Ea]
Service Point Solar	EA [Ea]	EA [Ea]	EA [Ea]
Ground Rod	EA [Ea]	EA [Ea]	EA [Ea]
Remove Service Point	EA [Ea]	EA [Ea]	EA [Ea]
Modify Service Point	EA [Ea]	EA [Ea]	EA [Ea]
Stl Pole Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Conc Pole Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Install Lighting Pole	EA [Ea]	EA [Ea]	EA [Ea]
Remove Lighting Pole	EA [Ea]	EA [Ea]	EA [Ea]
Reset Lighting Pole	EA [Ea]	EA [Ea]	EA [Ea]
Modify Lighting Pole	EA [Ea]	EA [Ea]	EA [Ea]
Remove Pole Foundation	EA [Ea]	EA [Ea]	EA [Ea]
Safety Cover	EA [Ea]	EA [Ea]	EA [Ea]
Single Conductor Wire # _____ AWG	FT [m]	ft [m]	FT [m]
Remove Single Conductor Wire	FT [m]	ft [m]	FT [m]
Signal Cable _____ Conductor # _____ AWG	FT [m]	ft [m]	FT [m]

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Lighting Cable _____ Conductor # _____ AWG	FT [m]	ft [m]	FT [m]
Loop Detector Wire	FT [m]	ft [m]	FT [m]
Loop Detector Shielded Lead-In Cable	FT [m]	ft [m]	FT [m]
Splicing Kit	EA [Ea]	EA [Ea]	EA [Ea]
Connector Kit—Fused _____	EA [Ea]	EA [Ea]	EA [Ea]
Connector Kit—Unfused _____	EA [Ea]	EA [Ea]	EA [Ea]
Signal Controller	EA [Ea]	EA [Ea]	EA [Ea]
Remove Signal Controller	EA [Ea]	EA [Ea]	EA [Ea]
Reset Signal Controller	EA [Ea]	EA [Ea]	EA [Ea]
Signal Controller Cabinet	EA [Ea]	EA [Ea]	EA [Ea]
Remove Signal Controller Cabinet	EA [Ea]	EA [Ea]	EA [Ea]
Reset Signal Controller Cabinet	EA [Ea]	EA [Ea]	EA [Ea]
Modify Signal Controller Cabinet	EA [Ea]	EA [Ea]	EA [Ea]
Signal Controller Aux Eqp	LS	LS	LS
Remove Signal Controller Aux Eqp	LS	LS	LS
Reset Signal Controller Aux Eqp	LS	LS	LS

Pay Item	**Pay Unit**	**Measure to the Nearest**	**Pay to the Nearest**
Time Clock	EA [Ea]	EA [Ea]	EA [Ea]
Remove Time Clock	EA [Ea]	EA [Ea]	EA [Ea]
Reset Time Clock	EA [Ea]	EA [Ea]	EA [Ea]
Signal Indication _____	EA [Ea]	EA [Ea]	EA [Ea]
Remove Signal Indication	EA [Ea]	EA [Ea]	EA [Ea]
Reset Signal Indication	EA [Ea]	EA [Ea]	EA [Ea]
Ped Signal Indication	EA [Ea]	EA [Ea]	EA [Ea]
Remove Ped Signal Indication	EA [Ea]	EA [Ea]	EA [Ea]
Reset Ped Signal Indication	EA [Ea]	EA [Ea]	EA [Ea]
Ped Instruction Sign _____	EA [Ea]	EA [Ea]	EA [Ea]
Ped Detector	EA [Ea]	EA [Ea]	EA [Ea]
Louvered Backplate _____	EA [Ea]	EA [Ea]	EA [Ea]
Mast Arm Framework	EA [Ea]	EA [Ea]	EA [Ea]
Post Top Framework	EA [Ea]	EA [Ea]	EA [Ea]
Side Bracket Framework	EA [Ea]	EA [Ea]	EA [Ea]
Remove Framework	EA [Ea]	EA [Ea]	EA [Ea]
Reset Framework	EA [Ea]	EA [Ea]	EA [Ea]
_____ Luminaire	EA [Ea]	EA [Ea]	EA [Ea]
Remove _____ Luminaire	EA [Ea]	EA [Ea]	EA [Ea]
Reset _____ Luminaire	EA [Ea]	EA [Ea]	EA [Ea]

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Saw Cut Loop Detector	EA [Ea]	EA [Ea]	EA [Ea]
Prefab Loop Detector	EA [Ea]	EA [Ea]	EA [Ea]
Microloop Detector	EA [Ea]	EA [Ea]	EA [Ea]
Microwave Detector	EA [Ea]	EA [Ea]	EA [Ea]
Loop Detector Sealant	GAL [L]	gal [L]	GAL [L]

701.5.2 Referenced Sections for Direct Payment

1 The engineer will pay for electrical power from the time of turn-on to the completion of the contract.

2 When specified, the engineer will measure and pay for Drilled Shaft Foundations in accordance with Section 506, Drilled Shaft Foundations.

SECTION 702
Signs, Delineators, and Reference Markers

702.1 DESCRIPTION

1 This section describes the requirements for providing and installing permanent roadside and overhead signs, delineators, and markers.

702.2 MATERIALS

1 Provide materials in accordance with the following:

Materials	Subsection
Bolts and Fasteners	816.8
Delineator Posts	816.5
Epoxy Mastic Paint	809.10
Galvanized Coating	815.14
High-Strength Bolts and Fasteners	815.2
Overhead Sign Supports	816.7
Retroreflectors	816.3
Roadway Sign Supports	816.6
Sheet Aluminum For Sign Panels	816.1
Signs and Traffic Devices	816
Structural Steel	815.1
Retroreflective Sheeting	816.4

2 For permanent signs, provide sheet aluminum 0.125 in [3 mm] thick.

3 For main load-carrying tension members at least ½ in [12 mm] thick, provide in accordance with the notch toughness requirements in Subsection 815.1, Structural Steel.

4 The department designates the diameter of round timber posts as determined from a circumferential measurement made 4 in [100 mm] above the ground. The department specifies dimensioned timber posts by nominal sizes and will accept *American Lumber Standard* dressed sizes as minimum net sizes.

702.3 EQUIPMENT

1 Ensure that the concrete batch plant and mixers meet the requirements of Subsection 513.3, Equipment.

702.4 CONSTRUCTION

702.4.1 Reference Markers

1 Install reference markers at the locations staked. Provide reference post panels manufactured from aluminum 0.125 in [3 mm] thick.

702.4.2 Posts

1 Ensure that post size, drilled hole size, and vertical hole location are in accordance with the specified details for breakaway posts. Do not order posts until the engineer has checked post lengths in the field, rounding measurements as follows:

1. **Timber Sign Posts**—to the next highest 24-inch [600 mm] increment.
2. **Steel Posts**—to the next highest 12-inch [300 mm] increment.
3. **Steel Supports (Break-Away)**—to the next highest 1-inch [25 mm] increment.

2 Provide either dimensioned or round timber posts; do not combine.

3 Around posts set directly in the ground, backfill and compact with suitable material in layers up to 6 in [150 mm] thick to set firmly. Hold driven posts in alignment during installation, and protect post tops with a cap during driving.

4 For square, tubular-steel sign posts, drive an anchor section into the ground to within 2 in [50 mm] above the surface. Extend a telescoping support post into the anchor at least 12 in [300 mm], and attach the post to the anchor with a bolt and nut.

702.4.3 Drilled Shaft Foundations

1 Construct drilled shaft foundations for sign posts to specified dimensions and in accordance with Section 506, Drilled Shaft Foundations. Securely fasten reinforcing steel, anchor bolts, and conduit, when specified, to prevent dislocation

while placing concrete. Place concrete against undisturbed earth, unless casing is used, and cure at least 14 calendar days before sign erection. Final grade in accordance with Subsection 203.4.5, Finishing, to leave the foundation top flush with the surface.

702.4.4 Sign Panels

1 Provide sign panels free of dents, wrinkles, and holes. When formed in multiple sections, ensure that joints are tight and smooth. Ensure that retroreflective sheeting is applied to the panels in accordance with the sheeting manufacturer's recommendations and with adjacent strips matched for color to provide a surface free of imperfections and uniform nighttime appearance and brilliance. Ensure that the panel background and tabs are clear-coated or edge-sealed before the legend is applied and that sign edges and faces are clear-coated or edge-sealed in accordance with the manufacturer's specifications for the type of sheeting applied. Repair marred paint by repainting after erection.

2 Install fasteners, backing strips, and other incidentals as specified. Ensure that the bolts do not protrude above the sign panel surface.

3 After erection, clean sign faces and repair marred or damaged surface coating with the same material as the original coating.

702.4.5 Removal and Resetting of Signs

1 Without damaging the sign or post, remove and stockpile existing signs to be reset.

2 Reset sign posts and sign panels as specified. Provide additional mounting hardware to reset sign panels on new or existing posts at no additional cost to the department. Replace removed posts that are too short to be reset as specified.

3 Backfill holes left by sign removal with approved material in layers 6 in [150 mm] thick. Compact each layer to at least the density of the adjacent material. Remove existing concrete foundations to at least 6 in [150 mm] below the ground surface, but remove them completely when installing a new foundation at the same location.

702.4.6 Overhead and Breakaway Signs

1 Submit shop drawings for overhead signs to the State Bridge Engineer in accordance with Section 105.2, Working Drawings.

2 After fabrication, blast-clean steel components of overhead signs in accordance with Society for Protective Coatings (SSPC)-SP 6. Paint with one coat of epoxy-mastic paint. Mix, apply, and allow paint to dry in accordance with the manufacturer's recommendations. Ensure it has a dry film thickness of at least 5 mil [130 μm]. Do not damage painted sign surfaces during transport; repair damaged areas in the field by applying a second coat of epoxy-mastic. Instead of painting, and if suitable for the structure, components may be galvanized in accordance with Subsection 501.4.1.25, Galvanizing.

3 For breakaway sign supports, ensure fabrication in accordance with specified details and galvanization in accordance with Subsection 501.4.1.25, Galvanizing.

702.4.7 Delineators

1 Remove existing delineators and do not reuse. Layout delineator locations. Match the delineator reflector color to the adjacent edge-line stripe color. Install delineators as shown in the contract. Position delineators to face traffic and obtain the most effective retroreflection.

702.5 MEASUREMENT and PAYMENT

702.5.1 General

1 The engineer will measure:

1. Delineators Type _____ by the each.
2. Reference Markers and Reference Marker Panels as the number of each installed.
3. Reset Signs as a complete unit.
4. Sign Panels, Aluminum and Sign Panels, Plywood by the square foot [square meter] of sign panel face installed.
5. Sign Posts, Sq Tubular Stl, and Sign Posts, Rnd Tubular Stl by the each.
6. Sign Posts, Stl Pipe (Break-away), other than steel pipe for overhead signs, by the pound [kilogram], with the weight [mass] calculated as the length of each post multiplied by the theoretical weight per foot [mass per meter], excluding the weight [mass] of galvanizing material, for the size of pipe post ordered and installed.

7. Sign Posts, Wood __×__ in [mm] and Sign Posts, Wood ___ in [mm] Rnd by the foot [meter].

8. Stl Break-away Sign Support ___ by the complete unit or the foot [meter].

9. Stl Overhead Sign Support as a complete unit.

2 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Delineators, Type _____	EA [Ea]	EA [Ea]	EA [Ea]
Reference Markers	EA [Ea]	EA [Ea]	EA [Ea]
Reference Marker Panels	EA [Ea]	EA [Ea]	EA [Ea]
Reset Signs	LS	LS	LS
Sign Panels, Aluminum	SF [m^2]	0.1 ft [0.05 m]	0.1 SF [0.01 m^2]
Sign Panels, Plywood	SF [m^2]	0.1 ft [0.05 m]	0.1 SF [0.01 m^2]
Sign Post, Rnd Tubular Stl	EA [Ea]	EA [Ea]	EA [Ea]
Sign Post, Sq Tubular Stl	EA [Ea]	EA [Ea]	EA [Ea]
Sign Posts, Stl Pipe (Break-away)	LB [kg]	0.5 lb [0.2 kg]	LB [kg]
Sign Posts, Wood _____ × _____ in [mm]	FT [m]	ft [0.5 m]	FT [0.5 m]
Sign Posts, Wood _____ Rnd	FT [m]	ft [0.5 m]	FT [0.5 m]
Stl Overhead Sign Support	LS	LS	LS
Stl Break-Away Sign Support _____	LS, FT [LS, m]	LS, 0.1 ft [LS, 0.05 m]	LS, FT [LS, 0.5 m]

702.5.2 Referenced Sections for Direct Payment

1 The engineer will measure and pay for new sign posts needed to replace removed sign posts that are too short in accordance with Subsection 109.4, Extra and Force Account Work.

2 When specified, the engineer will measure and pay for Drilled Shaft Foundations in accordance with Section 506, Drilled Shaft Foundations.

SECTION 703
Temporary Traffic Control

703.1 DESCRIPTION

1 This section describes the requirements for furnishing, placing, maintaining, repairing, and removing temporary traffic control devices.

703.2 MATERIALS

703.2.1 General

1 Use temporary traffic control devices that meet the testing requirements of the *Manual for Assessing Safety Hardware* (MASH) or NCHRP-350, test level 3. Maintain and submit certification records in accordance with Subsection 703.4.2, Documentation.

2 Use temporary traffic control devices and flagger paddles fabricated with retroreflective sheeting in accordance with Subsection 816.4, Retroreflective Sheeting.

703.2.2 Drums, Cones, and Tubular Markers

1 Use drums, cones, 42-inch [1067 mm] cones, and tubular markers that are plastic and predominantly orange.

2 Use drums and 42-inch [1067 mm] cones that have alternating stripes, two orange and two white with orange on top, that are retroreflective and equal width.

703.2.3 Signs

1 Use the same sign sheeting material for each sign face on any sign installation. If hinged signs are used, ensure that the hinge does not block any part of the sign message. Permanent sign posts that meet MASH or NCHRP - 350, test level 3 may be used as approved by the engineer. Use surfaced, four-sided (S4S), untreated timber for sign posts.

703.2.4 Sign Panels

1 Construct sign panels of either:

1. **Plywood.** At least ½ in [12 mm], medium density, exterior grade B-B, overlaid fir plywood sheets meeting the requirements of the Product Standards PS1-95 for construction and industrial plywood published by the U.S. Department of Commerce.

2. **Aluminum.** Sheet aluminum 0.125 in [3 mm] or 0.080 in [2 mm] thick meeting the requirements of Subsection 816.1, Sheet Aluminum for Sign Panels.

3. **Other materials meeting MASH or NCHRP-350.**

703.2.4.1 Backing Angles

1 Use sign panels backed with 2 in × 2 in × $^{3}/_{16}$ in [50 mm × 50 mm × 5 mm] galvanized steel or aluminum backing angles and mounted to the post with 2 in × 2 in × $^{3}/_{16}$ in [50 mm × 50 mm × 5 mm] galvanized steel clip or aluminum angles except that sign panels 48 in × 60 in [1220 mm × 150 mm] or smaller may be backed as follows:

1. Aluminum panels 0.080 in [2 mm] thick and backed with metal backing angles or 2 in × 4 in [50 mm × 100 mm] dimensional lumber.

2. Aluminum panels 0.125 in [3 mm] thick and unbacked.

3. Plywood panels ½ in [12 mm] thick and unbacked.

2 Use galvanized bolts, locknuts, and washers that meet the requirements of Subsection 815.6, Bolts and Fasteners, to attach the sign panels to the backing members. Use locknuts that have a fiber or nylon insert. Use elevator bolts with heads flush with the surface of the sign panel.

703.2.5 Striping Paint and Glass Beads

1 Use commercially manufactured yellow or white highway striping paint for temporary pavement markings, and apply it without dilution. Make the painted pavement markings reflective by dropping or spraying glass beads onto the wet paint. Use retroreflective beads that meet the requirements of AASHTO M 247, Type I.

703.2.6 Temporary Pavement Striping Tape

1 Use temporary retroreflective pavement striping tape that is pressure-sensitive and manufactured for use as pavement striping.

703.2.7 Temporary Raised Pavement Markers

1 Use temporary raised pavement markers that are the same color on the face and body as the markings for which they are substituted, have a dimension of at least 2 in × 4 in [50 mm × 100 mm], are constructed of a high impact-resistant plastic material, and have at least 1.0 in² [645 mm²] of retroreflective area in each face.

2 Use markers that are designed for adhesion to the road by either hot melt bitumen, epoxy, or butyl pads. Use an adhesion method that allows for easy removal of markers without pavement damage.

703.2.8 Flags

1 Use flags 24 in [600 mm] square, except on signs use flags 16 in [400 mm] square or larger. Use flags with weighted corners or reinforcing to keep the flag extended away from the post. Do not use mesh flags.

703.2.9 Portable Plastic Water Filled Barrier

1 Use portable, longitudinal, crashworthy plastic barrier that meets the following requirements:

1. MASH or NCHRP-350, test level 3.
2. Approximate dimensions of 78 in × 21 in × 32 in [1980 mm × 530 mm × 810 mm] (length × width × height).
3. White and orange striped in accordance with the MUTCD.
4. Provide a crashworthy end terminal, or barrier that acts as its own crashworthy end treatment, or flare barrier outside the clear zone.

703.2.10 Temporary Concrete Barrier and End Terminal

1 Provide temporary concrete barrier and terminals meeting the requirements of the contract. If the barrier is to remain the property of the contractor and

does not have to connect to state furnished barrier, it is acceptable to furnish another temporary concrete barrier type meeting the requirements of MASH or NCHRP-350, test level TL-3 with a maximum dynamic deflection of 4 ft [1.2 m]. Furnish FHWA letter of acceptance for the barrier type and connection detail and evidence of maximum dynamic deflection to the engineer. Provide crashworthy terminals where terminated within the clear zone or flare outside clear zone.

2 Use class B concrete in accordance with Section 513, Structural Concrete, and incorporate grade 40 [400] reinforcing steel. Finish with an ordinary surface and with a 1-inch [25 mm] chamfer on corners. Use anchor pins, connecting pins, and other miscellaneous hardware that meet or exceed the requirements of ASTM A 36 [ASTM A 36M]. Coat exposed steel with one coat of shop primer, applied at a minimum wet thickness of 3 mil [75 µm].

3 Use bidirectional delineators approved by the State Traffic Engineer that match the color of the adjacent edgeline pavement stripe. Attach delineators to the barrier and terminal in accordance with the manufacturer's recommendations.

703.3 EQUIPMENT

703.3.1 Sequential Chevron

1 Use portable, wheel-mounted units that meet the requirements of the MUTCD and provide or are capable of all the following:

1. A 48 in × 96 in [1200 mm × 2400 mm] panel.
2. Flash in both the left and right directional modes.
3. An automatic dimmer switch for reducing the nighttime illumination level by 50 percent or other levels as needed.
4. A manual override backup switch.

2 Replace units that are not reliable or do not provide the necessary constant light source.

3 Maintain sequential chevrons in working order at all times. Chevrons may be powered by a generator on site, utility power, or solar power. Ensure that the power source is able to maintain constant operation. Generator power will be allowed only as approved by the engineer.

703.4 CONSTRUCTION

703.4.1 General

1 Furnish, install, locate, maintain, and remove construction traffic control devices.

2 If changes to the traffic control plan are proposed, prepare a revised traffic control plan, and submit it to the engineer at the preconstruction conference, or as requested by the engineer, in accordance with Subsection 108.3.3, Preconstruction Conference. Do not change traffic operations from the details and standard plans included in the contract, unless an alternate plan is submitted to and approved in writing by the engineer. Ensure the alternate plan is the same quality and detail as the one shown in the contract. Modify the plan as the situation warrants, and submit the revised plan to the engineer for approval.

3 If traffic or workers may be affected, do not begin work until the necessary construction traffic control devices are in place and approved by the engineer.

4 When placing, maintaining, and removing traffic control devices, provide the traffic control necessary for the safety of the public and the workers, at no additional cost to the department.

5 Schedule work to minimize the number and duration of required traffic control set-ups. Whenever possible, sequence work operations so that traffic control can be removed at night to allow full use of the roadway.

6 Construction traffic control device spacing is approximate; adjust it to fit field conditions. To provide maximum visibility of warning devices to oncoming motorists, consider roadway conditions, obstacles, geometrics, and permanent signing when placing construction signs. Changes in location and spacing are subject to approval by the engineer.

7 Check construction sites periodically, day and night, to ensure adequate traffic control is in place.

8 Completely cover or remove existing traffic control devices conflicting with construction traffic control, as approved by the engineer, and return them to their previous locations, as necessary, at the completion of the work. Ensure the method of cover does not damage or puncture the existing sign. Remove or completely cover construction traffic control devices during seasonal suspensions and when not in use or needed.

9 When anchoring traffic control devices, sand bags or an approved alternate may be used for ballasting, not exceeding 12 in [300 mm] in height above ground level. Do not ballast devices by heavy objects such as rocks, chunks of concrete, or plant mix.

10 When construction work is suspended in accordance with Subsection 108.5, Suspension of Work, remove unneeded construction traffic control devices, including posts.

703.4.2 Documentation

1 Maintain certification records that each temporary traffic control device meets the MASH or NCHRP-350 testing requirements specified. Furnish appropriate documentation to the engineer upon request.

2 When temporary traffic control is paid by traffic control device (TCD) units, and unless agreed otherwise, provide a daily record of the traffic control device units and flagging hours used on the project for that day to the engineer. Include all of the information required on the "Daily Traffic Control Device Record" (Form E-101) in the daily record. If Form E-101 is not used, use a form with consistent layouts for every daily traffic control record submitted on the project. Discuss and agree on the submittal process for the daily traffic control record with the engineer at the preconstruction conference.

703.4.3 Traffic Control Maintenance

1 Submit the name(s) of a designated traffic control maintainer(s) and the telephone number where the contractor's superintendent and maintaining personnel can be contacted, at any time, to the engineer before installing any traffic control. Provide cellular or other portable phone service when needed to ensure the availability of the superintendent and maintaining personnel.

2 Provide a maintainer if traffic is being diverted or protected by channelizing devices, barricades, portable signs, flagging, or pilot car operations.

3 Ensure the traffic control maintainer(s) is available to respond to notification by the engineer, a law enforcement official, or a page from a portable traffic signal to perform traffic control maintenance.

4 Ensure the traffic control maintainer(s) performs the necessary traffic control device maintenance by keeping the devices in the proper location and in good

condition. Provide the number of traffic control maintainers necessary to meet the specified requirements.

5 Ensure traffic control devices are maintained while in use on the roadway.

703.4.4 Channelizing Devices

1 Mark initial channelization device locations with paint so that replacement devices can be installed in the proper locations without measuring again.

2 In rural areas, cones, 42-inch [1067 mm] cones, or 42-inch [1067 mm] tubular markers may be used instead of drums as channelizing devices during the daytime only.

3 The name and phone number of the channelizing device owner may be shown on the non-reflective surface at the bottom of the device or on the back of signs in letters and numbers that are a non-reflective color and not over 2 in [50 mm] in height.

703.4.5 Signs

703.4.5.1 General

1 “Road Work Next __ Miles” and “End Road Work” signs are not required for projects less than 2 mi [3 km] in length or less than 28 calendar days in anticipated duration.

2 Use “Road Work Ahead” warning signs on major approach ramps or roads in close proximity to construction areas, as approved by the engineer.

3 Ensure the backs of signs are not distractive to motorists and contain no visible message, design, or reflectivity except as provided herein.

4 Ensure backing angle materials are covered by sign sheeting.

5 If the duration of a sign installation is less than 14 calendar days, the sign mounting may be a portable. If the duration of a sign installation is 14 calendar days or more, use a fixed sign mounting, unless otherwise approved by the engineer.

6 Use sign posts that do not extend above the sign and are installed plumb. Determine sign post lengths. Use break away holes for timber posts as specified, and do not allow any additional or plugged break away holes within the visible post section.

7 If necessary, request detail layouts of temporary traffic control signs lettering from the engineer.

8 Flags may be added to construction signs for better daytime visibility. Use flags on the “Flagger Ahead” and the “Be Prepared to Stop” signs.

9 If sign panels installed without backing will be in use throughout the suspension, install backing angles in accordance with Subsection 703.2.4.1, Backing Angles, before the suspension of work.

703.4.5.2 Special Signs

1 Special signs that are unique to the project, i.e., signs not specified or included in part VI of the MUTCD, and signs containing a message which is unique to the project may be furnished by the contractor or the department, as specified. The engineer will stake locations for special signs. Furnish posts, hardware, and equipment for fixed and portable installations; determine post length; and erect special signs.

2 Upon removal, special sign panels will be the property of the department; posts, hardware, and portable installation equipment belong to the contractor.

703.4.5.3 Portable Signs and Mounts

1 When portable traffic control devices are not in use, remove them as far from traffic as possible and, at a minimum, outside of the clear zone specified, as approved by the engineer. Position them so as not to confuse approaching motorists.

703.4.6 Flagging

1 Use flaggers that have completed and passed a flagger training program approved by the State Construction Office before flagging. A three-day grace period will be allowed to meet this requirement in an unplanned emergency situation. Ensure that flaggers are tested every three years and that they have a current certification card in their possession when they are on the project.

2 Ensure that flaggers wear a strong yellow-green vest or an orange and strong yellow-green combination vest with reflectorization on the front, back, and sides and a strong yellow-green hard hat (full hard hat covers are acceptable), and they have a paddle and flag (optional) in their possession at all times. The color

of strong yellow-green for vests and hard hats is for flagger use only. Supply and maintain the vest, hard hat, paddle, and flag in a "like new condition." Do not place company name or logo on the flagger vest.

3 Ensure that flaggers have positive communication between flagging stations appropriate to the various types of operations. This communication may include but is not limited to the following:

1. Hand signals.
2. Passing of a baton.
3. Radio communication.
4. Combinations of the above.

4 Use flagger radios for communication between flagging stations only. Use radios that are good quality and reliable so that communications are continuous for various types of operations (including no sight and long distance situations). Do not use radios in electrically sensitive areas involving blasting or instances where the radio transmissions interfere with other established communication mediums.

5 For nighttime flagging, use overhead lights that are on site and operational before their intended use, provide full illumination of the flaggers, and do not create glare for the flagger or motorist.

703.4.7 No Passing Zones

1 "No-Passing Zone" signs may be used to delineate no passing zones after the centerline has been marked in the following situations:

1. **Traffic volumes less than or equal to 1000 AADT.** Up to 14 calendar days.
2. **Traffic volumes greater than 1000 AADT.** Up to three calendar days.

2 Use temporary pavement markings if no-passing zones are required for durations longer than those specified in the previous paragraph.

3 Place "No-Passing Zone" signs before removing the existing center line striping.

4 Place temporary signing, striping, or barrier markers for no-passing zones at the same location as the existing permanent no-passing zones. The department will determine temporary no-passing zones in extenuating circumstances.

703.4.8 Temporary Pavement Markings

703.4.8.1 General

1 Use retroreflective temporary pavement markings that are paint, tape, raised pavement markers, or motorist guidance markers, either white or yellow, as specified. Do not use motorist guidance markers when interstate or divided highway traffic is placed two-lane, two-way.

2 Use paint with beads for temporary pavement markings on all pavement lifts, except the final surface treatment, plant mix wearing course, chip seal, seal coat, or concrete pavement. Final surface treatment is defined as the existing surfacing on interstate or divided highway lanes that is designated to remain in place over the winter or the surface after the final surface designated in the contract has been applied.

3 Use yellow temporary centerline markings on two-lane, two-way highways.

4 Use white temporary lane line markings and white or yellow edge line markings on single direction, multi-lane highways.

5 When interstate (divided highway) traffic is placed two-lane, two-way, use white edge lines and yellow pavement markings dividing opposing traffic.

6 Ensure that the application surfaces for temporary pavement markings are free of foreign matter which would interfere with adhesion. Apply temporary pavement markings in accordance with the manufacturer's recommendations.

7 Place temporary pavement markings to provide delineation by the end of each day's operations. Place the markings in line with existing centerline or lane line markings at the beginning or end of the paving section. Taper the markings at the beginning or end of the paving section to line up with existing centerline or lane line markings.

8 Motorist guidance markers or temporary raised pavement markers may be approved for final lifts of plant mix pavement, chip seals, seal coats, and concrete pavement surfaces. Place temporary motorist guidance markers (tabs) in line with existing centerline or lane line markings.

9 Maintain the temporary pavement markings in their proper location and in a clean, undamaged, effective condition while in use.

10 Collect and properly dispose of removed temporary pavement markings and their protective coverings.

11 When pavement markings are required but cannot be applied because of the surface type, install channelizing devices for the following:

1. **Centerline delineation.** May be used for centerline delineation day or night, as required by the engineer.

2 **Edge of roadway delineation.** Use for edge of roadway delineation day and night.

703.4.8.2 Temporary Pavement Striping Tape

1 Temporary pavement striping tape may be used in the following circumstances:

1. **Intermediate Lifts of Plant Mix Pavement.** Striping tape may be applied in emergency situations only. If a removable type is used, remove it before placing the next lift of plant mix pavement.

2. **Final Lift of Plant Mix Pavement or Existing Pavement.** Use removable striping tape. After the permanent striping operations, remove temporary pavement striping tape without damaging the pavement surface.

703.4.8.3 Conflicting Pavement Markings

1 Remove or cover conflicting pavement markings as approved by the engineer for work zone traffic control anticipated to be in place longer than three calendar days. Remove the markings without damaging the pavement surface, or cover the markings with removable, nonreflective, preformed tape in accordance with the MUTCD and approved by the engineer. If existing striping is removed, temporary striping may be used for increased motorist guidance. Use temporary striping that consists of paint, removable tape, temporary motorist guidance markers, or raised pavement markers.

703.4.9 Paint

1 Apply paint at the rate of 100 ft²/gal [2.46 m²/L], which is a wet-paint thickness of 16 mil [405 µm]. Apply beads at the rate of 8 lb/gal [0.97 kg/L] of paint.

703.4.10 Sequential Chevrons

1 Place the units at specified locations or as directed by the engineer, and keep them on the project for as long as needed. Replace units that are not reliable, do not have automatic dimmers, or do not provide the necessary constant light source within the times indicated in Subsection 703.5.4, Liquidated Damages.

703.4.11 Permanent Striping

1 Permanent striping will be placed by the department.

2 Striping will be placed by department personnel for projects that are suspended in accordance with Subsection 108.5, Suspension of Work.

703.4.12 Portable Plastic Water Filled Barrier

1 Install as specified. Use an environmentally safe anti-freeze when freezing conditions are anticipated or encountered.

703.4.13 Temporary Concrete Barrier and Terminal

703.4.13.1 General

1 Use only one type of barrier and only one type of barrier connection, as approved by the engineer, on the project. Use barrier and end terminals that are in good condition, as determined by the engineer.

2 Place barrier in smooth lines with connecting and terminal anchor pins fully inserted and pulling against the connecting pins to establish a tight connection. Drive terminal anchor pins into the ground.

3 Repair or replace barrier or terminals that are damaged, as approved by the engineer, at no additional cost to the department.

703.4.13.2 Barrier to Become Property of the Department

1 Provide barrier that meets all the following requirements:

1. Of the exact length specified.

2. With three types of lifting mechanisms:

    2.1. Lifting hook.

    2.2. Lifting holes.

    2.3. Fork lift slots.

3. With delineators attached as follows:

    3.1. **Barrier.** On both sides and the top of the sections.

    3.2. **End Terminals.** Two on top and two on each side.

703.4.13.3 Barrier to Become Property of the Contractor

1 Provide barrier that meets all the following requirements:

1. At least one lifting device.

2. The length specified or longer.

3. With delineators attached as follows:

    3.1. **Barrier.** At a minimum, delineators on top and the side exposed to traffic.

    3.2. **End Terminals.** Two on top and two on each side.

703.4.14 Traffic Control Supervisor

1 Ensure the traffic control supervisor understands WYDOT requirements, items in the contract, the contractor's proposed operations, and Part VI of the MUTCD and holds a current certification as a WYDOT traffic control supervisor.

2 Furnish proof of certification to the engineer at the preconstruction conference or before starting work, whichever occurs first.

3 Duties include the following:

1. Ensure a set of contract documents is available for use at all times.

2. Ensure all devices, including replacements, have been delivered to the project before installation.

3. Inspect the condition of all traffic control devices to be used on the project before installation.

4. Review the project day and night within 24 hours of the installation of the traffic control devices, monthly, and after each change in the traffic control setup. Within one working day of the review, provide the engineer written documentation of the time and date of review, condition of traffic control devices and layout, and a list of modifications required or performed.

5. Propose changes to improve flow of traffic through the work zone.

6. Prepare, modify, and submit Traffic Control Plans in accordance with Subsection 703.4.1, General.

7. Provide the engineer with a 24-hour contact number.

8. Return the engineer's call within two hours of the time of the call.

4 Be on site for:

1. The layout, installation, and removal of the traffic control devices when switching and returning traffic on interstate projects.

2. The initial layout, when any changes are made to the layout, installation, and removal of traffic control devices on projects that do not require traffic to cross over.

3. Review of problems within 24 hours of notification from the engineer.

703.5 MEASUREMENT and PAYMENT

703.5.1 General

1 When temporary traffic control is paid by traffic control device (TCD) units, the engineer will verify the quantities on the daily traffic control device record submitted by the contractor, and if approved, will use this record as the basis for measurement and payment for TCD units and flagging hours, when applicable. Correct the record if requested and resubmit. Payment will not be made for quantities documented on a record when the corrected form is not received by the engineer within two working days after the mutually agreed to re-submission date.

2 The engineer will measure:

1. Temporary Traffic Control by the lump sum. Additional flagging locations required by the engineer beyond that specified in the contract will be measured and paid for per hour, to the nearest quarter hour. Payment for the accepted quantities of additional flagging will be an adjustment to the contract lump sum bid price for temporary traffic control and will be made at the predetermined hourly wage rate, or quarter-hour fraction thereof, specified in the contract, plus 81 percent of that rate.

   Additional temporary traffic control devices required by the engineer beyond those specified in the contract and replacements for Category I and Category II temporary traffic control devices destroyed by traffic will be measured and paid for per each traffic control device (TCD) unit. Payment for Category II devices destroyed by traffic will be limited to the number of devices exceeding four in a single incident of damage. The number of TCD units for payment will be determined by multiplying the accepted quantities of each of the various devices by the TCD unit value specified for the device in the TCD Unit Schedule. Payment will be an adjustment to the contract lump sum bid price for temporary traffic control and will be made at a price of $1.50 per TCD unit.

2. Special Signs in accordance with Subsection 703.4.5.2, Special Signs.

3. Category ___ TCD units per each unit. The unit value of each TCD will be as specified in the Traffic Control Device Unit Schedule

included in the contract. The number of TCD units will be determined by multiplying the number of each of the various devices by the TCD unit value specified for the device in the Traffic Control Device Unit Schedule.

4. Category II TCD units for drums and temporary barrier placed parallel to the centerline of the roadway that are relocated laterally only once at each location but will measure for payment at subsequent locations. The engineer will measure in accordance with the following guidelines:

    4.1. **Moves across centerline and lane lines on two-lane, non-divided multilane, and urban roadways.** Moves across centerline and lane lines to change lanes of closure will not be measured for payment, except the taper will be measured for payment as a new setup if the existing taper is in place for more than seven calendar days.

    4.2. **Moves from one lane to another on the interstate or similar median divided multilane highways.** Moves to the opposite directional lane, i.e., eastbound lane to westbound lane, will be measured for payment as a new setup.

    4.3. **Tapers.** If it is required that the taper be moved longitudinally, the new taper will be measured for payment.

    4.4. **Special requirements.** Labor to make minor moves to comply with department requirements or special situations, such as oversize loads, etc., will be measured for payment as Force Account Work, in accordance with Subsection 109.4, Extra and Force Account Work, when the work involves more than one hour per a five-working day week.

5. Category IV TCD units for striping paint or tape as the sum of the lengths of the individual stripes or segments placed.

6. TCD unit rates for signs that are not included in the Traffic Control Device Unit Schedule, other than special signs which are unique to the project, by the rate for the sign with the area in square feet [square meters] that most closely approximates the area of the sign being installed.

7. Flagging by the hour. Flagging will be used to pay for the portable signal when the signal is used in accordance with Standard Plan 703-2C.

8. Cones and tubular markers used as channelizing devices as Category III TCD units once daily without regard to the number of relocations. The number measured for payment will not exceed the maximum number in use at any one time during a day.

9. Tubular markers used as roadside delineation as a Category I TCD unit per each installation.

10. If pay items for particular TCD categories are included in the Traffic Control Device Unit Schedule but are not included in the contract as pay items, and the engineer specifies or authorizes the use of temporary traffic control devices in those categories, TCD units for each such device will be paid at the unit price of $1.50 per TCD unit.

11. Sequential Chevron by the each or as a complete unit.

12. Plastic Water Barrier and Temporary Concrete Barrier by the foot [meter]. The engineer will measure the length of one section of barrier and multiply that length by the number of sections to determine the length for payment. Lateral repositioning of the barrier for the contractor's convenience will not be measured and paid for directly.

13. Temporary Concrete Terminal by the each.

3 Relocation of portable traffic control devices within a 36 ft [11 m] radius or less will not be measured for payment. This applies to those devices that are temporarily moved from the edges of the traveled ways to allow for normal operation of the roadway.

4 If portable signs are mounted on WC-4 barricades, the engineer will measure and pay for the portable sign installation only.

5 If the engineer requests a WC-4 barricade with arrow or other specified signs attached to be placed at a particular location, measurement and payment will be made for each installation and for each subsequent relocation request.

6 The engineer will measure and pay to reinstall traffic control devices removed for seasonal suspensions.

7 The department will pay as follows:

Pay Item	Pay Unit	Measure to the Nearest	Pay to the Nearest
Category ____ TCD Units	EA [Ea]	EA [Ea]	EA [Ea]
Flagging	HR [h]	0.25 h	0.25 HR [0.25 h]
Plastic Water Barrier	FT [m]	0.1 ft [0.05 m]	FT [m]
Sequential Chevron [(1)]	EA, LS [Ea, LS]	EA, LS [Ea, LS]	EA, LS [Ea, LS]
Temporary Concrete Barrier	FT [m]	0.1 ft [0.05 m]	FT [m]
Temporary Concrete Terminal	EA [Ea]	EA [Ea]	EA [Ea]
Temporary Traffic Control [(1)] [(2)]	LS	LS	LS

(1) **When paid by lump sum:** Once the traffic control devices have been placed, 30 percent of the lump sum item will be paid. Thereafter, the percentage paid will equal the percentage of the work complete up to and including 90 percent. The remaining 10 percent will be paid when the sequential chevrons are no longer required for guidance and protection. If it can be demonstrated to the satisfaction of the engineer that the pay mechanism is not an accurate pay out for the work performed, the percentages may be changed.

(2) The engineer will adjust the lump sum payment if adjustments are required.

703.5.2 Referenced Sections for Direct Payment

1 When specified, the engineer will measure and pay for:

1. Traffic control devices not shown in the Traffic Control Device Unit Schedule as Force Account Work in accordance with Subsection 109.4, Extra and Force Account Work.

2. Flagging in accordance with Section 703, Temporary Traffic Control.

3. Special sign panels furnished by the contractor that are unique to the project as Force Account Work in accordance with Subsection 109.4, Extra and Force Account Work. Transporting department furnished special signs to the project will be paid at one Category I TCD unit per mile [1.6 kilometer].

703.5.3 Damaged Devices

1 Replace devices that are destroyed or deemed irreparable at no additional cost to the department except in the following instances:

1. **Category I Devices.** Category I devices destroyed by traffic will be measured for payment once as an additional installation, when replaced.

2. **Category II Devices.** Category II devices destroyed by traffic will be measured for payment once as an additional installation, when damage in a single incident exceeds four devices.

703.5.4 Liquidated Damages

1 During periods of work, the engineer will assess liquidated damages in the amount of $250 if damaged or deficient devices are not properly maintained within 30 minutes of notification or attempted notification, as specified in Subsection 703.4.3, Traffic Control Maintenance. During periods of non-work, the engineer will assess liquidated damages in the amount of $250 if damaged or deficient devices are not properly maintained within two hours after notification or attempted notification, as specified in Subsection 703.4.3, Traffic Control Maintenance. Thereafter, in either of the above cases, additional liquidated damages in the amount of $250 will be assessed for each successive two-hour period during which the required maintenance is not performed.

2 If more than 25 percent of the number of one type of device in use on the roadway is damaged in a single incident of damage, the assessment of liquidated damages will be waived for a period not to exceed eight hours after the notification as specified in Subsection 703.4.3, Traffic Control Maintenance, provided suitable arrangements are made with the engineer for interim traffic control measures.

3 The engineer will assess liquidated damages in the amount of $250 per working day for each and every working day that the traffic control supervisor reports are received after the required time.

4 These damages will be in addition to the overtime charges specified for failure to complete contract work on time and will be assessed simultaneously with the overtime charges.

DIVISION 800

Materials

800.1 Manufactured Product Certifications

1 The department requires that manufactured products delivered to the project be accompanied by the manufacturer's certification or by a "Certification of Materials," (Form T-168), with all supporting test data in accordance with the *Materials Testing Manual*, that the materials meet contract specifications. The department does not require such certification for materials manufactured by the contractor and tested by job control and check samples or by an authorized testing agency.

2 The engineer may approve the use of manufactured materials delivered to the site without the required certification(s) by using an "Engineer's Verification of Specification Compliance," (Form T-132) if:

1. The product has been precertified by the Materials Program;
2. The item costs less than $1500, meets the requirements stated in the *Materials Testing Manual* for approval of materials without certification, and is marked or labeled with the brand name specified or the test specification to which it was manufactured; or
3. The use is temporary and the contractor retains ownership.

3 In an emergency, the engineer may approve use of an item or items before the required certifications have been received. The engineer will evaluate (and document) each such circumstance based on its own merits. For this purpose, the department considers an emergency as a condition requiring prompt action to:

1. Protect the immediate safety or welfare of the public;
2. Avoid seriously affecting the normal progress of construction; or
3. Produce a benefit to the department and the public.

4 The use and incorporation of materials without the required certification does not constitute acceptance.

800.2 Point of Sampling

1 When directed by the engineer, obtain material samples for material acceptance in accordance with the *Materials Testing Manual*. Sample from the following points:

1. **Aggregates.**

	Stockpile [1]	Conveyor Belt [2]	Windrow
Plant Mix Materials (PMB, RPMB, PMP, RPMP & PMWC)		✔	
Subbase		✔	✔ [3]
Base		✔	✔ [3]
Maintenance Stockpile		✔	✔ [3]
Pervious Backfill Material & Bridge Approach Backfill Material		✔	✔ [3]
Gravel for Drains	✔		
Chip Seal	✔		
Microsurfacing	✔		
Concrete	✔ [4]		
Blotter	✔		
Bed Course Material	✔		
Class B Bedding	✔		
Riprap, Stone Filled Gabions & Stone Mattress Aggregates	✔		
Filter Aggregate	✔		
Flowable Backfill	✔		
Grout	✔		

[1] Sample the last stockpile prior to final placement of the aggregate material.

[2] Sample from the conveyor belt used to load the hauling unit for final placement of the material.

[3] When not using a conveyor belt.

[4] Stockpile or storage bin.

2. **Miscellaneous Materials.**

Sodium Chloride	Project Site
Portland Cement	Delivery or Storage Unit
Performance Graded Asphalt Binder	Between Storage Tank and Mixer
Liquid Cut-Back Asphalt	By Supplier at Time of Loading
Emulsified Asphalt	By Supplier at Time of Loading
Geotextile & Impermeable Plastic Membrane	Project Site
Paving Fabric	Project Site
Geogrid	Project Site
Hot-Poured Elastic Sealant	Applicator Nozzle
Preformed Expansion Joint Filler	Project Site
Preformed Elastometric Compression Joint Seal	Project Site
Compressed Joint Material	Project Site
Paint	Submitted by Supplier or Project Site
Reinforcing Steel	Project Site
Spiral Steel	Project Site
Dowel Bars	Project Site
Galvanized Wire Products	Project Site
Recycled Plastic Posts - See Subsection 812.8.3.3, Testing	Project Site
Water for Concrete - See Subsection 814.1, Water	At Source
High-Strength Bolts, Nuts & Washers - See Table 815.2.5-1, Required Test Bolts	Project Site

2 The point of sampling may be adjusted if mutually agreed to by the engineer and contractor.

3 If a mechanical sampler is used, correlate test results with belt samples using the "Correlation of Aggregate Gradations," (Form T-165AG).

SECTION 801
Cement and Admixtures

801.1 Portland Cement

801.1.1 General

1 Use masonry cement in accordance with ASTM C 91.

2 Use portland cement in accordance with ASTM C 150, as follows:

1. **Structural Concrete.** Type II, low alkali.
2. **Pavement Concrete.** Type II, low alkali.
3. **Commercial Additives.** Types I or II.
4. **Base or Subbase Treatment.** Types I or II.

3 Use portland cement from only one mill for any brand and type, unless otherwise approved by the engineer. Keep cement dry; the engineer will reject cement that has partially set or contains caked lumps. Do not use salvaged cement from discarded or used bags.

801.1.2 Type V Portland Cement

1 Use low alkali cement in accordance with ASTM C 150.

801.2 Fly Ash

1 Use fly ash in accordance with ASTM C 311 and ASTM C 618 for class C or F. Before use, obtain approval of the source from the Materials Program; approval will be based on test results provided by the fly ash supplier using the following sampling frequencies:

1. Daily individual samples for five days;
2. Weekly composite samples for four weeks; and
3. Monthly composite samples for six months.

2 Provide the above-specified test results from a laboratory independent from the supplier. The Materials Program may accept results from previous testing in lieu of the above. A list of approved sources of fly ash is available from the Materials Program.

3 The requirements in ASTM C 618, table 4, also apply if the Materials Program determines that the aggregate sources are reactive.

801.3 Blended Hydraulic Cement

1 Use blended hydraulic cement in accordance with ASTM C 595 for type I (PM) pozzolan-modified portland cement. Use pozzolan in accordance with ASTM C 618 and ASTM C 311. If the pozzolan consists of fly ash, obtain approval from the Materials Program prior to its use. Use portland cement in accordance with Subsection 801.1, Portland Cement.

801.4 Admixtures

1 Use concrete admixtures in accordance with the following:

1. **Air-Entraining Admixtures.** Meet the requirements of AASHTO M 154 (ASTM C 260).

2. **Water-Reducing, Accelerating, or Set-Retarding Admixtures.** Meet the requirements of AASHTO M 194 (ASTM C 494). Do not use admixtures containing calcium chloride.

3. **Silica Fume Admixture.** Use a dry compacted form in accordance with AASHTO M 307, including table 2.

801.5 Synthetic Fibers

1 Use 100 percent polypropylene collated, fibrillated fibers with the physical properties shown in Table 801.5-1, Synthetic Fiber Properties.

Table 801.5-1
Synthetic Fiber Properties

Property	Value
Specific Gravity, min.	0.91
Modulus of Elasticity	500,000 to 700,000 psi [3450 to 4830 MPa]
Tensile Strength	70,000 to 110,000 psi [485 to 760 MPa]
Length	Graded (¼ to 1 in [6 to 25 mm])

2 Ensure the polypropylene fibers are specifically manufactured from virgin polypropylene, containing no reprocessed olefin materials. Ensure product documentation includes certification from the original manufacturer of the fibers.

SECTION 802
Curing Materials

802.1 Curing Materials

1 Provide materials in accordance with Table 802.1-1, Curing Materials. The latest Section 701 in the *Materials Testing Manual* pre-approves all products.

Table 802.1-1
Curing Materials

Material	Specification
Burlap Cloth (Jute or Kenaf)	AASHTO M 182, Class 3
Sheet Materials	AASHTO M 171 (ASTM C 171)
Impervious Curing Compounds[(1)]:	
“Basic”	AASHTO M 148 (ASTM C 309), Class A
“Premium White”	AASHTO M 148 (ASTM C 309), Type 2, Class B, and Table 802.1-2 or ASTM C1315, Type II, Class A
“Premium Clear”	ASTM C 1315, Type I or I-D, Class A

(1) Provide compounds meeting all current VOC requirements and having flash points of at least 100 °F [38 °C].

Table 802.1-2
PAMS Compound Properties

Property	Minimum	Maximum	ASTM
Total solids by weight of compound, %	35	–	C 1315
Reflectance TiO_2 Pigment[(1)], %	60	–	E 1347
Drying Time, minutes: Set to touch Track free	–	 60 120	C 309
Water loss in 72 hours, lb/ft² [kg/m²]	–	0.06 [0.30]	C 156
Flash point, ºF [ºC]	100 [38]	–	D 56, D 93
VOC content, $lb/gal_{N.W.}$ $[g/L_{N.W.}]$	–	2.9 [350]	D 3960

(1) Applies only to AASHTO M 148 (ASTM C 309), type 2.

802.2 Evaporation Retardant

1 For evaporation retardant provide a thin monomolecular film producing compound designed to reduce the surface evaporation rate. Preapprove evaporation retardants through the Materials Program.

SECTION 803
Aggregate

803.1 General

1 Before producing aggregate, remove vegetation, topsoil, and overburden from the pit area to be used. Ensure that the materials are free of deleterious substances and do not contain an excess of thin, flat, elongated, soft, or disintegrated pieces. Ensure that aggregates for plant mix base, pavement, wearing course, microsurfacing, and chip seal do not have adherent films of clay or other matter that could prevent thorough coating with asphalt.

2 When crushed aggregate is specified for subbases, bases, or plant mix pavements, crush boulders with diameters up to 18 in [450 mm] and distribute uniformly throughout the material.

3 The department defines a gradation requirement as the percentage of material by weight [mass] that passes through a laboratory sieve with square openings and of a size or designation in accordance with AASHTO M 92 (ASTM E 11). The department defines “coarse aggregate” as material retained on a No. 4 [4.75 mm] sieve and “fine aggregate” as material that passes through a No. 4 [4.75 mm] sieve.

4 For quarried aggregate, material rejected during primary crushing may be used in subbase or crushed base, provided the combined material meets applicable specifications; dispose of other rejected material as directed by the engineer. If quarrying from limestone from an available or mandatory source listed in the contract, crush the quarried material with a primary crusher to 4 in [100 mm] or less, without allowing more than 5 percent to pass through a 1-inch [25 mm] sieve.

803.2 Aggregate for Concrete

803.2.1 Fine Aggregate

1 Use washed fine aggregate in accordance with AASHTO M 6 but not exceeding the limits in Table 803.2.1-1, Deleterious Substance Limits: Fine Aggregate for Concrete.

Table 803.2.1-1
Deleterious Substance Limits:
Fine Aggregate for Concrete

Substances	Max. %, by weight [mass]
Clay lumps	1.0
Coal and lignite	1.0
Material passing a No. 200 [75 µm] sieve	4.0

2 Ensure the sum of the above materials and other deleterious substances, such as shale alkali, mica, coated grains, or soft and flaky particles, does not exceed 4 percent by weight [mass].

3 Ensure aggregate gradation is in accordance with Table 803.2.1-2, Gradation Requirements: Fine Aggregate for Concrete.

Table 803.2.1-2
Gradation Requirements:
Fine Aggregate for Concrete

Sieve	% Passing
⅜ in [9.50 mm]	100
No. 4 [4.75 mm]	95 to 100
No. 16 [1.18 mm]	45 to 80
No. 50 [300 µm]	10 to 30
No. 100 [150 µm]	2 to 10
No. 200 [75 µm]	0 to 4

803.2.2 Coarse Aggregate

1 Wash coarse aggregate to remove adherent soil coatings and reduce the amount of material passing a No. 200 [75 µm] sieve at least 50 percent. Use aggregate consisting of crushed stone or gravel meeting the requirements of AASHTO M 80 but not exceeding the limits in Table 803.2.2-1, Deleterious Substance Limits: Coarse Aggregate for Concrete. When specified, provide aggregate in accordance with Subsection 803.6.2, Polish Resistant Aggregate.

Table 803.2.2-1
Deleterious Substance Limits:
Coarse Aggregate for Concrete

Substances	Max. %, by weight [mass]
Shale or coal	0.1
Clay lumps	0.5
Material passing a No. 200 (75 µm) sieve	2.0
Other deleterious substances such as friable, thin, elongated, or laminated pieces	3.0
All deleterious substances combined	5.0

2 Ensure coarse aggregate gradation for silica fume modified concrete meets the requirements of Table 803.2.2-2, Gradation Requirements: Coarse Aggregate for Silica Fume Modified Concrete.

3 Provide aggregate with an LA abrasion loss less than 40 percent when tested in accordance with AASHTO T 96 and that loses no more than 12 percent of its weight [mass] when tested in sodium sulfate solution in accordance with MTM 403.0. Ensure that the aggregate meets the requirements of Table 803.2.2-3, Gradation Requirements: Coarse Aggregate for Concrete.

Table 803.2.2-2
Gradation Requirements:
Coarse Aggregate for Silica Fume Modified Concrete

Sieve	% Passing	
	Min.	Max.
½ in [12.5 mm]	100	–
⅜ in [9.50 mm]	85	100
No. 4 [4.75 mm]	10	30
No. 8 [2.36 mm]	0	10
No. 16 [1.18 mm]	0	5
No. 200 [75 µm]	0	1.5

Table 803.2.2-3
Gradation Requirements: Coarse Aggregate for Concrete

Sieve	% Passing		
	Structural Concrete		Portland Cement Concrete Pavement[1]
	Classes A & B	Class S[1]	
2½ in [63 mm]	–	–	–
2 in [50 mm]	–	–	–
1½ in [37.5 mm]	100	–	100
1 in [25.0 mm]	95 to 100	100	95 to 100
¾ in [19.0 mm]	–	90 to 100	–
½ in [12.5 mm]	25 to 60	–	25 to 60
⅜ in [9.50 mm]	–	20 to 55	–
No. 4 [4.75 mm]	0 to 10	0 to 10	0 to 10
No. 8 [2.36 mm]	0 to 5	0 to 5	0 to 5
No. 200 [75 µm]	0 to 2	0 to 2	0 to 2

(1) For these, and for class A concrete used for pavement, ensure that at least 50 percent of the material retained on the No. 4 [4.75 mm] sieve has at least one fractured face.

803.3 Aggregate for Mortar

1 For mortar, use aggregate in accordance with AASHTO M 45.

803.4 Aggregate for Subbase and Base

803.4.1 General

1 For base and subbase, use coarse aggregate consisting of hard, durable particles or fragments of stone or gravel; use fine aggregate consisting of crushed stone, crushed gravel, or natural sand.

803.4.2 Subbase

1 For subbase, use crushed or natural stone or gravel in accordance with the following:

1. **Pit Run Subbase.** Use the maximum size specified. Remove oversize material at the source.
2. **Crusher-Run Subbase.** Use crusher-run material of the maximum size specified.
3. **Crushed Subbase.** Ensure that at least 40 percent of the material retained on the No. 4 [4.75 mm] sieve has at least one fractured face.

803.4.3 Crushed Base

1 For crushed base, provide and use base aggregate that meets the requirements of Table 803.4.4-1, Gradation Requirements: Subbase and Base; Table 803.4.4-2, Aggregate Properties: Subbase and Base; and that is not moisture sensitive as determined by the *Materials Testing Manual*. Ensure that at least 50 percent of the material retained on the No. 4 [4.75 mm] sieve has at least one fractured face.

803.4.4 Gradation and Properties

1 Provide and use subbase and base that meets the requirements of Table 803.4.4-1, Gradation Requirements: Subbase and Base and Table 803.4.4-2, Aggregate Properties: Subbase and Base.

Table 803.4.4-1
Gradation Requirements: Subbase and Base

Sieve	Grading				
	J	GR	L	K	W
	% Passing				
2 in [50 mm]	100	–	–	–	–
1½ in [37.5mm]	90 to 100	–	100	100	100
1 in [25 mm]	–	100	90 to 100	90 to 100	90 to 100
¾ in [19 mm]	–	90 to 100	–	–	–
½ in [12.5 mm]	–	65 to 85	60 to 85	–	60 to 85
⅜ in [9.50 mm]	–	–	–	–	–
No. 4 [4.75 mm]	35 to 75	50 to 78	35 to 55	40 to 65	45 to 65
No. 8 [2.36 mm]	–	37 to 67	25 to 50	30 to 55	33 to 53
No. 30 [600 µm]	–	13 to 35	10 to 30	–	–
No. 200 [75 µm]	0 to 15	4 to 15	3 to 15	3 to 15	3 to 12

Table 803.4.4-2
Aggregate Properties: Subbase and Base

Properties	Subbase	Crushed Base	Crushed Base (Gravel Roads)
LA abrasion loss, max., %	50	50	50
Liquid limit, max.	25	25	30
Plasticity index	0 to 6	0 to 3	4 to 12
R-Value, min.	60	75	60
Soundness ($MgSO_4$)[1] loss for coarse aggregate, max.	–	18	18

(1) Soundness ($MgSO_4$) will be tested on coarse aggregate.

803.5 Aggregate for Flexible Pavement

803.5.1 General

1 Use aggregate that is tough and sound, of uniform quality, and crushed to size. Stockpile coarse and fine aggregates separately. Use aggregate consisting of crushed stone or crushed or natural gravel; do not use pit run filler or RAP unless designated in the contract.

803.5.2 Pit Run Filler

1 When specified, use nonplastic granular pit run filler that meets the requirements of Table 803.5.2-1, Gradation Properties: Pit Run Filler, and Table 803.5.2-2, Aggregate Properties: Pit Run Filler. Stockpile in its own pile.

Table 803.5.2-1
Gradation Properties: Pit Run Filler

Sieve	Grade 1	Grade 2
	% Passing	
⅜ in [9.50 mm]	100	100
No. 4 [4.75 mm]	90 to 100	90 to 100
No. 8 [2.36 mm]		
No. 30 [600 µm]	30 to 60	
No. 200 [75 µm]	0 to 15	

Table 803.5.2-2
Aggregate Properties: Pit Run Filler

Property	Grade 1	Grade 2
Fine Aggregate Angularity, max., %	40	35
Plasticity index	NP	NP

803.5.3 Reclaimed Asphalt Pavement

1 Crush and screen reclaimed asphalt pavement (RAP) greater than 2 in [50 mm] so that all material is prepared for recycling and a uniform mixture is maintained. Handle, screen, and crush material so as not to produce unnecessary fractured aggregate or cause undue degradation. Ensure that 100 percent of RAP used for recycled plant mix pavement passes through a 2 in [50 mm] sieve. Stockpile in its own pile.

803.5.4 Recycled Plant Mix Pavement

1 Ensure that the combined virgin aggregate gradation meets the narrow band specification developed during the mix design.

803.5.5 Gradation and Properties

1 Size, grade, and combine aggregate fractions for the mixture, including RAP when specified, in proportions such that the resulting composite blend meets the requirements of Table 803.5.5-1, Gradation Requirements: Marshall and Superpave Mixes.

Table 803.5.5-1
Gradation Requirements: Marshall and Superpave Mixes

Sieve	% Passing, Nominal Maximum Size			
	1 in [25 mm]	¾ in [19 mm]	½ in [12.5 mm]	⅜ in [9.5 mm]
1¼ in [31.5 mm]	100	–	–	–
1 in [25.0 mm]	90 to 100	100	–	–
¾ in [19.0 mm]	65 to 90	90 to 100	100	–
½ in [12.5 mm]	50 to 85	55 to 90	90 to 100	100
⅜ in [9.5 mm]	40 to 75	45 to 85	55 to 90	90 to 100
No. 4 [4.75 mm]	30 to 60	30 to 65	35 to 70	45 to 85
No. 8 [2.36 mm]	20 to 45	20 to 50	20 to 55	30 to 65
No. 30 [600 µm]	5 to 25	5 to 30	5 to 35	10 to 40
No. 200 [75 µm]	2 to 7	2 to 7	2 to 7	2 to 7

2 For specific types of aggregate, provide in accordance with Table 803.5.5-2, Aggregate Properties: Flexible Pavements.

Table 803.5.5-2
Aggregate Properties: Flexible Pavements

Property	Aggregate Type				
	I	II	III	IV	V
LA abrasion loss, max., %	35	40	40	40	40
Flat and elongated (1:5 ratio), max., %	10	10	10	10	–
Sand equivalent, min.[(2)], %	45	45	45	40	40
Fractured faces, min.[(1)], %	95/90	95/90	85/80	75/–	55/–
Fine aggregate angularity, min.[(2)], %	45	45	45	40	40
Plastic index[(2)]	NP	NP	NP	NP	NP
Soundness ($MgSO_4$)[(3)] loss, max., %	18	18	18	18	18

(1) "95/90" denotes that 95 percent of the coarse aggregate has one or more fractured faces and 90 percent has two or more fractured faces.

(2) Based on the minus No. 4 [4.75 mm] fraction of the composite blend.

(3) Soundness ($MgSO_4$) will be tested on coarse aggregate.

803.6 Aggregate for Plant Mix Wearing Course

803.6.1 General

1 For plant mix wearing course, use crushed stone or gravel for aggregate in accordance with the requirements for aggregate type I in Table 803.5.5-2, Aggregate Properties: Flexible Pavements, and Table 803.6.1-1, Gradation Requirements: Plant Mix Wearing Course.

2 When specified, provide aggregate in accordance with Subsection 803.6.2, Polish Resistant Aggregate.

Table 803.6.1-1
Gradation Requirements: Plant Mix Wearing Course

Sieve	% Passing
½ in [12.5 mm]	100
⅜ in [9.5 mm]	97 to 100
No. 4 [4.75 mm]	25 to 45
No. 8 [2.36 mm]	10 to 25
No. 200 [75 µm]	2 to 7

803.6.2 Polish Resistant Aggregate

1 Provide aggregate that is in accordance with one of the test methods in Table 803.6.2-1, Polish Resistant Aggregate Requirements.

Table 803.6.2-1
Polish Resistant Aggregate Requirements

Test Method	Description	Specification
ASTM D 3042	Insoluble Residue min., %(1)	70
AASHTO T 279	9 hour (Polish Value), min.	32
AASHTO T 242	Skid Number, min.(2)	40

(1) Alternatively, the Insoluble Residue may be determined in accordance with the *Materials Testing Manual* procedure No. 426.0.

(2) Base the skid number on historical skid numbers accumulated for a period of at least five years for a pavement that has carried traffic exceeding 3,500,000 accumulated 18-kip equivalent single axle loads.

803.7 Aggregate for Microsurfacing

1 Use 100 percent crushed stone or gravel of which 95 percent is retained on a ½-inch [12.5 mm] sieve before crushing. Ensure a sand equivalent of at least 65 percent, a maximum soundness ($MgSO_4$) loss of 20 percent on the coarse aggregate, and an LA abrasion loss of no more than 30 percent; supply the test results. Submit the job mix formula in accordance with Subsection 401.4.13, Composition of Plant Mix; ensure accordance with Table 803.7-1, Gradation Requirements: Microsurfacing.

Table 803.7-1
Gradation Requirements: Microsurfacing

Sieve	% Passing
⅜ in. [9.5 mm]	100
No. 4 [4.75 mm]	70 to 90
No. 8 [2.36 mm]	45 to 70
No. 16 [1.18 mm]	28 to 50
No. 30 [0.60 mm]	19 to 34
No. 50 [0.30 mm]	12 to 25
No. 100 [150 µm]	7 to 18
No. 200 [75 µm]	5 to 15

2 When specified, provide aggregate in accordance with Subsection 803.6.2, Polish Resistant Aggregate.

803.8 Aggregate for Chip Seal

1 For chip seal, provide and use aggregate types in accordance with the following:

1. **Types B, C, and K.** Nonplastic crushed stone or gravel, of which, before crushing, at least 95 percent is retained on a ½-inch [12.5 mm] sieve.

2. **Types B and C.** Process produced aggregate over a slotted screen that has openings ¼ in [6.25 mm] wide by at least ¾ in [18.75 mm]. Do not use material that passes through the screen.

3. **Type D.** Crushed stone or gravel, or clean pea gravel.

4. **Types B, C, D and K.** LA abrasion loss maximum of 35 percent.

5. **Type E.** Crushed sand-gravel.

6. **Type S.** Screened or pit-run sand.

7. **Types E and S.** Plasticity index no greater than 3.

2 Provide and use aggregate well-graded from coarse to fine and in accordance with Table 803.8-1, Gradation Requirements: Chip Seal.

Table 803.8-1
Gradation Requirements: Chip Seal

Sieve	% Passing					
	Type					
	B	C	D	E	K	S
1 in [25.0 mm]	–	–	–	–	–	–
¾ in [19.0 mm]	100	–	100	100	–	–
½ in [12.5 mm]	95 to 100	100	95 to 100	95 to 100	100	100
⅜ in [9.5 mm]	40 to 70	90 to 100	–	–	95 to 100	95 to 100
No. 4 [4.75 mm]	0 to 15	0 to 10	0 to 15	35 to 70	0 to 35	85 to 100
No. 8 [2.36 mm]	0 to 7	0 to 5	–	–	0 to 20	–
No. 200 [75 µm]	0 to 2	0 to 2	0 to 10	0 to 10	0 to 3	0 to 5

3 When specified, provide aggregate in accordance with Subsection 803.6.2, Polish Resistant Aggregate.

803.9 Aggregate for Blotter

1 For blotter material, provide aggregate with a plasticity index of 3 or less and in accordance with Table 803.9-1, Gradation Requirements: Blotter.

Table 803.9-1
Gradation Requirements: Blotter

Sieve	% Passing
⅜ in [9.5 mm]	100
No. 4 [4.75 mm]	85 to 100
No. 200 [75 µm]	0 to 20

2 For chip seal applications, provide blotter aggregate with the same color as the chip seal aggregate.

803.10 Aggregate for Bed Course Material

1 Provide and use aggregate consisting of, sand, gravel, crushed stone, or other approved material of which 100 percent passes through a ½-inch [12.5 mm] sieve.

803.11 Aggregate for Class B Bedding

1 Provide and use aggregate in accordance with Table 803.11-1, Gradation Requirements: Class B Bedding.

Table 803.11-1
Gradation Requirements: Class B Bedding

Sieve	% Passing
⅜ in [9.5 mm]	100
No. 200 [75 µm]	0 to 10

803.12 Gravel for Drains

1 Provide and use aggregate that is crushed or natural sand and gravel or other free-draining material approved by the engineer and that meets the requirements of Table 803.12-1, Gradation Requirements: Gravel For Drains, (use grading B if not specified).

Table 803.12-1
Gradation Requirements: Gravel for Drains

Sieve	% Passing		
	Grading		
	A	B	C
2 in [50 mm]	100	–	–
1½ in [37.5 mm]	95 to 100	100	–
1 in [25.0 mm]	–	95 to 100	–
¾ in [19.0 mm]	35 to 70	–	100
⅜ in [9.50 mm]	10 to 30	–	95 to 100
No. 4 [4.75 mm]	0 to 5	0 to 10	–
No. 8 [2.36 mm]	–	–	65 to 95
No. 16 [1.18 mm]	–	–	5 to 30
No. 100 [150 µm]	–	–	0 to 10

803.13 Aggregate for Maintenance Stockpiles

803.13.1 Type A

1 Provide and stockpile aggregate consisting of clean, hard, durable particles of crushed gravel or stone having a percentage of wear of no more than 40. For a maximum nominal size of ½ in [12.5 mm], ensure that 95 percent of the material is retained on a ½-inch [12.5 mm] sieve before crushing. For a maximum nominal size of ⅜ in [9.50 mm], ensure that 95 percent is retained on a ⅜-inch [9.50 mm] sieve before crushing. Ensure that the material meets

the requirements of Table 803.13.1-1, Gradation Requirements: Maintenance Stockpiles (Type A). For the fraction passing the No. 4 [4.75 mm] sieve, ensure a liquid limit no greater than 25 and a plasticity index no greater than 3.

Table 803.13.1-1
Gradation Requirements: Maintenance Stockpiles (Type A)

Sieve	% Passing	
	½ in [12.5 mm]	⅜ in [9.50 mm]
¾ in [19.0 mm]	100	–
½ in [12.5 mm]	90 to 100	100
⅜ in [9.50 mm]	60 to 90	90 to 100
No. 4 [4.75 mm]	45 to 65	50 to 80
No. 8 [2.36 mm]	30 to 50	33 to 63
No. 200 [75 µm]	3 to 12	3 to 12

803.13.2 Type B

1 Provide and stockpile aggregate consisting of clean, hard, durable particles of crusher-run gravel or screened stone obtained from designated portions of the pit. Ensure that the material has a plasticity index no greater than 3 and meets the requirements of Table 803.13.2-1, Gradation Requirements: Maintenance Stockpiles (Type B).

Table 803.13.2-1
Gradation Requirements: Maintenance Stockpiles (Type B)

Sieve	% Passing				
	¾ in [19 mm]	**½ in [12.5mm]**	**⅜ in [9.50 mm]**	**No. 4 [4.75 mm]**	**No. 4 [4.75 mm] Modified**
1 in [25.0 mm]	100	–	–	–	–
¾ in [19.0 mm]	95 to 100	100	–	–	–
½ in [12.5 mm]	–	95 to 100	100	–	–
⅜ in [9.50 mm]	–	–	95 to 100	100	100
No. 4 [4.75 mm]	0 to 75	0 to 75	0 to 75	95 to 100	95 to 100
No. 200 [75 µm]	0 to 15	0 to 15	0 to 15	0 to 5	0 to 12

803.13.3 Type C

1 Provide and stockpile aggregate consisting of crusher-run scoria meeting the requirements of Table 803.13.3-1, Gradation Requirements: Maintenance Stockpiles (Type C).

Table 803.13.3-1
Gradation Requirements: Maintenance Stockpiles (Type C)

Sieve	% Passing
⅜ in [9.5 mm]	100
No. 4 [4.75 mm]	85 to 100
No. 200 [75 µm]	0 to 10

803.13.4 Sodium Chloride for Maintenance Stockpiles

1 Provide and stockpile type 1, sodium chloride meeting the requirements of AASHTO M 143 (ASTM D 632). Ensure that gradation samples taken after delivery meet the requirements of Table 803.13.4-1, Gradation Requirements: Sodium Chloride.

Table 803.13.4-1
Gradation Requirements: Sodium Chloride

Sieve	% Passing
½ in [12.5 mm]	100
⅜ in [9.50 mm]	95 to 100
No. 4 [4.75 mm]	20 to 95
No. 8 [2.36 mm]	10 to 75
No. 30 [0.60 mm]	19 to 34

2 Provide and stockpile sodium chloride to which the producer has added yellow prussiate of soda (YPS) or other chemical additive approved by the engineer, at a rate of not less than 200 ppm. Ensure that the sodium chloride is delivered to the mixing site in bags or other containers acceptable to the engineer or in bulk lots and that the manufacturer’s name and the net weight [mass] is marked on each bag or container, or in the case of bulk lots, on the shipping or delivery invoice.

803.14 Aggregate for Pervious Backfill Material

1 Provide and use nonplastic aggregate consisting of crushed gravel, crushed rock, manufactured sands, or combinations thereof. Ensure the material has a liquid limit no greater than 30 and meets the requirements of Table 803.14-1, Gradation Requirements: Pervious Backfill Material.

Table 803.14-1
Gradation Requirements: Pervious Backfill Material

Sieve	% Passing
2 in [50 mm]	100
No. 4 [4.75 mm]	0 to 50
No. 30 [600 µm]	0 to 35
No. 100 [150 µm]	0 to 10
No. 200 [75 µm]	0 to 4

2 For reinforced bridge approach fills, ensure that the materials provided and used have an internal friction angle of at least 35 degrees.

803.15 Aggregate for Riprap

803.15.1 General

1 Use aggregate consisting of hard, durable, crushed, quarried, or natural stone or broken concrete. Ensure an apparent specific gravity of at least 2.4, an absorption no greater than 4 percent, that the pieces are free of weak laminations and cleavages, and that at least 60 percent weigh 77 lbs [35 kg] or more. Do not provide material that will disintegrate in water or weather.

803.15.2 Hand-Placed Riprap

1 Provide and use stones at least 3 in [75 mm] thick and weighing at least 55 lb [25 kg]. Use choke stones consisting of fragments or spalls to fill the voids between the riprap stones.

803.15.3 Machine-Placed Riprap

1 Provide and use stone graded with enough smaller stones uniformly distributed throughout to stabilize the installation.

803.15.4 Grouted Riprap

1 Provide and use stone in accordance with the requirements for hand-placed or machine-placed riprap.

803.15.5 Wire-Enclosed Riprap

1 Provide and use round or angular stones of which at least 95 percent are retained on a screen or wire having 3 in [75 mm] square openings.

803.15.6 Stone-Filled Gabions

1 Provide and use round or angular stones of which:

1. At least of 95 percent are retained on a screen with 4-inch [100 mm] square openings;
2. No more than 5 percent are retained on a screen with 6½-inch [152.5 mm] square openings; and
3. 100 percent pass through a screen with 8-inch [200 mm] square openings.

803.15.7 Stone Mattress

1 Provide and use round or angular stones of which at least 95 percent are retained on a screen or wire with 3 in [75 mm] square openings.

803.15.8 Filter Aggregate for Riprap

1 Provide and use aggregate consisting of hard, durable particles or fragments of crushed stone or natural gravel, screened or crushed to meet the requirements of Table 803.15.8-1, Gradation Requirements: Riprap Filter Aggregate.

Table 803.15.8-1
Gradation Requirements: Riprap Filter Aggregate

Sieve	% Passing
3 in [75 mm]	100
No. 4 [4.75 mm]	20 to 50
No. 200 [75 µm]	0 to 10

803.16 Aggregate for Flowable Backfill

1 Provide and use nonplastic aggregate with a liquid limit no greater than 25 and meeting the requirements of Table 803.16-1, Gradation Requirements: Flowable Backfill.

Table 803.16-1
Gradation Requirements: Flowable Backfill

Sieve	% Passing
¾ in [19.0 mm]	100
No. 200 [75 µm]	2 to 10

SECTION 804
Asphalt Materials

804.1 Performance Graded Asphalt Binder

1 Provide PGAB in accordance with the high- and low-grade temperatures specified.

804.1.1 Binder Properties

1 Provide binder in accordance with AASHTO M 320, excluding pressure aging vessel residue tests for dynamic shear, physical hardening, and direct tension. When the difference between specified high- and low-grade temperatures is at least 90, provide binder that also is in accordance with AASHTO T 301 with at least 60 percent elongation recovery. Test at 77 ºF [25 ºC] using RTFO residue, and sever the specimen immediately after elongation.

2 Do not provide or use PGAB with fibers or other discrete particles larger than 0.010 in [250 μm] or with carcinogenic modifiers.

3 Base asphalt may be modified with no greater than 0.50 percent phosphoric acid. Ensure the total phorsphous content does not exceed 1900 ppm.

804.1.2 Source Qualification

1 Ensure that the supplier is qualified annually for each facility shipping PGAB. Ensure the supplier submits documentation and samples required for qualification to the Materials Program at least 30 calendar days before the supplier's qualification expires.

1. **Request for Authorization.** Ensure that the supplier submits a written request to the Materials Program for authorization to ship specific grades of PGAB to department projects. The department will not grant authorizations lasting longer than 12 months.

2. **Approval Sample.** Ensure the manufacturer submits approval samples annually for its facilities. Approval samples consist of PGAB for both mix design and authorization. If approved by the Materials Program, a manufacturer may submit approval samples from its common product (i.e., formulation) laboratory to qualify multiple facilities. Submit approval samples and documentation as follows:

2.1. For authorization

2.1.1. ½ gal [2 L] of PGAB in two, 1-quart [1 L] containers, for each single PGAB grade;

2.1.2. Classification test results and other applicable properties described in Subsection 804.1.1, Binder Properties; and

2.1.3 Phosphorus content of each different asphalt binder as determined by ASTM D 1091, D 6443, or D 6481.

2.2. For mix design

2.2.1. 10 gal [40 L] of PGAB in two 5-gallon [20 L] containers, for each different PGAB expected to be used during the next 12 months indicating the grade or multiple grades applicable to the sample;

2.2.2. A temperature versus rotational viscosity chart in degrees Fahrenheit versus Pascal-seconds [degrees Celsius vs Pascal-seconds], showing a minimum range of from 275 ºF to 347 ºF [135 ºC to 175 ºC], and with data points at every 18 ºF [10 ºC];

2.2.3. A written statement clearly indicating the laboratory mixing and compaction temperature ranges, in degrees Fahrenheit [Celsius]; for unmodified asphalt binders, this corresponds to rotational viscosities from 0.150 Pa•s to 0.190 Pa•s and 0.250 Pa•s to 0.310 Pa•s, in accordance with AASHTO T 245; for modified asphalts, indicate recommended temperatures;

2.2.4. Specific gravity; and

2.2.5. The type or class of modifier.

The Materials Program will test the samples for applicable properties described in Subsection 804.1.1, Binder Properties. If the authorization sample fails, ensure the manufacturer submits an additional source approval sample for the appropriate grade(s), including both authorization and mix design sample quantities. For each separate grade of PGAB, the department will not test more than two samples for authorization. Perform additional sample testing beyond these two samples by an independent third party laboratory, selected through mutual agreement with the Materials Program, at no additional cost to the department; submit testing results to the Materials Program.

3. **Quality Control Plan.** Ensure that the PGAB supplier submits to the Materials Program its proposed quality control plan, including sampling and testing protocols, laboratory certification(s), transport procedures, etc., for manufacturing and shipping. Ensure that the plan is in accordance, at a minimum, with AASHTO R 26, sections 9.1 through 9.5, except as modified by the appropriate technical sections of these *Standard Specifications* and this specification regarding initial testing, frequency of testing, and reporting requirements.

804.1.3 Testing

1 Ensure that supplier testing is in accordance with AASHTO R 26, section 7, and that samples tested are production PGAB obtained from sales or shipping tanks.

1. **Daily Quality Control.** Ensure that the supplier tests daily for dynamic shear and rotational viscosity on the original binder for each grade of PGAB. The department requires only one dynamic shear and rotational viscosity test if multiple projects are using the same grade on any given day.

2. **Specification Compliance Testing.** Ensure that the supplier tests (for applicable properties described in Subsection 804.1.1, Binder Properties) each grade of PGAB, at the quantity, time interval, or both detailed in the supplier's quality control plan.

   Ensure that the supplier performs additional testing whenever there is a change in binder or modifier source or a major change in PGAB properties. The department defines such a change as a variation in any measured property of 15 percent or more from the averaged value of the three previous consecutive tests or a variation of 25 percent or more from the previous test value. The department will consider both its own quality assurance test results and supplier's specification compliance test results for determining if a major change has occurred.

3. **Reporting.** Ensure the supplier submits test reports, in electronic format, to the Materials Program on a weekly basis; include all test data for the previous week. Ensure data is submitted in spreadsheet format compatible with Microsoft Excel version 97.

804.2 Liquid Cut-Back Asphalt

1 For liquid cut-back asphalts, provide and use in accordance with AASHTO M 81 or AASHTO M 82 but without applying the Saybolt-Furol viscosity alternate.

804.3 Emulsified Asphalt

1 Provide and use a blend of asphalt binder, water, emulsifiers, and polymer, if specified. When specified, polymerize using at least 3 percent polymer by weight [mass] of the asphalt binder.

2 Ensure that emulsions show no separation, such as a white/milky appearance after mixing/stirring/agitating in tank, are smooth and homogeneous throughout, and are in accordance with the *Materials Testing Manual*. Provide pumpable emulsion suitable for application through a distributor without plugging or reducing flow through filters, piping, or nozzles.

3 For the type of emulsified asphalt specified, provide in accordance with the following:

1. **Anionic.** AASHTO M 140 and ASTM D 977.
2. **Cationic.** AASHTO M 208 and ASTM D 2397.
3. **Recycling Agents.** AASHTO R 14 and ASTM D 4552 and ASTM D 5505
4. **Other.** Table 804.3-1, Applicable Requirements: Emulsified Asphalt.

Table 804.3-1
Applicable Requirements: Emulsified Asphalt

Property	AASHTO or ASTM TEST METHOD		EMULSION TYPE						
			HFRS-2P	HFMS-2P	HFMS-2PS	HFMS-2SS, HFMS-1000	CMS-2P, CRS-2P	CQS-1HP, CSS-1HP	RA1+
Demulsibility, 35 mL, 0.02 N, CaCl2, %	T59	min. max.	40 —	20 80 [1]	— —	— —	40 — [2]	— —	— —
Flash Point, COC, ºF [ºC]	T48	min.	—	—	—	—	—	—	424 [218]
Residue, %	[3]	min. max.	65 —	65 —	65 —	65 —	65 —	65 —	60 65 [4]
Oil Distillate by volume, %	T59	max.	—	—	7.0	7.0	—	—	—
Sieve, %	T59	max.	0.1	0.1	0.1	0.1	0.1	0.1	0.1 [5]
Storage stability, 24 hours, %	T59	max.	1.0	1.0	1.0	1.0	1.0	1.0 [6]	—
Miscibility, coagulation	[7]	min.	—	—	—	—	—	—	None
Particle Charge	T59	—	—	—	—	—	—	—	Pass
Viscosity, Saybolt Furol, 122 °F [50 °C], sec	T72	min. max.	50 450	100 400	50 400	50 400	100 400	20 100 77 °F [25 °C]	15 40 77 °F [25 °C]
TESTS ON DISTILLATION or EVAPORATION RESIDUE									
Solubility in trichloroethylene, %	T44	min.	97.5	97.5	97.5	97.5	97.5	97.5	—
Kinematic Viscosity, cSt [mm²/sec]	T201	min. max.	— —	— —	— —	— —	— —	— —	100 200
Penetration, sec, 0.004 in [0.1 mm]	T49	min. max.	70 150	90 200	275 —	300 —	90 200	40 90	— —
Float test, 140ºF [60 ºC], sec	T50	min.	1200	1200	1200	1200	—	—	—
Ductility, in [mm]	T51	min.	30 [750]	16 [400] 39 °F [4 °C]	16 [400]	—	16 [400] 39 °F [4 °C]	16 [400]	—
Softening Point, ºF [ºC]	T53	min.	—	—	—	—	—	135 [57]	—
Elastic Recovery, 77 ºF [25 ºC], %	[8]	min.	55	50 39 °F [4 °C]	50	—	50 39 °F [4 °C]	—	—

(1) For mixing-type emulsions use 0.11 pt [50 mL], 0.10 N, $CaCl_2$ for the solution.

(2) For cationic emulsions use 0.74 pt [35 mL], 0.8%, $C_{20}H_{37}NaO_7S$ (sodium dioctyl sulfosucinate) for the solution. Demulsibility is not applicable to CMS-2P.

(3) Modify and perform the AASHTO T 59 distillation procedure in accordance with the manufacturer's recommendations.

(4) The AASHTO T 59 modified evaporation test for percent residue consists of heating a 1.61 oz [50 g] sample to 300 ºF [148 ºC] until foaming stops; cool immediately and calculate results.

(5) Test procedure is AASHTO T 59; use distilled water in place of 2 percent sodium oleate solution.

(6) Storage Stability is not applicable to CQS-1HP.

(7) Test procedure is AASHTO T 59; use 0.02N $CaCl_2$ solution in place of distilled water.

(8) Test procedure is AASHTO T 301; sever the specimen immediately after elongation.

804.4 Dust Control Agent

804.4.1 Dust Control Oil

1 Provide and use oil in accordance with Table 804.4.1-1, Dust Control Oil Properties.

Table 804.4.1-1
Dust Control Oil Properties

Test	ASTM Method	Minimum	Maximum
Kinematic Viscosity 100 ºF [38 ºC], cSt [mm²/sec]	D 2170	20	100
Flash Point (COC), ºF [ºC]	D 92	200 [93]	–
Relative Density, 60/60 ºF [15 ºC]	D 1298	1.0000	1.2000
Water and Sediment, %	D 96	–	0.5

804.4.2 Dust Control Brine Solution

1 Provide and use a solution containing from 28 to 35 percent magnesium chloride, as tested in accordance with ASTM E 449, in uncontaminated water; the department allows small amounts of sodium, potassium, and sulfate with other trace ions.

804.5 Asphalt Mastic for Field Coating

1 For field coating structures, provide and use asphalt mastic in accordance with AASHTO M 243.

SECTION 805
Geotextiles, Membrane, and Fabrics

805.1 General

1 When storing, keep geotextile, membrane, and fabric rolls wrapped for protection against moisture, weather, and extended ultraviolet exposure. Elevate the rolls and protect with a waterproof cover. Label or tag each roll to provide product identification sufficient for inventory and quality control.

805.2 Geotextile and Impermeable Plastic Membrane

1 Provide impermeable plastic membrane consisting of a polypropylene, polyethylene, or polyester geotextile with a bonded polypropylene or polyethylene film.

2 In the manufacture of woven or nonwoven geotextiles and threads used in joining geotextiles by sewing, use fibers consisting of long-chain synthetic polymers, composed of at least 95 percent, by weight, of polyolefins or polyesters. Form fibers into a stable network while retaining their dimensional stability relative to each other, including selvages. Provide both in accordance with Table 805.2-1, Geotextile and Membrane Requirements (Minimum Average Roll Values), as applicable for the specified use.

3 Clearly label each roll with the product name, type of material, and the lot or batch identification.

4 Use high-strength polyester, polypropylene, or Kevlar thread for sewn seams; do not use nylon.

Table 805.2-1
Geotextile and Membrane Requirements (Minimum Average Roll Values$^{(1)}$)

Fabric and Membrane Property	Test Method	Drainage & Filtration	Erosion Control	Silt Fence	Separation & Stabilization (Non-Woven)	Embankment & Retaining Wall Reinforcement	Impermeable Plastic Membrane	Subgrade Reinforcement
PERFORMANCE CRITERIA DURING SERVICE LIFE								
Equivalent or Apparent Opening Size, US Standard Sieve, in [mm]	ASTM D 4751	40-100 [0.425-0.150]	40-100 [0.425-0.150]	20-50 [0.850-0.300]	40-100 [0.425-0.150]	30-60 [0.600-0.250]	–	30-50 [0.600-0.300]
Thickness, mils [mm]	ASTM D 5199	–	–	–	–	–	12 [0.305]	–
Permittivity, Sec-1	ASTM D 4491	1.0	1.0	0.05	1.0	0.02	$<10^{-7}$ cm/sec $^{(2)}$	0.25
STRENGTH REQUIREMENTS								
Wide Width Tensile Strength, Ultimate, lbs/ft [kN/m]	ASTM D 4595	–	–	–	–	–	–	2400 [35]
Wide Width Tensile Strength @ 2% strain, lbs/ft [kN/m]	ASTM D 4595	–	–	–	–	–	–	450 [6.5]
Grab Tensile Strength, lb [N]	ASTM D 4632	100 [445]	180 [800]	100 [445]	160 [710]	300 [1335]	150 [665]	250 [1110]
Elongation at Failure, min., %	ASTM D 4632	50	50	15	50	15	15	10
Trap Tear Strength, lb [N]	ASTM D 4533	45 [200]	70 [310]	50 [220]	60 [270]	110 [500]	50 [220]	110 [490]
Puncture Strength, lb [N]	ASTM D 4833	60 [265]	90 [400]	50 [220]	85 [380]	110 [500]	60 [265]	120 [535]
Seam Efficiency, %	ASTM D 4632	90	90	90	90	90	–	90
ENVIRONMENTAL REQUIREMENTS								
Ultraviolet Resistance, % Strength Retention after 500 hours of exposure	ASTM D 4355	50 $^{(3)}$	70	80	50 $^{(3)}$	50 $^{(3)}$	50 $^{(3)}$	50 $^{(3)}$

(1) Property values, with the exception of apparent opening size, in these specifications represent minimum average roll values (MARV) in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values provided herein).

(2) Permeability Coefficient (ASTM D 4491).

(3) Nonstabilized or low susceptible geotextiles shall not be exposed to ultraviolet radiation for more than five calendar days.

805.3 Paving Fabric

1 Provide and use material in accordance with AASHTO M 288, table 8, with a roll width of at least 10 ft [3 m]. Ensure the material has a minimum asphalt retention of 0.2 gal/yd² [0.90 L/m²]. When submitting the certification for the paving fabric, include notarized test results for grab strength, ultimate elongation, and weight [mass] per unit area for samples taken from the lot delivered to the project. Take the number of test samples specified in procedure A of ASTM D 4354. A production lot is defined in ASTM D 4354, section 6.2.1 for an individual roll of fabric.

2 For glass fiber reinforced paving fabric, provide composite material that consists of a polymer coated fiberglass structural grid bonded to a non-woven paving fabric meeting or exceeding the following requirements:

Table 805.3-1
Glass Fiber Reinforced Paving Fabric

Composite Requirements	
Unit Weight	16 oz/yd^2 [0.54 kg/m^2], min
Peel Strength (ASTM D 413)	20 lb/ft [30 kg/m], min
Grid Requirements	
Tensile Strength (ASTM D 4595)	560 lb/in [10 kg/mm], min
Ultimate Elongation (ASTM D 6637)	5% max
Grid Jct. Strength (GRI/GG-2)	18 lb [8.2 kg], min
Aperture Size(1) MD and XD	½ in [13 mm] to 1 in [25 mm]
Paving Fabric Requirements	
Asphalt Retention of Fabric (ASTM D 6140)	0.20 gal/yd^2 [0.9 L/m^2], min
Grab Tensile Strength (ASTM D 4632)	101 lb [46 kg]

(1) Centerline to Centerline

3 Submit both the notarized test results from the above-listed tests performed on samples taken from the same lot of composite material delivered to the project and the certification for the glass fiber reinforced paving fabric to the engineer. Ensure the number of samples taken for testing are in accordance with ASTM D 4354 for the quantity of composite material produced for that lot.

SECTION 806
Erosion Control and Reclamation

806.1 Seed and Fertilizer

806.1.1 General

1 Provide and use seeds in accordance with the Wyoming Seed Law (W.S. 11-12-101 through 11-12-123) and the Federal Seed Act. Purchase seeds through a dealer licensed with the Wyoming Department of Agriculture. Provide and use fertilizer in accordance with the Wyoming Fertilizer Law (W.S. 11-14-101 through 11-14-116).

806.1.2 Seeds

1 Provide and use seeds in containers with plainly-labeled tags attached by the supplier, showing the following:

1. Seed's species, genus, and variety;
2. Seed's common name;
3. Percentage of pure seed, crop seed, inert material, weed seeds by weight [mass], germination, and hard seed;
4. Month and year of the germination test;
5. Seed's origin;
6. Lot or mixture number or other lot identification;
7. Supplier's full name and address;
8. Name and quantity of each kind of restricted noxious weed seeds per pound [kilogram] pursuant to the Wyoming Seed Law; do not provide seed containing any noxious weed seeds prohibited by any state's law;
9. Net weight [mass] of seed in each container; and
10. Words "poisonous treated" in bold print on the label of seeds treated with chemicals toxic to humans, livestock, or wildlife.

2 Before seeding, give the engineer copies of a certification signed by the vendor and certifying that each lot of seed has been tested by a state testing laboratory, commercial seed-testing laboratory, or registered member of the Society of Commercial Seed Technologists. Ensure that the testing laboratory is in accordance with Association of Official Seed Analysts testing rules. Give the engineer copies of seed analysis reports prepared by the respective seed testing authority.

3 Provide seed tested less than 12 months before use.

4 The department will accept a Tetrazolim (TZ) Viability Test instead of the germination portion of the Service Sample Seed Analysis Report prepared by the seed testing laboratory. The Wyoming Department of Agriculture reserves the right to randomly sample seed entering the state or delivered to the project (W.S. 11-12-112). Ensure that the total percentage of crop seed does not exceed 3 percent by weight [mass]. Provide species and varieties of seed, or blends of seeds, in accordance with the pure live seed (PLS) rates specified. Provide and use cool-season grass or legume seed with at least 70 percent pure live seed. Provide and use warm-season grass or wildflower seed with at least 50 percent pure live seed.

806.1.3 Fertilizer

1 Provide and use fertilizers as follows:

1. With nitrogen (N) derived from ammonia compounds, such as ammonium nitrate, urea, and ammonium sulfate;

2. With phosphorous (P) derived from ammonium phosphate or super phosphate, not raw rock;

3. With potassium (K) derived from potash ores or natural salt brines;

4. In the following N:P:K ratios and to supply the specified pounds [kilograms] of available nitrogen per acre [hectare]:

    4.1. **Fertilizer Type I.** 2:1:1.

    4.2. **Fertilizer Type II.** 18:46:0 diammonium phosphate or 11:52:0 monoammonium phosphate.

4.3. **Fertilizer Type III.** 2:1:1, with at least 25 percent of the nitrogen source in slow release form, either by sulfur-coated urea, urea/formaldehyde polymer, or polymer-coated urea.

4.4. **Fertilizer Type IV.** 2:1:1, plus 2 percent iron as ferric sulfate ($Fe_2(SO_4)_3$) and 4 percent elemental sulfur.

4.5. **Fertilizer Type V.** Composted manure of the type specified (cattle, horse, hog, sheep, poultry, etc.) mixed with a carbon source, and with at least 50 percent organic matter, transformed by heat and aerobic microbes into a nutrient-rich, weed-free plant food. Ensure that the composted manure contains no more than 35 percent water by weight [mass], mature and stable nitrogen with no obvious ammonia odors, no weeds, and no harmful bacteria. Provide with each shipment a certified statement from a commercial testing laboratory stating that the manure complies with the Wyoming Fertilizer Law as to nutrient content, the percentages of water, organic matter, and soluble salts and the C:N ratio. The department does not require bagging.

4.6. **Fertilizer Type VI.** 21:0:0 ammonium sulfate plus 24 percent elemental sulfur or 34:0:0 ammonium nitrate.

806.2 Mulch, Straw, or Hay

806.2.1 Dry Mulch

1 Provide and use dry mulch consisting of small-grain straw or grass-hay and free of noxious weeds or undesirable plant species pursuant to W.S. 11-5-102(a)(viii)(x)(xi); W.S. 11-5-302(a)(viii)(xi); federal law (P.L. 93-629); other local county regulations; and classified by another state as undesirable, injurious, or poisonous. Also ensure that:

1. The crop has been inspected and certified by proper, authorized officials in the state of origin;

2. The crop has been inspected in the field of origin, including the surrounding ditches, fence rows, roads, easements, rights-of-way, and buffer zones;

3. The crop has been inspected before cutting or harvesting;

4. Mulch crop shipments are accompanied by an original "Transit Certificate" (Form WDA-70) or similar original certificate issued by authorized officials in the state of origin. The engineer will not accept photocopied certificates and will reject shipments not accompanied by an original form. The department considers officials authorized to issue a "Transit Certificate" to be a representative as follows:

   4.1. From Wyoming

      4.1.1. A state weed and pest control district or

      4.1.2. The state Department of Agriculture.

   4.2. From another state

      4.2.1. A representative of the state's Department of Agriculture;

      4.2.2. The state's weed supervisor or weed superintendent;

      4.2.3. An extension agent from the state's university; or

      4.2.4. Any individual designated by the state's law.

2 The engineer may accept mulch crops containing "designated" or "restricted" noxious weeds, other undesirable plant species, or weeds classified as "noxious" by another state if the certification documents that, by thorough visual inspection before cutting or harvesting, it has been determined that:

1. The crop or field was treated no later than the prohibited species' bud stage to prevent seed formation or ripening. Treatment may include but is not limited to burning, mowing, cultural methods, or chemical treatment.

2. The prohibited species' propagative parts will not produce new plants.

806.2.2 Hydraulic Mulch

1 For hydraulic spreading or in hydraulic seeding, provide and use mulch made of virgin wood fibers prepared so as to be free of growth- or germination-inhibiting factors. Ensure also that the mulch:

1. Is appropriately colored to facilitate metering;
2. Will remain in uniform suspension in water under agitation;
3. Blends with seed, fertilizer, and other additives to form a homogenous slurry;
4. Has been processed with heat and pressure to soften the wood chips so that the mechanical refining yields fibers of a suitable shape and size; and
5. Will form a blotter-like ground cover after application, with moisture-absorption and percolation properties and the ability to cover and hold seeds in intimate contact with the soil, without inhibiting the penetration of seedlings.

2 The department will allow the use of nonvirgin or nonthermally processed wood and recycled-paper mulches on slopes 1V:2H or flatter and as components of dry mulch tack mixtures.

3 Ensure that material for mulch is shipped in packages marked with the manufacturer's name and the air-dry weight [mass] based on the weight [mass] standard for wood cellulose of the Technical Association of the Pulp and Paper Industry. The air-dry weight may include a moisture content from 12 to 18 percent. Give the engineer the manufacturer's statement certifying that the material provided has been laboratory- and field-tested and meets the department's requirements and intent.

806.3 Sod

1 Provide and use nursery-grown, 99.0 percent Kentucky Bluegrass consisting of two or more varieties and no more than 1.0 percent weeds. In areas south of US 26/20 and lower than 6000 ft [1830 m], nursery-grown, 95 percent turf-type Tall Fescue sod consisting of two or more turf-type varieties adapted to plant hardiness zone 4 may be used. Ensure that the 1 percent of allowable weeds does not include undesirable perennials, annual grasses, or plant parts. The department will not allow noxious weeds.

2 Provide and use machine-cut sod strips with from ⅜ in to 1 in [10 mm to 25 mm] of soil adhering to the root system. Keep sod rolls moist and protected from the sun and wind by tarps or shade cloth. Do not use sod that:

1. Is dried;

2. Has adhering soil that breaks, tears, or crumbles; or

3. Was cut and harvested more than 36 hours before placement.

806.4 Erosion Control Blanket

806.4.1 General

1 When the department uses the word "or" to specify more than one type of erosion control blanket, provide and use only one type. Provide the blankets packaged in plastic or paper-composite wrappers.

806.4.2 Erosion Control Blanket, Type Jute

1 Provide and use matting composed of a plain, uniform, open weave of new, unbleached single-strand jute yarn. Ensure that the yarn is of loosely-twisted construction and does not vary in thickness by more than one-half its normal diameter. Ensure a minimum of 78 yarn counts per width (warp) and a minimum of 42 yarn counts per linear yard [0.9 meter] (weft) in accordance with ASTM D-3775. Ensure the weight [mass] of the matting is 0.92 lb/yd^2 [500 g/m^2] and 0.97 lb/yd^2 [526 g/m^2], minimum, when smolder-resistant is specified.

806.4.3 Erosion Control Blanket, Types ST1 and ST2

1 Provide and use a machine-made mat consisting entirely of agricultural straw, weighing approximately 0.50 lb/yd^2 [270 g/m^2], and of consistent thickness with the straw evenly distributed. Ensure that the blankets are sewn with durable thread, treated with an EPA-labeled fumigant to kill weed seeds and pests and as follows for each type:

1. **ST1.** Covered on top with photodegradable polypropylene netting weighing approximately 1 lb/1000 ft^2 [485 g/100 m^2].

2. **ST2.** Covered top and bottom with lightweight polypropylene netting weighing approximately 1 lb/1000 ft^2 [485 g/100 m^2].

806.4.4 Erosion Control Blanket, Type STC

1 Provide and use a machine-made mat that is:

1. 70 percent agricultural straw weighing at least 0.35 lb/yd² [190 g/m²] and 30 percent coconut fiber weighing 0.15 lb/yd² [80 g/m²];
2. Of consistent thickness, with straw and coconut fiber evenly distributed;
3. Covered on top with heavyweight polypropylene netting containing ultraviolet additives to resist breakdown and weighing at least 3 lb/1000 ft² [1460 g/l00 m²];
4. Covered on the bottom with a lightweight photodegradable polypropylene netting weighing approximately 1 lb/1000 ft² [485 g/100 m²];
5. Sewn with durable thread; and
6. Treated with an EPA-labeled fumigant to kill weed seed and pests.

806.4.5 Erosion Control Blanket, Types EX1 and EX2

1 Provide and use a machine-made excelsior mat of curled, consistent-width wood fibers evenly distributed throughout the mat. Ensure a weight of at least 0.8 lb/yd² [430 g/m²] and that blankets are covered with photodegradable, polypropylene mesh netting as follows for each type:

1. **EX1.** On top.
2. **EX2.** Top and bottom.

806.4.6 Erosion Control Blanket, Type EX3

1 Provide and use a machine-made excelsior mat of curled wood, 80 percent of which has fibers at least 6 in [150 mm] long, evenly distributed. Ensure a weight of at least 1.4 lbs/yd² [760 g/m²] and that blankets are encased top and bottom with high-strength, polypropylene netting stitched to form a matrix.

806.4.7 Coconut Fiber Ditch Lining Type COC

1 Provide and use a machine-made mat of 100 percent coconut or equivalent fibers, weighing at least 0.5 lb/yd² [270 g/m²], of consistent thickness and with the fiber evenly distributed. Cover the blanket top and bottom with heavyweight, UV-stabilized, polypropylene netting weighing approximately 3 lb/1000 ft² [1500 g/100 m²]; sew with UV-stabilized, durable thread to form a matrix.

806.5 Erosion Control Agent

1 For erosion control, provide and use a concentrated liquid-polymer agent that:

1. Consists of at least 40 percent solids by weight [mass];
2. Effectively prevents soil erosion caused by wind and water;
3. When cured, allows water and air to penetrate the soil surface and does not re-emulsify in water;
4. Is nontoxic to seed, plant, or animal life; and
5. Does not stain concrete or painted surfaces.

806.6 Erosion Control Netting

1 Provide and use a polypropylene-extruded, oriented net with openings of 0.75 in [19 mm] or smaller, weighing approximately 2.8 lb/1000 ft² [1.3 kg/100 m²] and colored to resist UV breakdown.

806.7 Mulch Tack

806.7.1 Type AR

1 For tackifier, provide and use an acrylic-copolymer emulsion consisting of at least 45 percent resin solids, by weight [mass], disbursed in water. Ensure that the product is nonflammable, nontoxic (to both plants and animals), and contains a low-temperature coalescing agent, glycol or similar, to accelerate curing at near-freezing temperatures. Ensure that the cured film resists alkaline degradation, allows exchange of air and soil moisture, and does not disperse in water.

806.7.2 Type MC

1 For tackifier, provide and use a natural mucilage gum made from psyllium (*Plantago insularis*) seed husks. Ensure that the product:

1. Is a free-flowing, noncorrosive powder;
2. Binds the slurry to the soil surface when mixed with water and wood fiber; and
3. Contains no growth- or germination-inhibiting factors.

806.7.3 Type GU

1 For tackifier, provide and use a natural polysaccharide-gum made from guar (*Cyamopsis tetragonoloba*) endosperm and combined with a mechanical or chemical cross-linking agent to resist rewetting. Ensure that the product:

1. Is a free-flowing, noncorrosive powder;
2. Binds the slurry to the soil surface when mixed with water and wood fiber; and
3. Contains no growth- or germination-inhibiting factors.

806.8 Burlap Bag Curbs

1 Provide and use burlap in accordance with AASHTO M 182, class 3, and consisting of 10-ounce [285 g] or heavier material treated with copper napthenate or other approved agent to provide mildew-resistance. Provide in 40-inch [1015 mm] widths sewn to form a tube.

SECTION 807
Joint Materials

807.1 Silicone Joint Sealant

1 Provide and use a nonsag or self-leveling, one-part silicone that is formulated specifically for sealing sawed joints in portland cement concrete pavement and in accordance with ASTM D 5893, except as noted in Table 807.1-1, Silicone Joint Sealant Requirements.

Table 807.1-1
Silicone Joint Sealant Requirements

Test	Limit	Test Method
Ultimate Elongation	800% min.	ASTM D 5893, section 6.9.1
Weathering (UV and ozone resistance) 5000 hours	No chalking, cracking, or bond loss	ASTM C 793
Tack Free Time	20 to 75 minutes (nonsag) 180 minutes, max. (self-leveling)	ASTM C 679
Specific Gravity	1.01 to 1.515 (nonsag) 1.10 to 1.40 (self-leveling)	ASTM D 792 (Method A)
Bond to Concrete Mortar	50 psi [345 kPa] min. (nonsag) 40 psi [275 kPa] min. (self-leveling)	(1) (2)

(1) Samples air cured 7 calendar days (nonsag) or 21 calendar days (self-leveling) from 74 ºF to 80 ºF [23 ºC to 27 ºC].

(2) Briquettes molded in accordance with AASHTO T 132, sawed in half and bonded with approximately 10 mil [0.25 mm] of sealant and tested using clips meeting AASHTO T 132. Dry to a constant weight [mass] in an oven at a temperature from 200 ºF to 220 ºF [95 ºC to 105 ºC] and test in tension at a loading rate of 0.3 in/min [7.6 mm/min].

2 Ensure that sealant is delivered in the manufacturer's original, sealed container with the original manufacturer's label attached and intact. Ensure that the label is tamper-proof, nonremovable, and legibly marked with the manufacturer's batch or lot number and the expiration date of the manufacturer's shelf-life warranty.

3 Before approving sealant for use on department projects based on certification, the department requires the sealant manufacturer to establish sealant performance of less than 1 percent failure, cohesive or adhesive, in one year, on in-place field applications.

4 Provide sealant with a shelf life of six months from the date of manufacture. Do not use sealant that has exceeded the shelf life warranty expiration date; sealant may be retested in accordance with ASTM C 719 and recertified for six months from the retest date. Perform retesting at no additional cost to the department; the department will not pay costs incurred in procuring and testing out-of-compliance materials.

807.2 Hot-Poured Elastic Sealant

1 Provide and use sealant in accordance with AASHTO M 324 Type I WY Modified or AASHTO M 324 Type IV WY Modified as specified. Use AASHTO M 324 WY Modified if the sealant type is not specified. To enhance performance, materials including recycled rubber and fillers (such as calcium carbonate to prevent rubber particles from sticking together) may be blended into the sealant mixture; do not allow the incorporation of wire, fabric, or other deleterious matter. As applicable, ensure that sealant is in accordance with Table 807.2-1, Hot-Poured Elastic Sealant Specification Limits.

Table 807.2-1
Hot-Poured Elastic Sealant Specification Limits[1]

Property	AASHTO or ASTM Test Method	Sealant Type: AASHTO M 324 Type I WY Modified		Sealant Type: AASHTO M 324 Type IV WY Modified	
		Min.	Max.	Min.	Max.
Cone Penetration	M 324, Type I and IV	–	90	90	150
Flow	M 324, Type I and IV	–	5	–	3
Bond	M 324, Type I	5	–	–	–
Bond 200% extension	M 324, Type IV	–	–	3	–
Relative Density	D 71 WY Modified	–	1.193	–	1.113
Softening Point ºF [ºC]	D 36	–	–	170.0 [77.0]	–

(1) For unit information see the appropriate test method.

807.3 Elastic Joint Sealant

1 Provide and use a two-component polyurethane or polysulfide-base product sealant in accordance with the physical flow and strength requirements of ASTM C 920, type M, grade NS, class 25, use T.

807.4 Preformed Expansion Joint Filler

1 Provide and use a product in accordance with AASHTO M 213 and punched to admit the dowels.

807.5 Preformed Elastomeric Compression Joint Seals

1 Provide and use a product in accordance with AASHTO M 220 (ASTM D 2628), manufactured to a size and shape proposed by the manufacturer after approval by the engineer based on submission of the following:

1. Proposed seal type and dimensions, including computations that show the material will be in compression over the temperature range from -40 ºF to 120 ºF (-40 ºC to 50 ºC) and

2. Recommended joint width and depth dimensions.

2 When recommended by the manufacturer, use an approved lubricant-adhesive, compatible with the seal, in accordance with ASTM D 2835, to provide lubrication and bond for the seal.

807.6 Compressed Joint Material

1 Provide and use open-cell, polyurethane foam impregnated with water-repellant material in a single- or factory-bonded, layered unit. Ensure that the density of the impregnated, compressed, and packaged material is at least 8 lbs/ft^3 [130 kg/m^3]; that the uncompressed thickness of the material is at least four times as large as the specified applicable gap width; and that the compressed material conforms to the depth and gap size specified. Provide and use adhesive for installation and sealant for splices as recommended by the joint-material supplier. Provide a product approved by the Bridge Program. Store materials in accordance with the supplier's recommendations.

807.7 Backer Rod

1 For installations with silicone sealant, provide and use backer rod in accordance with ASTM D 5249, type 1 or type 3.

2 For installations with hot-poured elastic sealant, provide and use backer rod in accordance with ASTM D 5249, type 1, with a melting temperature higher than the sealant's application temperature.

807.8 Waterstop

1 Provide and use waterstops manufactured from PVC in accordance with US Army Corps of Engineers specification CRD-C572.

SECTION 808
Pipe

808.1 Reinforced Concrete Pipe

808.1.1 General

1 For reinforced concrete pipe, provide and use in accordance with Table 808.1.1-1, Reinforced Concrete Pipe Specifications.

Table 808.1.1-1
Reinforced Concrete Pipe Specifications

Material	AASHTO Specification
Circular Pipe and FE	M 170 [M 170M]
Elliptical Pipe and FE	M 207 [M 207M]
Pipe Arch and FE	M 206 [M 206M]

2 For circular pipe, the department considers pipe wall design and the use of elliptical reinforcement optional.

3 For precast flared ends, provide and use sections in accordance with requirements for the pipe size and type provided, with equivalent wall thickness, concrete, and reinforcement as specified therein for class II, A-II, or HE-II.

4 The engineer will approve reinforced concrete pipe in accordance with section 5.1.2, under the above-mentioned AASHTO specifications, modified as follows:

5 *The engineer will determine acceptability of pipe in all diameters and classes by compression tests on concrete cores or cured concrete cylinders; by absorption tests on selected samples from the wall of the pipe; by materials certifications for materials required by sections 5, "Basis of Approval," and 6, "Materials"; by results of materials tests required in accordance with section 7, "Design"; and by inspection of the finished pipe, including the quantity and placement of reinforcement, to determine its conformance with the design specified.*

6 Ensure that plants producing RCP and HERCP are certified in accordance with Subsection 603.4.1, General.

808.1.2 Manhole Risers and Tops

1 As specified, provide precast, reinforced-concrete manhole risers and tops in accordance with AASHTO M 199 [AASHTO M 199M].

808.1.3 Reinforced Concrete Pipe, Type V Cement with Fly Ash

1 Use cement meeting the requirements of Subsection 801.1.2, Type V Portland Cement, and class F fly ash meeting the requirements of Subsection 801.2, Fly Ash. Use 20 to 30 percent fly ash by weight [mass].

808.1.4 Epoxy Coated Reinforced Concrete Pipe

1 Prior to the application of the epoxy coating, prepare the interior and exterior surfaces of the reinforced concrete pipe in accordance with the requirements of Joint Surface Preparation Standard SSPC-SP 13/NACE No. 6, Surface Preparation of Concrete, Table 1, Severe Service, moisture content per ASTM D 4263. Epoxy coat the interior and exterior surfaces of the reinforced concrete pipe in accordance with the requirements of SSPC-PS 13.01, Epoxy Polyamide Painting System, except section 4.

808.2 Reinforced Concrete Stock Passes

1 For reinforced concrete stock passes, provide and use sections made and with materials in accordance with AASHTO M 170 [AASHTO M 170M]. Determine stock pass-section classes in accordance with fill height requirements and the fill height table specified. Provide flared end sections made in accordance with the same requirements, except that the department requires only one reinforcement cage for the open portion.

808.3 Reinforced Concrete Siphon Pipe

1 For reinforced concrete siphon pipe, provide and use pipe in accordance with and in classifications meeting ASTM C 361M. For siphon drains, provide and use type PSM polyvinylchloride (PVC) pipe with cemented joints in accordance with ASTM D 3034.

808.4 Plastic Pipe for Underdrain

808.4.1 General

1 For plastic underdrain, provide and use PVC or polyethylene (PE) pipe and fittings in accordance with Table 808.4.1-1, Plastic Pipe Specification Requirements.

Table 808.4.1-1
Plastic Pipe Specification Requirements

Type of Pipe	Pipe and Fitting Specification	Class of Pipe & Fittings	Perforation Specification
PVC	ASTM D 3034	SDR 35	ASTM D 2729
Corrugated PVC	AASHTO M 304	–	AASHTO M 304
Corrugated PE	AASHTO M 252	type S [(1)]	AASHTO M 252
	AASHTO M 294	type S	AASHTO M 294

(1) Provide standard fittings in accordance with AASHTO M 252.

2 For PVC bushings and saddle connections, provide and use commercial-grade solvent cement and primer made specifically for use with PVC and PE pipe and fittings.

808.4.2 Hardware Cloth for Drains

1 For drains, provide and use 6-mesh wire hardware cloth made from galvanized steel or commercial-grade aluminum-alloy wire with a minimum diameter of 0.0029 in [760 µm] before galvanizing.

808.5 Corrugated Steel Pipe and Pipe Arches

808.5.1 General

1 Identify culverts by stamping each section as outlined in AASHTO M 218.

2 Provide and use conduit and coupling bands in accordance with AASHTO M 36 [AASHTO M 36M] and AASHTO M 218.

3 Ensure that damage incurred in fabrication is repaired before shipment. Ensure that damaged spelter coating is repaired in accordance with Subsection 603.4.8, Repair of Damaged Coating, and that polymeric coating is repaired by coating the damaged area with a similar and compatible polymeric coating.

808.5.2 Fabrication

1 When specified, ensure that the vertical diameter of round pipe is shop-elongated by 5 percent.

2 Ensure that pipe fabricated with resistance-spot-welded seams is in accordance with AASHTO M 36 [AASHTO M 36M], modified as follows:

1. When double welding is required, do not make adjacent welds closer than two spot-weld-nugget diameters, center to center.
2. Weld so that at least 0.6 oz/ft² [180 g/m²] of spelter coating is retained on the spot weld and no base metal is exposed when the area adjacent to the weld is wire brushed. The department does not consider discoloration of spot weld surfaces cause for rejection.
3. Do not spot weld longitudinal seams on corrugated aluminum pipe.

3 For pipe with helical seams, fabricate pipe so that seams will not affect the pipe's shape, nominal diameter, or strength. The engineer will reject pipe with seams indicating slippage or unraveling.

4 Reroll the ends of helical pipe to produce at least two annular corrugations.

5 The engineer will accept butt-welded joints at sheet ends if a good weld is made and damaged spelter coating is repaired as specified; sawed ends are allowed.

808.5.3 Corrugations

1 Ensure that the following specified corrugations are in accordance with AASHTO M 36 [AASHTO M 36M] and M 218:

1. 2⅔ in × ½ in [68 mm × 13 mm].
2. 3 in × 1 in [75 mm × 25 mm].
3. 5 in × 1 in [125 mm × 25 mm].

2 Ensure that corrugations specified as 3 in × 1 in [75 mm × 25 mm] are from 2¾ in to 3 in [70 mm to 85 mm], center to center, with a depth of at least 1 in [25 mm].

808.5.4 Bituminous-Coated Corrugated Steel Pipe and Pipe Arches

1 Provide and use conduits and coupling bands coated in accordance with AASHTO M 190 for the type of bituminous coating. When no coating type is specified, use AASHTO M190, type A. Fully coat coupling bands.

808.5.5 Corrugated Steel Pipe for Underdrains

1 As specified for underdrains, provide and use corrugated steel pipe in accordance with AASHTO M 36 [AASHTO M 36M] for the specified sizes; any one of the four classes may be provided.

808.5.6 Bituminous-Coated Corrugated Steel Pipe for Underdrains

1 As specified for underdrains, provide and use bituminous-coated corrugated steel pipe coated in accordance with AASHTO M 190, type A (but to a coating thickness of at least 0.03 in [760 µm]). Fully coat coupling bands. Ensure that perforations meet the specified minimum diameter after coating.

808.5.7 Polymeric-Precoated Galvanized Steel Pipe

1 Provide and use polymeric-precoated galvanized steel pipe in accordance with AASHTO M 245M and AASHTO M 246M with a polymeric coating at least 10 mil [255 µm] thick inside and outside. Make the pipe with helical lock seams; do not rivet or weld seams.

2 Provide and use coupling bands and flared ends that are galvanized and coated with bituminous material.

808.5.8 Aluminum-Coated Pipe

1 Provide and use aluminum-coated pipe in accordance with AASHTO M 36 [AASHTO M 36M] and AASHTO M 274, joined with bands of the same base metal and coating.

808.6 Corrugated Aluminum-Alloy Pipe

1 As specified for culverts and underdrains, provide and use corrugated aluminum-alloy pipe in accordance with AASHTO M 196M and AASHTO M 197M. Ensure that corrugations specified as 2 in × ½ in [68 mm × 13 mm] are in accordance with AASHTO M 196M.

808.7 Corrugated Metal Units

1 Provide and use corrugated steel units made from galvanized steel sheet in accordance with AASHTO M 36 [AASHTO M 36M]. When used in conjunction with nongalvanized pipe, provide corrugated metal units that are bituminous-coated in accordance with AASHTO M 190, type A.

2 As specified, provide and use aluminum alloy units made from aluminum alloy sheets in accordance with AASHTO M 196M.

3 When used in conjunction with siphons or when specified for watertight installations, provide units with joints sealed by close-riveting, welding, soldering, gasketed bands, or other approved means.

808.8 Structural Plate Pipe

1 Provide and use structural plate pipe in accordance with AASHTO M 167M. Ensure that corrugations specified as 6 in × 2 in [150 mm × 50 mm] are from 5¾ in to 6¼ in [146 mm to 158 mm], center to center, with a depth of from 2 in to 2¼ in [50 mm to 56 mm]. Ensure fabrication as follows:

1. **Forming Plates.** Provide plates factory-formed from corrugated metal sheet of the gauges and dimensions specified; for circular structural plate pipe, ensure a factory-formed 5 percent elliptical.

   For pipe arches, ensure that plates form a cross-section made up of four circular arcs tangent to each other at their junctions and symmetrical about the vertical axis. Ensure that the top is an arc of from 155 to 180 degrees, the bottom is an arc of from 10 to 50 degrees, and that the top is joined to the bottom by an arc of from 75 to 87.5 degrees, with a radius of at least 16 in [400 mm].

   For plates cut for forming skewed or sloped ends, ensure that burned edges are free from oxide and burrs. Place legible identification numerals on each component plate to designate its position in the finished structure.

Stagger joints so that no more than three plates come together at any one point.

2. **Punching Plates.** For bolt holes, punch so that plates with like dimensions and curvature, and with the same number of bolts per 12 in [300 mm] of seam length, are interchangeable. Stagger bolt holes along longitudinal seams in two rows, 2 in [50 mm] apart, with one row in the valley and one row in the crest of corrugations. Space holes along circumferential seams no more than 12 in [300 mm] apart. Ensure that the distance from the center of the hole to the plate edge is at least 1.75 times the bolt diameter. In longitudinal seams, ensure that hole diameter does not exceed bolt diameter by more than ⅛ in [3 mm].

808.9 Aluminum-Alloy Structural Plate Pipe

1 Provide and use pipe in accordance with AASHTO M 196M and AASHTO M 219M and made from plates formed and punched in accordance with Subsection 808.8, Structural Plate Pipe.

808.10 Corrugated Steel Siphon Pipe

1 Provide and use corrugated steel siphon pipe in accordance with AASHTO M 245M and AASHTO M 246M.

808.11 Welded Steel Siphon Pipe

1 Provide and use welded steel siphon in accordance with American Water Works Association (AWWA) C200, with an inside protective coating in accordance with AWWA C203, C205, or C210, and an outside protective coating in accordance with AWWA C203, C210, or C214. With the State Bridge Engineer's approval, other coatings may be used.

808.12 Ductile Iron Water Pipe

1 Provide and use ductile iron water pipe in accordance with AWWA C151 and with mechanical joints in accordance with AWWA C111. Provide pipe bends and fixtures made from ductile or cast iron, class 250, in accordance with AWWA C110, and with mechanical joints in accordance with AWWA C111. Ensure that pipe and fixtures are cement-mortar-lined in accordance with AWWA C104, that

valve boxes are cast-iron with a diameter of 5¼ in [135 mm], and sufficiently long for the pipe depth. Provide cast iron covers with "WATER" stamped on top and a directional arrow for the valve opening.

808.13 Nestable Metal Pipe

1 Provide and use pipe and pipe arch made from corrugated metal sheets in modular, half-round sections with side flanges or fasteners for in-place assembly.

808.14 Pipe Joint Mortar

1 Provide and use mortar consisting of one part portland cement, two parts approved sand, and water as necessary to obtain the required consistency.

808.15 Preformed Flexible Joint Sealants

1 For concrete pipe, provide and use preformed flexible joint sealants in accordance with AASHTO M 198 (ASTM C 990). For steel pipe, provide and use in accordance with AASHTO M 36 [AASHTO M 36M].

808.16 Steel Mitered End Sections

1 Use galvanized steel sheet metal in accordance with AASHTO M 218M. When a grate is specified, provide and use schedule 40 galvanized steel pipe grate bars in accordance with Subsection 815.5, Steel Pipe.

808.17 Slide Gates

1 Provide commercially prefabricated, corrosion-resistant slide gates of the size corresponding to the opening provided by the pipe and designed to operate and be watertight under the specified head of water. Ensure slide gates use a steel frame at least ¼ in [6 mm] thick and adjustable cast iron wedge blocks to ensure a proper seating closure.

SECTION 809
Paint

809.1 General

1 Based on specified ingredients, provide and use paint that is a homogeneous blend of its constituent components, stable in storage, free from grit and coarse particles, with no rosin or rosin derivatives unless specifically allowed. Unless specifically prohibited, the department will allow beneficial additives such as anti-skinning agents, anti-settling agents, or wetting aids.

2 Ensure that paint is shipped in sealed containers constructed and packed to withstand rough handling and plainly marked with contents, batch number, date of manufacture, and the manufacturer's name and address. The engineer will reject containers received in a damaged condition.

3 Provide paints in accordance with Federal Color Standard 595 and Table 809.1-1, Paint Color Standards, ± 2 delta E units.

Table 809.1-1
Paint Color Standards

Color	Federal Number	Tinting Compounds
Blue	25053	(1)
Brown	20059	(2)
Gray	36595	(3)
Gray Tan	20318	(4)
Green	24272	(5)
White	27925	–

(1) Copper phthalocyanine blue (green shade), phthalocyanine green (blue shade), perylene vermillion, and quinacridone red.

(2) Natural or synthetic red iron oxide (blue shade), natural burnt umber, chrome yellow medium (red shade), and lampblack.

(3) Benzimidazolone yellow, copper phthalocyanine blue (green shade), and natural raw umber.

(4) Yellow iron oxide, hydrated; natural or synthetic red iron oxide (blue shade) and lampblack.

(5) Yellow iron oxide, hydrated; copper phthalocyanine blue (red shade), benzimidazolone yellow, phthalocyanine green (blue shade), and natural raw umber.

4 Ensure maximum percentage by weight [mass] of lead (Pb) is no greater than 0.01 percent (100 ppm).

5 Ensure paint coatings dry to a smooth finish without visible cracking, grit, seeding, or skins.

809.2 Testing and Sampling Requirements

1 Submit paint samples, for testing by the department, as follows:

1. **Project quantities of less than 25 gal [100 L].** The department does not require a sample and will approve paint based on certification; include paint analysis test results from the supplier with certification.

2. **Project quantities of 25 gal [100 L] or more.** Ensure the manufacturer submits either 1 qt [1 L] of pre-mixed paint or components to prepare 1 qt [1 L] of paint to the Materials Program at least 20 calendar days before use. Include with sample all test results, certifications, and transmittance IR spectra, if applicable.

   Submit samples in metal, friction-top, cylindrical paint cans that are clearly marked with the batch number, quantity of the batch, type of paint, manufacturer's name and address, project number, and the painting contractor's name. Do not use screw top cans or plastic bottles for sample containers.

   For inorganic zinc, epoxy, and acrylic latex products, submit manufacturer's transmittance IR spectra per ASTM D 2621 for each batch of each component (vehicle, activator, etc.).

   2.1. **Field samples.** If manufacturer samples cannot be submitted, take representative paint samples for each different paint, in the presence of the engineer, as follows:

      2.1.1. Use only dry, clean sample cans. Remove all debris and other deleterious materials from the 1 qt [1 L] sample can.

      2.1.2. Set the paint bucket, pail, or drum to be sampled on a level, solid surface. Remove lid carefully; alkyd or oil base paints have layer of solvent and resin on top, and waterborne paints may have an ammonia float layer on top. Avoid inhaling fumes.

2.1.3. Use a stirring rod/stick to check the bottom of the container for skins and settlement. Remove skins. Lift any settlement off the bottom prior to remixing.

2.1.4. Position the mixer and remix contents for 15 minutes to a smooth and homogeneous consistency.

2.1.5. Remove mixer. Use a cup to dip sample from the freshly mixed paint to fill the 1 qt [1 L] sample can to within ½ in [12 mm] of the top lip of the can. Immediately place lid on sample can and secure with four lid clips. Reattach lid on paint bucket, pail, or drum.

2.1.6. Give 1 qt [1 L] sample can and documentation to the engineer.

Previously tested and approved paint may be used for a period not to exceed 18 months from its most recent date of department approval or its maximum shelf life from date of manufacture, whichever is shorter. The department maintains a current list, available from the Materials Program, of pretested/approved paints that do not require samples.

809.3 Ingredients

1 Provide and use paint made from ingredients in accordance with Table 809.3-1, Paint Ingredients.

Table 809.3-1
Paint Ingredients

Ingredient		Specification
Inorganic Pigments	titanium dioxide	ASTM D 476 type II
	zinc dust	ASTM D 520
	zinc oxide	ASTM D 79 french process
	aluminum paste	ASTM D 962, class B, type II
	calcium carbonate	ASTM D 1199, type GC, grade I
	chrome oxide green	ASTM D 263
	diatomaceous silica	ASTM D 604 type A
	lampblack	ASTM D 209
	magnesium silicate	ASTM D 605 max. oil absorption: 30
	wet ground mica	ASTM D 607
Iron Oxide Pigments	natural red	ASTM D 3722 (85% min. Fe2O3)
	synthetic red	ASTM D 3721
	yellow, hydrated	ASTM D 768
Organic Pigments	copper phthalocyanine blue	ASTM D 963
	phthalocyanine green	ASTM D 3021
	quinacridone red	Federal standard 595
	perylene vermillion	Federal standard 595
	benzimidazolone yellow	Federal standard 595
	natural raw umber	Federal standard 595
	natural burnt umber	Federal standard 595
	chrome yellow medium	Federal standard 595

Table continued on next page

Table 809.3-1
Paint Ingredients, *continued*

Ingredient		Specification
Vehicles	long oil-alkyd resin solution	Federal specification TT-R-266D, type I class A
	epoxy resin	SSPC Paint No. 22
	liquid type polyamide resin	SSPC Paint No. 22
	raw linseed oil	ASTM D 234
	boiled linseed oil	ASTM D 260
	high-solids alkyl-silicate	SSPC Paint No. 20
Thinners	mineral spirits	ASTM D 235
	manufacturer's recommendation	–
Dryers	liquid dryers	ASTM D 600

809.4 System A—Alkyd Bridge Paint System

809.4.1 General

1 Ensure that primer and intermediate field coat(s) are applied to structural steel accordance with SSPC Paint Specification No. 25.

809.4.2 Shop Primer

809.4.2.1 Properties

1 Ensure the provision and use of primer having properties in accordance with Table 809.4.2-1, Properties of Alkyd Primer.

Table 809.4.2-1
Properties of Alkyd Primer

Property	Value
Viscosity, KU	75 to 85
Density , lb/gal [kg/L]	12.3 [1.470], min.
Dry time (hard), hours	36, max.
Finish gloss at 60 °F [15.5 °C]	30, min.

809.4.2.2 Composition

1 Ensure the provision and use of primer having composition in accordance with SSPC Paint Specification No. 25, Table 1, “Composition, SSPC-Paint 25, Type I.”

809.4.3 Intermediate Field Coat

809.4.3.1 General

1 For intermediate field coat(s), provide and use a zinc oxide, raw-linseed-oil, alkyd primer with 1.54 lb [0.7 kg] of lampblack pigment added for each 26 gal [100 L] of primer. The lampblack may be added to the primer dry or as a paste in the linseed oil, in which case use enough paste to equal 6 lb [2.7 kg] of dry pigment per 100 gal [380 L] of paint. Ensure lampblack pigment is added during batching at the manufacturer’s facility; do not field-tint.

809.4.3.2 Properties

1 Ensure the provision and use of paint having properties in accordance with Subsection 809.4.2.1, Properties.

809.4.3.3 Composition

1 Ensure the provision and use of paint having composition in accordance with SSPC Paint Specification No. 25, Table 1, “Composition, SSPC-Paint 25, Type I.”

809.4.4 Alkyd Topcoat

809.4.4.1 General

1 For topcoat except gray tan, provide and use tinted, gloss alkyd paint in accordance with SSPC paint specification No. 104, type IV, as modified here. For gray tan, provide tinted, low-gloss alkyd paint provide in accordance with SSPC paint specification No. 104, type II, as modified herein. Ensure the paint is intended for brush or spray application on steel surfaces coated with primer and intermediate field coat(s).

809.4.4.2 Properties

1 Ensure the provision and use of paint having properties in accordance with Table 809.4.4-1, Properties of Alkyd Topcoat.

Table 809.4.4-1
Properties of Alkyd Topcoat

Property	Value			
	Blue	Brown	Gray Tan	Green
Density, lbs/gal [kg/L], minimum	9.1 [1.090]	9.4 [1.130]	10.7 [1.280]	9.4 [1.130]
Water, percent by weight [mass]	0.5, max.			
Fineness of dispersion, rating	6, min.			
Cleanliness, Rating	A, min.			
Flash point, ºF [ºC]	85 [30], min.			
Sag resistance, mils [µm]	6 [152], max.			
Viscosity, KU	75 to 85			
Dry time (dry through) at 3.0 mils [76 µm], hours	24, max.			
Finish gloss at 60 ºF [15.5 ºC], minimum rating	60	60	30	60

809.4.4.3 Composition

1 Ensure the provision and use of paint having composition in accordance with Table 809.4.4-2, Composition of Alkyd Topcoat.

Table 809.4.4-2
Composition of Alkyd Topcoat

<table>
<tr><th colspan="2" rowspan="2">Component</th><th colspan="4">Percent by Weight [Mass]</th></tr>
<tr><th>Blue</th><th>Brown</th><th>Gray Tan</th><th>Green</th></tr>
<tr><td rowspan="9">Pigment</td><td colspan="5">Topcoat</td></tr>
<tr><td></td><td>24.5 to 29.5</td><td>27.5 to 32.5</td><td>40.0 to 45.0</td><td>27.5 to 32.5</td></tr>
<tr><td>coarse particles and skins retained on No. 325 [45 µm] sieve</td><td colspan="4">1.0, max.</td></tr>
<tr><td colspan="5">Extracted Component Only</td></tr>
<tr><td>chrome oxide green</td><td>16.5, min.</td><td colspan="3">–</td></tr>
<tr><td>titanium dioxide</td><td>3.2, min.</td><td>–</td><td>30.0, min.</td><td>20.0 to 22.0</td></tr>
<tr><td>zinc oxide</td><td>11.2, min.</td><td colspan="3">11.3-13.3</td></tr>
<tr><td>reinforcing compounds[(1)]</td><td rowspan="2">69.1, max.</td><td>53.7, max.</td><td rowspan="2">58.7, max.</td><td rowspan="2">68.7, max</td></tr>
<tr><td>tinting compounds[(2)]</td><td>35.0, max.</td></tr>
<tr><td rowspan="6">Vehicle</td><td colspan="5">Topcoat</td></tr>
<tr><td></td><td>70.5 to 75.5</td><td>67.5 to 72.5</td><td>55.0 to 60.0</td><td>67.5 to 72.5</td></tr>
<tr><td colspan="5">Extracted Component Only</td></tr>
<tr><td>long oil-alkyd resin solution</td><td colspan="2">52.0, min.</td><td>50.1, min.</td><td>52.0, min.</td></tr>
<tr><td>mineral spirits and dryers</td><td colspan="2">48.0, max.</td><td>49.9, max.</td><td>48.0, max.</td></tr>
</table>

(1) Provide magnesium silicate and calcium carbonate for reinforcing compounds.

(2) Provide tinting compounds in accordance with Table 809.1-1, Paint Color Standards.

809.5 System B—Zinc-Rich, Epoxy, and Latex Bridge Paint System

809.5.1 Zinc-Rich Primer

809.5.1.1 General

1 Ensure the provision and use of an inorganic zinc, high-solids alkyl-silicate primer that is shop applied in accordance with manufacturer's recommendations by brush or spray on new structural steel.

809.5.1.2 Properties

1 Ensure the provision and use of primer having properties in accordance with Table 809.5.1-1, Properties of Zinc-Rich Primer.

Table 809.5.1-1
Properties of Zinc-Rich Primer

Property	Value
Viscosity, KU	80 to 95
Density, lb/gal [kg/L]	26.5 [3.170], min.
Volatile organic content, lb/gal [kg/L]	2.8 [0.340], max.
Dry time (hard), at 73 °F ±4 °F [23 °C ±2 °C] and 45 to 90 percent relative humidity, hours	1.0, max.

809.5.1.3 Composition

1 Ensure the provision and use of primer in accordance with requirements for composition specified in SSPC Paint No. 20, high-solids alkyl-silicate, type 1C inorganic zinc-rich primer and AASHTO M 300, type 1A, zinc-rich, self-curing, ready-to-mix primer. Do not use pigments with chromate.

2 Ensure the provision and use of primer having composition in accordance with Table 809.5.1-2, Composition of Zinc-Rich Primer.

Table 809.5.1-2
Composition of Zinc-Rich Primer

Component	Proportion
Total solids, percent by weight [mass] of primer	89.0 to 93.0
Zinc dust, percent in dry film	82.0 to 86.0

809.5.2 Epoxy Intermediate Field Coat

809.5.2.1 General

1 Ensure the provision and use of a two-part, epoxy polyamide paint as field primer or intermediate field coat and suitable for brush or spray application when reconstructing or overcoating existing structures. Alkyd-type paint is not allowed.

809.5.2.2 Properties

1 Ensure the provision and use of paint having properties in accordance with Table 809.5.2-1, Properties of Epoxy Intermediate Field Coat.

Table 809.5.2-1
Properties of Epoxy Intermediate Field Coat

Property	Value
Density, lb/gal [kg/L]	11.0 [1.320] to 14.0 [1.680]
Volatile organic content, lb/gal [kg/L]	2.8 [0.340], max.
Dry time (hard), hours	8.0, max.
Adhesion (elcometer), lb/in² [MPa]	400 [2.8], min.

809.5.2.3 Composition

1 Ensure the provision and use of epoxy intermediate field coat in accordance with requirements for composition specified in SSPC Paint No. 22 for intermediate coat.

2 Ensure the epoxy intermediate field coat consists of a two-part epoxy, including the following:

1. Base containing an epoxy resin that is a di-epoxide condensation product of biphenol A and epichlorhydrin with the terminal epoxide group and
2. Curing agent containing volatile solvent and a liquid type polyamide resin that is a condensation product of dimerized fatty acids and polyamines.

3 Ensure the provision and use of paint having composition in accordance with Table 809.5.2-2, Composition of Epoxy Intermediate Field Coat.

Table 809.5.2-2
Composition of Epoxy Intermediate Field Coat

<table>
<tr><th colspan="2">Component</th><th colspan="2">Percent by Weight [Mass]</th></tr>
<tr><td colspan="2">Volatile compounds (solvents, etc.)</td><td colspan="2">20.0, max.</td></tr>
<tr><td rowspan="4">Nonvolatile (NV) film-forming solids (pigment and binder)</td><td>Natural or synthetic red iron oxide (pigment)</td><td>10.0, min.</td><td rowspan="4">80.0, min.</td></tr>
<tr><td>Magnesium silicate (extender pigment)</td><td>8.0, min.</td></tr>
<tr><td>Wet ground mica (extender pigment)</td><td>3.0, min.</td></tr>
<tr><td>Base component solids (vehicle binder)</td><td>(NV solids-pigment)</td></tr>
</table>

809.5.3 Latex Topcoat

1 Provide and use an industrial, single-component, ready-to-use, semi-gloss, 100 percent acrylic latex, waterborne-type paint in accordance with Subsection 809.8, Latex Emulsion Paint.

809.6 Aluminum Paint

809.6.1 General

1 Provide and use a ready-mixed, aluminum paint intended for use as a field topcoat and suitable for brush or spray application over previously applied primer on concrete, masonry, and metal.

809.6.2 Properties

1 Ensure the provision and use of paint having properties in accordance with Table 809.6.2-1, Properties of Aluminum Paint, and Table 809.6.2-2, Properties of Vehicle Component of Aluminum Paint.

Table 809.6.2-1
Properties of Aluminum Paint

Property	Value
Viscosity (No. 4 Ford Cup), seconds	40 to 55
Density, lb/gal [kg/L]	8.8 [1.050], min.
Water, percent by weight [Mass]	0.1, max.
Dry time (set to touch) (1), hours	1.0 to 4.0
Dry time (hard) (1), hours	24.0, max.
Film comparison (2)	Smoothness, color, luster, and opacity matches with standard comparison paint (2) (4)
Film comparison (2) after storage (full, tightly closed container for 30 days at temperature (3))	
Gas pressure after 30 day storage (3)	None visible on container

(1) Wet-film thickness is 1.6 mils [40 µm].

(2) Paint flowed onto a clean glass panel supported at 45°; dried at temperature (3) for 24 hours; panel protected from air drafts during drying.

(3) Drying/storage temperature is 77 °F ±5 °F [25 °C ±3 °C].

(4) Standard comparison paint is mixture of 115 g aluminum paste and 0.5 L long oil-alkyd varnish.

Table 809.6.2-2
Properties of Vehicle Component of Aluminum Paint

Property	Value
Viscosity (Tubes C to E, Gardner Bubble Viscometer), cP [Pa•sec]	85 [0.085] to 125 [0.125]
Water, percent by weight [Mass]	0.1, max.
Dry time (set to touch), hours	1.0 to 4.0
Dry time (hard), hours	18.0, max.
Water immersion (77 °F ±5 °F [25 °C ±3 °C] for 24 hours, no serious defects after removal), hours	2.0, min.
Volatile matter, percent by weight [Mass]	48.0, min.
Phthalic anhydride (quantitative, based on nonvolatile), percent by weight [Mass]	23.0, min.

809.6.3 Composition

1 Ensure the provision and use of paint having composition in accordance with Table 809.6.3-1, Composition of Aluminum Paint.

Table 809.6.3-1
Composition of Aluminum Paint

Component		Percent by Weight [Mass]	
Pigment	Aluminum paste	99.8, min.	13.0, min.
	Coarse particles and skins retained on No. 325 [45 µm] sieve	0.2, max.	
Vehicle	Long oil alkyd resin solution	71.4, min.	87.0, max.
	Mineral spirits	28.6, max.	

809.7 White Paint

809.7.1 General

1 Provide and use a white paint intended for use as a field topcoat and suitable for brush or spray application over previously applied primer on concrete, masonry, and metal.

809.7.2 Properties

1 Ensure the provision and use of paint having properties in accordance with Table 809.7.2-1, Properties of White Paint.

Table 809.7.2-1
Properties of White Paint

Property	Value
Viscosity (Stormer Viscometer, 150 to 190g load), KU	72 to 80
Density, lb/gal [kg/L]	12.0 [1.440], min.
Dry time (set to touch), hours	6.0 to 8.0
Dry time (hard), hours	12.0 to 18.0

809.7.3 Composition

1 Ensure the provision and use of paint having composition in accordance with Table 809.7.3-1, Composition of White Paint.

Table 809.7.3-1
Composition of White Paint

Ingredient		Percent by Weight [Mass]	
Pigment	Titanium dioxide	18.4, min.	52.0, min.
	Zinc oxide	33.3, min.	
	Magnesium silicate and diatomaceous silica	48.3, max.	
Vehicle	Long oil-alkyd resin solution	40.0, min.	48.0, max.
	Boiled linseed oil	25.0, min.	
	Mineral spirits and dryers	35.0, max.	

809.8 Latex Emulsion Paint

809.8.1 General

1 Provide and use an acrylic latex emulsion paint intended for use as a field topcoat and suitable for brush or spray application over previously applied primer on concrete, masonry, and metal. Provide and use paint in accordance with SSPC Paint No. 24.

809.8.2 Properties

1 Ensure the provision and use of paint having properties in accordance with Table 809.8.2-1, Properties of Latex Emulsion Paint.

Table 809.8.2-1
Properties of Latex Emulsion Paint

Property	Value
Density, lbs/gal [kg/L]	varies with color
Hiding power (contrast ratio), unitless	0.95, min.
Viscosity, KU	75 to 110
Dry time (set to touch), hours	2.0, max.
Dry time (hard), hours	12.0, max.

809.8.3 Composition

1 Ensure the provision and use of paint having composition in accordance with Table 809.8.3-1, Composition of Latex Emulsion Paint.

Table 809.8.3-1
Composition of Latex Emulsion Paint

<table>
<tr><th colspan="2" rowspan="2">Component</th><th colspan="2">Percent by Weight [Mass]</th></tr>
<tr><th>Gray, White</th><th>Blue, Brown, Gray Tan, Green</th></tr>
<tr><td colspan="4">Emulsion</td></tr>
<tr><td colspan="2">Nonvolatile solids</td><td>50.0, min.</td><td>36.0, min.</td></tr>
<tr><td colspan="2">Vehicle</td><td colspan="2">varies with color</td></tr>
<tr><td colspan="2">Pigment</td><td colspan="2">varies with color</td></tr>
<tr><td rowspan="3">Extracted Pigment Component Only</td><td>titanium dioxide</td><td>18.4, min.</td><td rowspan="3">varies with color</td></tr>
<tr><td>zinc oxide</td><td>33.3, min.</td></tr>
<tr><td>reinforcing and tinting compounds[(1)]</td><td>48.3, max.</td></tr>
</table>

(1) Provide magnesium silicate and calcium carbonate for reinforcing compounds and tinting compounds in accordance with Table 809.1-1, Paint Color Standards.

809.9 Epoxy Mastic Paint

809.9.1 General

1 Provide and use a two-part, one coat, high build, self-priming, modified aluminum epoxy mastic paint intended for use as a field topcoat that is suitable for brush application over inorganic or organic zinc primers, rusted steel, aged alkyd coatings, epoxy coatings, and tightly adhering epoxy-coal tar coatings. Ensure paint contains rust inhibitors that effectively control undercutting and is aluminum colored, well ground and not caked, skinned, or settled in the container; supply as a two part package with a 1:1 volumetric mix ratio.

809.9.2 Properties

1 Ensure the provision and use of paint having properties in accordance with Table 809.9.2-1, Properties of Epoxy Mastic Paint.

Table 809.9.2-1
Properties of Epoxy Mastic Paint

Property	Value
Viscosity cP [Pa•sec]	8000 [8.0] to 16,000 [16.0]
Density, lb/gal [kg/L]	10.0 [1.200] to 15.0 [1.800]
Volatile organic content, lb/gal [kg/L]	2.8 [0.340], max.
Dry time (hard), hours	24.0, max.
Adhesion (elcometer), lb/in² [MPa]	400 [2.8], min.
Pot life at 77 °F [25 °C], hours	4.0, min.
Shelf life, months	12.0, min.
Film build (1), visible evidence of runs or sags, percent	0.0, max.
Mandrel/bent plate (2), visible evidence of cracking or loss of adhesion, percent	0.0, max.
Salt fog exposure (3), pinpoint rusting or ⅛-inch [3 mm] blisters, percent	5.0, max.
Salt fog exposure (3), undercutting from the scribe, millimeter	6.0, max.

(1) The catalyzed mixture, thin 10 percent by volume with the specific thinner; spray-applied at 10 mils [254 µm] wet-film thickness.

(2) Uniform 5.1 mils [130 µm] coating applied to sand blasted steel panel; cured for two weeks at 77 °F±5 °F [25 °C ±3 °C]; coated panel uniformly bent around 7.875 inch [200 mm] diameter mandrel.

(3) Uniform 5.1 mils [130 µm] coating applied to wire-brushed, weather-rusted steel panel; 2 inch [50 mm] vertical scribe in middle of panel; panel exposed to 10 percent salt fog at 104 °F [40 °C] for six months.

809.9.3 Composition

1 Ensure the provision and use of paint having composition in accordance with Table 809.9.3-1, Composition of Epoxy Mastic Paint, for the base and curing agent combined.

Table 809.9.3-1
Composition of Epoxy Mastic Paint

Component	Proportion
Total solids, percent by weight [mass]	87.5, min.
Total solids, percent by volume	88.0, min.
Aluminum paste, percent by volume	6.0, min.

SECTION 810
Concrete Repair

810.1 Concrete Patching Material

810.1.1 General

1 Ensure aggregate extension in accordance with the manufacturer's recommendations; use aggregate in accordance with Table 810.1.1-1, Extension Aggregate Gradation Requirements.

Table 810.1.1-1
Extension Aggregate Gradation Requirements

Sieve Size	Percent Passing
⅜ in [9.50 mm]	100
No. 8 [2.36 mm]	0

810.1.2 Horizontal Repair Material

1 Provide and use a concrete repair product preapproved by the Materials Program or equivalent nonchloride, nonvapor barrier, high-alumina cementitious mortar in accordance with ASTM C-928-99a and Table 810.1.2-1, Horizontal Repair Material.

Table 810.1.2-1
Horizontal Repair Material

Property	Test	Value
Neat Material		
Compressive Strength	ASTM C 109	5000 psi [35 MPa] in 24 hours 8000 psi [55 MPa] in 28 days
Final Set	–	25 minutes, min.
Freeze/Thaw Resistance	ASTM C 666	96% min. @ 300 cycles
Drying Shrinkage	ASTM C 596	0.13% max. @ 4 days
With Maximum Aggregate Extension		
Compressive Strength	ASTM C 39	4000 psi [28 MPa] in 24 hours 7000 psi [48 MPa] in 28 days
Bond Strength	ASTM C 882 Modified	2000 psi [14 MPa] in 24 hours

810.1.3 Vertical/Overhead Repair Material

1 Provide and use a concrete repair product preapproved by the Materials Program or equivalent nonchloride, nonvapor barrier, high-alumina cementitious mortar designed for vertical and overhead applications in accordance with ASTM C-928-99a and Table 810.1.3-1, Vertical/Overhead Repair Material.

Table 810.1.3-1
Vertical/Overhead Repair Material

Property	Test	Value
Neat Material		
Compressive Strength	ASTM C 109	3000 psi [28 MPa] in 24 hours 6000 psi [55 MPa] in 28 days
Final Set	–	25 minutes, min
Freeze/Thaw Resistance	ASTM C 666	96% min. @ 300 cycles
Drying Shrinkage	ASTM C 596	0.13% max. @ 4 days
Bond Strength	ASTM C 882 Modified	1500 psi [10 MPa] in 24 hours

810.2 Bond-Breaking Compound

1 For bond breaking, provide and use liquid, membrane-forming, bond-breaking compound in accordance with AASHTO M 148 (ASTM C 309), type 2, class A or B, or other approved release agent. Obtain the engineer's approval before use.

810.3 Caulking Filler

1 For caulking filler, provide and use a standard commercial silicone sealer designed for concrete surfaces and containing at least 50 percent silicone.

810.4 Foam Core Board

1 For filling joints, provide and use foam core board at least ⅜ in [10 mm] thick, with ½ in [12 mm] high × 1 in [25 mm] long tabs on top, and consisting of closed-cell foam faced on each side with poster board or plastic (referred to by office suppliers as "foam core") or a dense closed-cell foam insulation faced with plastic or foil. If necessary, provide a thicker foam core board for transverse cracks or larger transverse joints.

810.5 Dowel Bar Retrofit Concrete

1 Provide and use a concrete product pre-approved by the Materials Program or equivalent in accordance with Table 810.5-1, Dowel Bar Retrofit Concrete Material.

Table 810.5-1
Dowel Bar Retrofit Concrete Material

Property	Test	Value
	Neat Material	
Compressive Strength	ASTM C 109	3000 psi [21 MPa] in 6 h
5000 psi [34 MPa] in 24 h		
Shrinkage in 4 Days	ASTM C 596	0.13 percent, max.
Final Set	–	25 minutes, min.
	With Maximum Aggregate Extension	
Flexural Strength	Calif. Test 551	500 psi [3.5 MPa] in 24 h
Bond to Dry PCCP	Calif. Test 551	400 psi [2.8 MPa] in 24 h
Bond to Saturated Surface Dry PCCP	Calif. Test 551	300 psi [2.1 MPa] in 24 h

2 Provide and use coarse aggregate extension in accordance with Subsection 803.2.2, Course Aggregate, and Table 810.5-2, Dowel Bar Retrofit Concrete Gradation Requirements.

Table 810.5-2
Dowel Bar Retrofit Concrete Gradation Requirements

Sieve Size	Percent Passing
⅜ in [9.50 mm]	100
No. 8 [2.36 mm]	0

3 Ensure a coarse aggregate extension no greater than eight parts coarse aggregate to ten parts dry patching material by weight [mass]. Provide dry patching material consisting of the manufacturer's cementitious material and fine aggregate. If the fine aggregate is not included as part of the manufacturer's product, blend it with the cementitious material at a proportion recommended by the manufacturer and approved by the engineer. Use fine aggregate in accordance with Subsection 803.2.1, Fine Aggregate.

810.6 Epoxy Resin

1 For repairing concrete with epoxy resin, provide and use a class suitable for the concrete temperature at the time of use. The engineer may approve the use of other polymer adhesives. Ensure accordance with the following:

1. **Injection Material.** ASTM C 881, type I, grade 2.
2. **Bonding Compound.** ASTM C 881, type V, grade 2.

SECTION 811
Reinforcing Steel, Wire Rope, and Wire Enclosures

811.1 Reinforcing Steel

811.1.1 General

1 Bundle and tag reinforcing steel with weather-resistant tags.

811.1.2 Reinforcing Steel Bars

1 Provide and use reinforcing steel bars in accordance with ASTM A 615 [ASTM A 615M]. Provide grade 40 or 60 [grade 300 or 420] ties and stirrups and grade 60 [grade 420] for all other bars.

2 For epoxy-coated reinforcing steel bars, ensure coating in accordance with ASTM A 775 [ASTM A 775M], including the certification requirements in sections 4.1.8 and 14.1. From the epoxy coating manufacturer, obtain patching or repair material that is compatible with the coating, inert in concrete, and suitable for field use.

3 Provide and use galvanized reinforcing steel bars, tie wires, and bar supports in accordance with ASTM A 767 [ASTM A 767M], class 1 coating.

4 Use spiral reinforcement in accordance with ASTM A 82.

811.1.3 Steel Bar Mats

1 Use fabricated steel bar mats for concrete reinforcement in accordance with AASHTO M 54 [AASHTO M 54M] for deformed, intermediate grade, new billet steel for either clipped or welded mats.

811.1.4 Welded-Wire Fabric

1 Provide and use welded-wire fabric in accordance with AASHTO M 55 [AASTHO M 55M].

811.2 Dowel Bars and Tie Bars

811.2.1 General

1 Provide and use saw-cut, epoxy-coated smooth dowel bars in accordance with AASHTO M 254, type B, free of burrs or projections restricting movement.

2 Provide dowels of at least grade 40 steel in accordance with AASHTO M 31 [grade 300 in AASHTO M 31M]; dowels may be cut from longer coated bars. The department does not require epoxy coating of cut dowel bar ends.

3 Provide epoxy-coated tie bars in accordance with Subsection 811.1.2, Reinforcing Steel Bars. Tie bars may be cut from longer bars.

4 For existing pavement thicker than 8 in [200 mm], provide and use 1½-inch [38 mm] diameter bars 18 in [450 mm] long. For existing pavement equal to or less than 8 in [200 mm] thick, provide and use 1¼-inch [32 mm] diameter bars 18 in [450 mm] long.

811.2.2 Dowel Bar End Caps

1 Provide and use nonmetallic dowel bar end caps with inside protrusions that allow for ¼ in [6 mm] movement of the bar at each end and prevent compression of the cap against the end of the bar during installation.

811.2.3 Dowel Bar Sleeves

1 Provide and use metal sleeves for dowel bars of an approved design to cover from 1¾ in to 2¼ in [45 mm to 55 mm] of the dowel, with a closed end and suitable stop to hold the end of the sleeve at least 1 in [25 mm] from the end of the dowel bar.

811.2.4 Dowel Bar Release Agent

1 Use a dowel bar release agent pre-approved by the Materials Program.

811.2.5 Chairs

1 For supporting and holding dowel bars in place, provide epoxy-coated or nonmetallic chair devices capable of ensuring a clearance of at least ½ in [12.5 mm] between the bottom of the bar and the surface upon which the chair is placed and designed to prevent movement of the bar during placement of the grout.

811.3 Wire Rope or Wire Cable

1 Provide wire rope or cable in accordance with AASHTO M 30 for the specified diameter and strength class.

811.4 Steel Wire Strand

1 Provide steel wire strand in accordance with ASTM A 475 for the nominal diameter, grade, and coating class specified.

811.5 Prestressing Steel

1 Provide and use high-tensile wire strand in accordance with ASTM A 416, grade 270 [ASTM A 416M, grade 1860]. With the approval of the State Bridge Engineer of submitted computations, high-tensile wire strand in accordance with ASTM A 416, grade 250 [ASTM A 416M, grade 1725], high-tensile wire in accordance with ASTM A 421, or high-tensile-strength alloy bars meeting the requirements of this section may be substituted.

2 Ensure that the cross-sectional area of steel wire strand is within 0.005 in^2 [3 mm^2] of the nominal steel areas shown in table 1 of ASTM A 416.

3 Ensure that high-tensile-strength alloy bars have been thermally stress-relieved to produce a suitable, uniform metallurgical structure, and individually proof-tested during manufacturing to at least 90 percent of the manufacturer's minimum guaranteed ultimate strength. Provide bars in accordance with Table 811.5-1, Prestressing Steel Mechanical Properties.

Table 811.5-1
Prestressing Steel Mechanical Properties

Mechanical Properties	Regular Grade	Special Grade
Ultimate tensile strength, min., psi [MPa]	145,000 [1000]	160,000 [1100]
Yield strength (measured by the 0.7% extension-under-load method), min., psi [MPa]	130,000 [900]	140,000 [965]
Elongation, % min. (in 20 bar diameters after rupture)	4.0	4.0
Reduction of area, %, min.	25	20
Modulus of elasticity (at 70% of manufacturer's min. guaranteed ultimate strength), min., psi [MPa]	25×10^6 [1.72×10^5]	25×10^6 [1.72×10^5]

4 Ensure that diameter tolerances are in accordance with ASTM A 29 [ASTM A 29M]. Use only one grade of bars for any individual member, unless allowed otherwise by the engineer.

811.6 Wire-Enclosed Riprap, Gabions, and Revet Mattresses

1 For enclosing riprap, provide and use 2 in × 4 in [50 mm × 100 mm], V-mesh woven-wire fabric with double strand 12½-gage [2.51 mm] horizontal wires and 12½-gage [2.51 mm], single-strand cross wires. Provide wire in accordance with ASTM A 116, class 1 or better.

2 For gabions and revet mattresses, provide and use a woven wire fabric in accordance with ASTM A 975, style 1.

3 Provide galvanized, 12½-gage [2.51 mm], smooth steel lacing and tie wire; galvanized 9-gage [3.76 mm] hog rings at 4-inch [100 mm] spacing may be used to fasten ends, sides, and top panels.

4 For steel stakes, provide 5-foot [1.5 m] crane rails, nominal 3-inch [75 mm] standard pipe, or angles 4 in × 4 in × ⅜ in [100 mm × 100 mm × 10 mm]. Rail, pipe, or angles free from rust or damage that could affect the stake's strength may be reused.

SECTION 812
Fence and Cattle Guards

812.0 General Fence Requirements

1 Provide wire coated as follows:

1. **Barbed and Twisted Barbless.** In accordance with AASHTO M 280.

2. **Woven Wire Fabric.** In accordance with AASHTO M 279.

3. **Industrial.** In accordance with AASHTO M 181.

2 Use one of the following:

1. Coating Type A (aluminum alloy wire and barbs only);

2. Coating Type Z, Coating Class 1; or

3. Coating Type ZA, Coating Class 40. Use Class C for industrial fence.

812.1 Barbed Wire

1 Provide two-wire strands with two-point, round barbs spaced at intervals no greater than 4 in [100 mm] or four-point, round barbs spaced at intervals no greater than 5 in [125 mm], double wrapped in accordance with AASHTO M 280 either:

1. Design Number 12-2-4-14R or

2. Design Number 12-4-5-14R.

2 Use either:

1. Steel line wire and barbs;

2. Aluminum alloy wire and barbs. Use the same aluminum alloy for both line wire and barbs; or

3. High tensile steel wire (minimum breaking strength 1600 lbf [726 kgf]).

3 For braces, tie wires, and wire stays, provide 12½-gage or larger steel wire.

812.2 Twisted Barbless Wire

1 Provide twisted wire consisting of two strands of 12½-gage steel wire without barbs and in accordance with AASHTO M 280.

812.3 Woven Wire

1 For right-of-way and barrier fence, provide woven wire fabric in accordance with AASHTO M 279 for No. 11, grade 60, with stay wires 6 in [150 mm] apart.

812.4 Industrial Fence

1 Provide industrial fence fabric of the type specified, tension wire, posts, required hardware, and fittings in accordance with AASHTO M181. Provide grade 2 posts. If not specified, aluminum or galvanized steel fabric, posts, hardware, and fittings may be used.

2 Alternatively, posts, braces, rails, and gate framing members may be steel pipe in accordance with ASTM A 569 [ASTM A 569M], with a yield strength of at least 50,000 psi [350 MPa] and with an outside diameter no less than specified for schedule 40. Ensure that the outside is coated with at least 0.9 oz/ft² [275 g/m²] of zinc, at least 15 micrograms/ft² [25 g/m²] of zinc chromate, and acrylic at least 0.3 mil [8 µm] thick. Ensure that the inside is coated with a zinc-rich coating containing at least 80 percent zinc powder by weight [mass]. Replace pipe with visible coating damage at no additional cost to the department.

812.5 Galvanized Steel Gates

1 As specified, provide galvanized steel gates of the indicated width, at least 50 in [1.3 m] high, and with hinges and fittings. Provide a frame made of 1⅜-inch [35 mm] outside-diameter galvanized pipe with all joints welded and braced where necessary. Provide 2-inch × 4-inch [50 mm × 100 mm] V-mesh fabric with double-strand, 12½-gage [2.51 mm] horizontal wires and at least 14-gage [2.03 mm] cross or diagonal wires. Submit alternate or equivalent designs to the engineer for approval before ordering.

812.6 Cattle Guard Units

812.6.1 Prefabricated

1 For prefabricated cattleguards, ensure the provision and use of cross-bar members made from carbon-steel structural tubing in accordance with ASTM A 500, grade A or B, or from cold-formed, high-tensile, low-alloy steel plate, with good weldability and in accordance with Table 812.6.1-1, Steel Plate Properties.

Table 812.6.1-1
Steel Plate Properties

Mechanical Property	Requirements
Yield Point, min.	45,000 psi [310 MPa]
Min. Tensile Strength	60,000 psi [410 MPa]

2 Provide cattle guard supports and detachable wings fabricated from steel meeting the above requirements or from structural steel in accordance with ASTM A 709, grade 36 [ASTM A 709M, grade 250]. Concrete footings may be precast. Provide bolts in accordance with ASTM A 307 or SAE grade 2.

812.6.2 Welded Grill

1 For welded grills, provide units consisting of steel rails of the weight [mass] specified, arc-welded with low-hydrogen electrodes to structural steel beams. Salvaged rails may be used if they are clean, rust-free, of uniform section and weight [mass], and at least 95 percent of the original weight [mass]. For structural steel other than rails, ensure accordance with ASTM A 709, grade 36 [ASTM A 709M, grade 250].

812.7 Nails and Spikes

1 Provide nails and spikes in accordance with the *National Design Specification* published by the American Wood Council. When specified, provide hot-dip galvanized nails and spikes of common diameter and length.

812.8 Fence Posts

812.8.1 Wood

1 For wood fencing materials, provide and use posts, cross braces, and deadmen cut from sound, growing Douglas Fir, Lodgepole Pine, Southern Yellow Pine, or Ponderosa Pine trees. Ensure that posts have been machine-peeled, with the outer bark removed completely, and no remaining strip of inner bark is wider than 2 in [50 mm] or longer than 3 in [75 mm].

2 For line posts, ensure the wood has no seasoning check wider than ⅜ in [10 mm], dry heart, sap rot, rotten knots, or more than one 2-inch [50 mm] crook measured from end to end. Ensure the same for posts in end and brace panels, but allow no crook greater than 1 in [25 mm]. Ensure that tapering does not exceed ¼ in/ft [21 mm/m].

3 Ensure that posts are treated and certificates and reports thereof are submitted, in accordance with Section 817, Structural Timber and Lumber.

812.8.2 Steel

1 Provide steel posts, fittings, hardware, and other steel appurtenances of standard commercial grade, manufactured in accordance with current standard practice and painted with an approved, dark green paint. The top 6 in [150 mm] of posts may be painted with the supplier's identification paint.

812.8.3 Recycled Plastic

812.8.3.1 General

1 The department will use these definitions in reference to fence posts made from recycled plastic:

1. **Recycled Plastic.** Plastics made of post-consumer material, recovered industrial material, or both, processed as necessary to make usable products.

2. **Post-Consumer Material.** Used products generated by a business or consumer that have been separated from solid waste for collection, recycling, and redisposition.

3. **Recovered Material.** Materials and by-products recovered or diverted from solid waste, not including materials and by-products generated from and commonly used within an original manufacturing process.

2 For recycled-plastic posts, ensure the use of at least 70 percent recycled plastic by weight [mass] and of a uniform composition throughout the post, with no more than 20 percent voids; do not use posts with a void exceeding 25 percent of the diameter or side of the post. Provide brown posts that are free of cracking, chipping, flaking, peeling, or splintering. The department will allow only chemicals, including fillers and coloring agents, designed to inhibit photo degradation, biological/biochemical decomposition, insect infestation, or burning.

812.8.3.2 Certification

1 In addition to meeting the requirements of Subsection 800.1, Manufactured Products Certifications, ensure that for each lot shipped the manufacturer certifies the following:

1. The source of the recycled plastic waste, including its state of origin and its type (consumer or industrial);
2. The total percent of recycled plastic in the final product; and
3. The quantity and size of posts.

2 Submit certifications to the engineer at least 21 calendar days before installation.

812.8.3.3 Testing

1 For each different type of recycled-plastic post (e.g., cross-section, size, and shape), the department will use an acceptance lot size of no more than one thousand posts. Provide a sample of at least one additional post per lot, or a minimum of one post per project, for independent laboratory testing and certification.

2 The department will not accept posts in a lot until the lot has been approved; do not ship lots to the project until the sample has been tested and approved. Ensure that posts are delivered in wrapped bundles of no more than 25 posts and that each bundle is marked with the lot number.

812.8.3.4 Physical Requirements

1. **Dimension and Shape.** When providing recycled-plastic posts, ensure the same dimensions, shape, and length as specified for wood. For round posts, ensure a minimum diameter within ½ in [12 mm] of that specified.

2. **Straightness.** Provide and use recycled-plastic posts in accordance with the straightness criteria specified in Subsection 812.8.1, Wood.

3. **Flexural Strength.** Provide and use recycled-plastic posts in accordance with the specifications for flexural strength in the Western Wood Products Association (WWPA) *Standard Grading Rules* for posts and timbers for select structural grade timber, with maximum or extreme fiber stress of at least 1000 psi [6895 kPa]. Test posts in accordance with ASTM D 790.

4. **Surface Finish.** Provide and use posts with a homogeneous, smooth surface finish relatively free of surface imperfections.

812.8.3.5 Fasteners

1 For attaching wire fence to recycled-plastic posts, provide and use fasteners that connect at predrilled pilot holes; do not use staples or nails.

SECTION 813
Guardrail and Barrier

813.1 Corrugated Metal Beam Rail

1 For rail elements and terminal sections, provide and use 12-gage [2.51 mm], corrugated steel sheet beams in accordance with AASHTO M 180, type 1, class A.

813.2 Guardrail Hardware

1 For guardrails and barriers, ensure the provision and use of hardware galvanized in accordance with Subsection 501.4.1.25, Galvanizing, and Subsection 815.14, Galvanized Coating. For bridge rail connections, guardrail, median barrier, and box beam splice connections, provide and use bolts in accordance with ASTM A 325 [ASTM A 325M]; provide and use other bolts, washers, fittings, and accessories in accordance with ASTM A 307, grade A. Provide and use wire rope or wire cable in accordance with Subsection 811.3, Wire Rope or Wire Cable.

813.3 Box Beam Barrier

1 For box beam barriers, provide and use rail elements made from tubing in accordance with ASTM A 500 grade A or B; provide and use other structural steel elements in accordance with ASTM A 36 [ASTM A 36M] and galvanized in accordance with Subsection 501.4.1.25, Galvanizing, and Subsection 815.14, Galvanized Coating. Ensure that galvanized bolts thread easily into nuts on the splice plates.

813.4 Corrugated Beam Guardrail (Self-Oxidizing)

1 For self-oxidizing guardrail elements, terminals, anchorages, and hardware (except reflector tabs and bolts), provide and use unpainted, ungalvanized, blast-cleaned, dry steel. Provide rail elements made of corrugated steel sheet beams in accordance with AASHTO M 180, type IV, class A, as modified here. For all components, including hardware, ensure the provision and use of "weathering" steel in accordance with Table 813.4-1, Weathering Steel: Chemical Composition Requirements.

Table 813.4-1
Weathering Steel: Chemical Composition Requirements

Chemical	% (Heat Analysis)
Carbon	0.12, max.
Manganese	0.20 to 0.50
Phosphorus	0.07 to 0.15
Sulfur	0.05, max.
Silicon	0.25 to 0.75
Copper	0.25 to 0.55
Chromium	0.30 to 1.25
Nickel	0.65, max.

2 The department will allow the use of steel not in accordance with Table 813.4-1, Weathering Steel: Chemical Composition Requirements, if given certification that the proposed alternative steel has a corrosive resistance of at least four times that of carbon steel with a maximum copper content of 0.02 percent or twice that of carbon steel with a copper content from 0.25 to 0.55 percent.

3 For beam rails, ensure the use of sheet steel in accordance with ASTM A 606, type 4; the sheet may be in coils or cut lengths when corrugated.

Do not allow foreign material to contact steel surfaces. Ensure that parts are placed during shipment to allow free drainage and air circulation on the surfaces.

4 Provide and use retroreflector tabs, nuts, and bolts made of steel meeting the requirements in previous paragraphs, ASTM A 36 [ASTM A 36M], or other acceptable steel galvanized in accordance with Subsection 501.4.1.25, Galvanizing, and Subsection 815.14, Galvanized Coating.

813.5 Wyoming Box Beam End Terminal for Guardrails

813.5.1 Steel Components

1 Ensure that steel components used in fabricating Wyoming Box-Beam End Terminals (WYBET) are galvanized in accordance with Subsection 501.4.1.25, Galvanizing, and Subsection 815.14, Galvanized Coating, with corners, edges, and burrs ground smooth before galvanization. Ensure that the inner rail, impact head, and steel spacer slide smoothly and freely inside the outer rail for their full length of travel. Correct warping caused by welding or fabrication to ensure a loose fit. Instead of galvanization, the intermediate spacer may be shop painted with two coats of zinc-rich paint.

813.5.2 Rubber Stops

1 For rubber stops in WYBETs, ensure the provision and use of hard rubber in accordance with *AASHTO Standard Specifications for Highway Bridges Division II*, Section 18.2 for elastomeric bearing pads, of rubber commonly used for temporary roadway rumble strips or of an approved equal.

813.5.3 Composite Tubes

813.5.3.1 General

1 For use in WYBETs, ensure the provision of fiberglass-and-epoxy composite material in the following elements:

1. **Stage 1 Tube.** A 6-inch [150 mm] diameter tube with a wall thickness of 0.125 in [3 mm].

2. **Stage 2 Tube.** A 6-inch [150 mm] diameter tube with a wall thickness of 0.25 in [6 mm].

2 Cut tubes to the specified length, leaving both ends of each tube with neat tulips (serrations) of the proper dimensions for the specified stage so as to form four symmetric points at each end; do not over-cut.

813.5.3.2 General Properties for Composite Tube Materials

1 Ensure that tubes are manufactured using the pultrusion process, that they consist of a glass-fiber-reinforced resin matrix with a glass to resin ratio of approximately 1:1, that the resin consists of isophthallic polyester, and that the glass reinforcement includes the following:

1. A surface mat used on exterior surfaces for chemical resistance and containment of other reinforcement fibers;
2. Continuous glass strand rovings used internally for longitudinal strength; and
3. Continuous strand mats used internally for transverse strength.

2 Ensure also that the composite material is in accordance with Table 813.5.3.-1, Mechanical Property Requirements: Composite Material.

Table 813.5.3-1
Mechanical Property Requirements: Composite Material

Property	Requirements
Ultimate Tensile Strength:	
Longitudinal Coupon	30,000 psi [205 MPa]
Transverse Coupon	7,000 psi [48 MPa]
Full Section in Bending	20,000 psi [138 MPa]
Ultimate Compressive Strength:	
Longitudinal Coupon	30,000 psi [205 MPa]
Transverse Coupon	15,000 psi [102 MPa]
Full Section in Bending	20,000 psi [138 MPa]
Ultimate Shear Strength	4,500 psi [31 MPa]
Ultimate Breaking Strength	30,000 psi [205 MPa]
Modulus of Elasticity:	
Full Beam Section in Bending	2.5×10^6 psi [17 000 MPa]
Barcol Hardness	50

813.5.3.3 Crush Force Characteristics

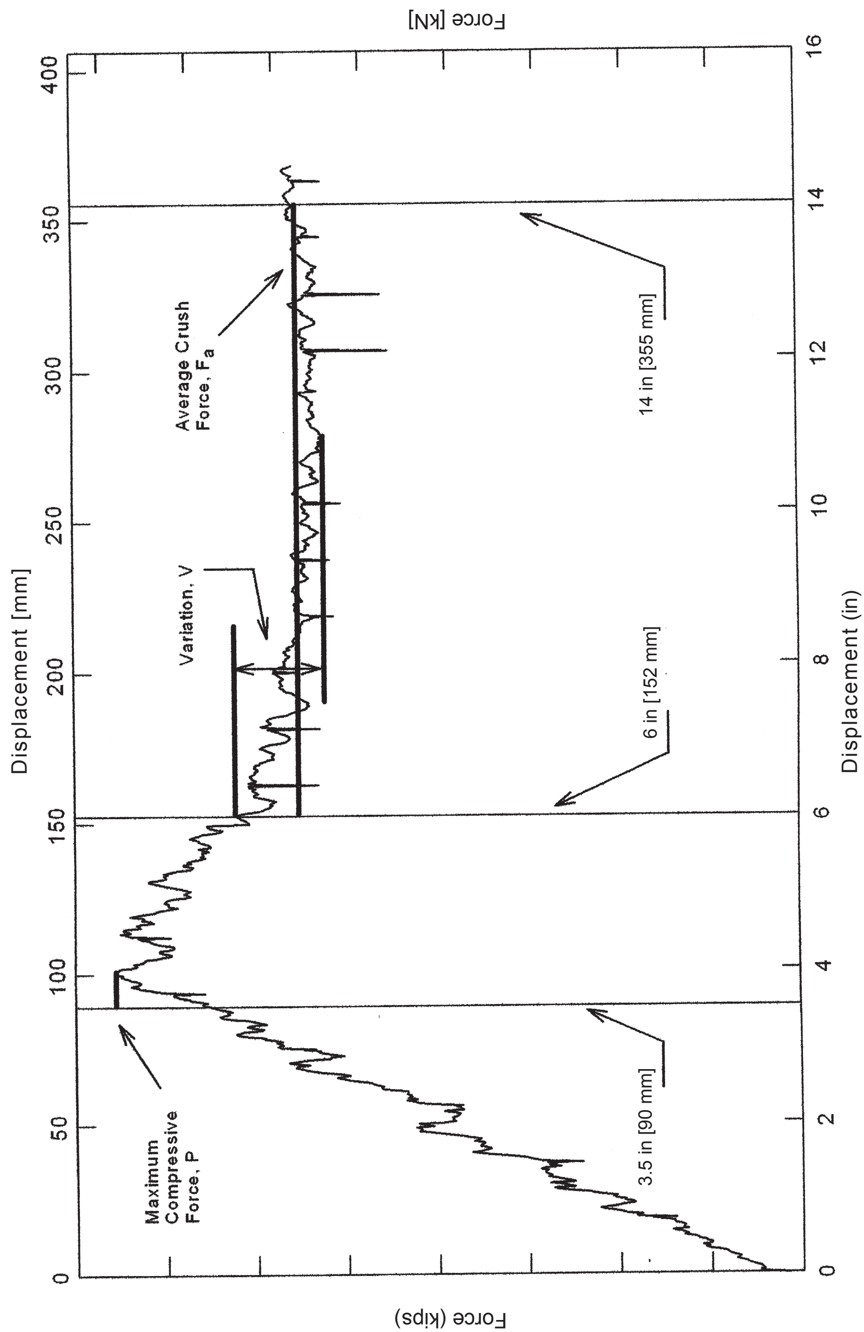
1 Ensure that the composite tubes for WYBETs possess static energy dissipation properties in accordance with Table 813.5.3-2, Static Energy Dissipation Property Limits: Composite Tubes.

Table 813.5.3-2
Static Energy Dissipation Property Limits: Composite Tubes

Property	Limits	
	Average of 3 test specimens	Each individual test specimen
Stage 1 Tube		
Average Crush Force, F_a	19 ± 3 kips [85 ± 13 kN]	19 ± 5 kips [85 ± 22 kN]
Max. Compressive Force, P	26 kips [116 kN]	28.5 kips [127 kN]
Stage 2 Tube		
Average Crush Force, F_a	40 ± 4 kips [178 ± 18 kN]	40 ± 8 kips [178 ± 36 kN]
Max. Compressive Force, P	55 kips [245 kN]	60 kips [267 kN]

2 Definitions of the average crush force (F_a), and maximum compressive force (P), are contained in Figure 813.5.3-1, Static Crush Test: Pultruded Fiberglass Tube. Determine the average crush force based on crush forces from 6 in to 14 in [150 mm to 355 mm] of crush; determine the maximum compressive force between 3.5 in and 6 in [90 mm to 150 mm] of crush.

Figure 813.5.3-1
Static Crush Test: Pultruded Fiberglass Tube



813.5.3.4 Test Procedures

1 Ensure the provision and use of composite tubes with the specified energy dissipation properties by using static compressive testing procedures performed as follows:

1. Using an independent laboratory, test at least three randomly selected samples, one each from the beginning, middle, and end of the tubes' production run.
2. For each test, use a 24-inch [600 mm] length of tube, with a tulip cut 4 in [100 mm] long in one end and caps on both ends.
3. Place the tube in the testing machine such that the crush force will be applied along the tube's longitudinal axis and centered under the loading head.
4. Statically crush the tube at a rate of 2 in/min [50 mm/min] for a total crush length or displacement of at least 14 in [355 mm]. If the testing machine has insufficient stroke to crush the specimen in one continuous application, crush in stages, with a crush length of at least 6 in [150 mm] for each stage.

813.6 Guardrail Posts

813.6.1 General

1 For guardrails, ensure that wood posts are cut from sound, growing trees of the species and with the ratings indicated for the intended use. For both wood and metal, ensure the provision and use of posts in accordance with Table 813.6.1-1, Guardrail Posts.

Table 813.6.1-1
Guardrail Posts

Post Designation	Allowable Section	Allowable Material Type and Grade
Standard W-Beam Guardrail Post	6 in × 8 in [150 mm × 200 mm](1)	Douglas Fir-Larch (P & T No. 1) Southern Yellow Pine (P & T No. 1)
	8 in × 8 in [200 mm × 200 mm]	Lodgepole Pine (P & T No. 1) Ponderosa Pine (P & T No. 1)
	8 in [200 mm] round	Douglas Fir-Larch (P & T No. 1) Southern Yellow Pine (P & T No. 1) Lodgepole Pine (P & T No. 1) Ponderosa Pine (P & T No. 1)
	W 6 × 9 (2)	ASTM A 6 (ASTM A 36 Steel) [ASTM A 6M (ASTM A 36M Steel)]
Transition Post	10 in [250 mm] round (3)	Douglas Fir-Larch (P & T No. 1) Southern Yellow Pine (P & T No. 1) Lodgepole Pine (P & T No. 1) Ponderosa Pine (P & T No. 1)
CRT Post	6 in × 8 in [150 mm × 200 mm](1)	Douglas Fir-Larch (P & T No. 1) Southern Yellow Pine (P & T No. 1)
BCT Post	6 in × 8 in [150 mm × 200 mm](1)	Douglas Fir-Larch (P & T No. 1) Southern Yellow Pine (P & T No. 1) SAS only
WYBET & WYBET MB Post #1	8 in × 6 in [200 mm × 150 mm](1)	Douglas Fir-Larch (P & T No. 1) Southern Yellow Pine (P & T No. 1) SAS only

(1) Ensure a minimum stress grade of 1200 psi [8 MPa] (Extreme Fiber Bending).

(2) W 6 × 8.5 may be substituted.

(3) 10 in × 10 in [250 mm × 250 mm] may be substituted.

813.6.2 Wood Posts

1 Ensure that wooden posts and blocks for guardrails are treated, and certificates and reports thereof submitted, in accordance with Section 817, Structural Timber and Lumber.

813.6.2.1 Round Posts

1 Provide and use decay-free posts as follows:

1. Machine-peeled with the outer bark removed and no remaining strip of inner bark wider than ½ in [12 mm] or longer than 1½ in [38 mm];
2. Having no seasoning check wider than ½ in [12 mm] or deeper than 1½ in [38 mm] for the full post length and no wider than ¼ in [6 mm] or deeper than 2 in [50 mm] through the bolt hole;
3. With knots that are sound and tight; allow only one, with a maximum 1 in [25 mm] in diameter, per 6 ft [2 m] of post length;
4. Without multiple crooks;
5. With no more than one half-twist in the grain for the full post length;
6. Tapered so that no difference in diameters exceeds 1 in [25 mm] over 6 ft [2 m] of post length; and
7. Without scars at the ground line or scars longer than 6 in [150 mm] or wider than 2 in [50 mm]; trim allowable scars.

813.6.2.2 Dimensioned Posts and Blocks

1 For timber posts and blocks, provide as rough sawn or surface four sides (S4S).

813.6.3 Steel Posts

1 For steel guardrail posts, provide and use in the specified length and section, in accordance with ASTM A 36 [ASTM A 36M], and galvanized in accordance with AASHTO M 111 [AASHTO M 111M].

SECTION 814
Water

814.1 Water

814.1.1 General

1 Provide and use clean water free of oil, salt, acid, alkali, algae, sugar, vegetable, or other deleterious substances.

814.1.2 Water for Concrete

1 For concrete, provide and use mixing or curing water in accordance with Table 814.1.2-1, Properties of Water For Concrete; do not neutralize by chemical additives. The engineer may allow the use of water known to be potable.

Table 814.1.2-1
Properties of Water For Concrete

Property	Specification	Min	Max
Chloride ion, ppm	ASTM D 512, method B	–	1000
Hydrogen ion (1), pH	AASHTO T 26, acidity method B	4.5	8.5

(1) If pH is not within range, compare mortar specimens prepared from source and distilled water in accordance with Table 814.1.2-2, Properties of Mortar Specimens.

Table 814.1.2-2
Properties of Mortar Specimens

Property	Specification	Max
Autoclave expansion, %	AASHTO T 107 (1)	0.07
Vicat time of setting, minutes	AASHTO T 131 (2)	34.0, initial; 56.0, final
Compressive strength, lb/in² [MPa]	AASHTO T 106 (3)	10% reduction

(1) Determine difference in results (Source - Distilled); nearest 0.01%.

(2) Determine difference in results (Source - Distilled); nearest 0.1 minute.

(3) Determine the percent reduction in compressive strength as equal to (100.0 ×{(Source - Distilled)/Distilled}); nearest 0.1%.

SECTION 815
Structural Metals and Metal Castings

815.1 Structural Steel

1 Ensure the provision and use of structural carbon steel in accordance with ASTM A 709, grade 36 [ASTM A 709M, grade 250].

2 Ensure the provision and use of high-strength, low-alloy structural steel in accordance with ASTM A 709, grade 50, or 50W [ASTM A 709M, grade 345, or 345W].

3 Ensure the provision and use of high-performance steel in accordance with ASTM A 709, grade HPS70W [ASTM A 709M, grade HPS485W].

4 On main girders for highway bridges, ensure the provision and use of structural steel for W-shape rolled beams, webs and tension flanges of welded-plate girders, and splice plates in accordance with the impact test requirements of ASTM A 709 [ASTM A 709M], table S1.2 for zone 2. The department defines tension flanges as the bottom flanges of simple-span girders and all flanges of continuous-span girders.

815.2 High-Strength Bolts and Fasteners

815.2.1 Bolts, Nuts, and Washers

1 Ensure the provision and use of high-strength bolts, nuts, and washers as follows:

1. **Bolts.** In accordance with ASTM A 325 [ASTM A 325M], except with a maximum Rockwell C hardness of 33.

   For unpainted ASTM A 709 grade 50W or HPS70W [ASTM A 709M, grade 345W or HPS485W] steel, use only type 3 bolts.

   Mark bolts “A 325” and with a symbol identifying the manufacturer; for type 3 bolts, underline the mark as follows: “A 325.” Type 1 bolts may be marked with three radial lines spaced at 120 degree intervals. Mark metric bolts as described in ASTM A 325M.

2. **Nuts.** In accordance with ASTM A 563 [ASTM A 563M] and the following:

   2.1. Lubricate galvanized nuts with clean lubricant, dry to the touch, and dyed to contrast with the galvanizing color.

   2.2. Classed and finished in accordance with Table 815.2.1-1, Nut Class and Finish Requirements.

Table 815.2.1-1
Nut Class and Finish Requirements

Bolt Type and Finish	Class
Type 1 plain, uncoated	A 563 C, Plain [Class 8S]
Type 1 galvanized	A 563 DH, Galv. [Class 10S]
Type 3 plain, weathering	A 563 C3 [Class 8S3]

   2.3. Mark nuts with the class shown above and a symbol identifying the manufacturer.

3. **Washers.** Except load-indicating washers, in accordance with ASTM F 436 [ASTM F 436M], and marked with symbols identifying the manufacturer. Mark type 3 weathering-grade washers with a "3."

4. **Load-Indicating Washers.** Type 325, in accordance with ASTM F 959 [ASTM F 959M], and marked with a symbol identifying the type and manufacturer, lot number, or private label distribution, as appropriate. Use galvanized washers for galvanized bolts. Use epoxy-coated washers for type 3 bolts.

5. **Twist-Off Bolts.** With domed heads and the entire assembly, including bolt, nut, and washer, in accordance with ASTM F 1852. Use only type 3 assemblies for unpainted ASTM A 709, grade 50W or HPS70W [ASTM A 709M, grade 345W or HPS485W] structural steel. Provide nuts and washers for twist-off bolts from the same manufacturer as the bolts and lubricated in accordance with manufacturer's recommendations.

6. **Lock-Pin and Collar Fasteners.** May be substituted for high-strength bolts if they meet the material, manufacturing, and chemical-composition requirements of ASTM A 325 [ASTM A 325M], the mechanical property requirements of the same specification in full-size tests and have a body diameter and bearing area under the head not less than those provided by the bolt of the same nominal dimensions. They may differ in other dimensions.

   Ensure that each fastener provides a solid-shank body of sufficient diameter to provide tensile and shear strengths equaling or exceeding that of equivalent ASTM A 325 [ASTM A 325M] bolts. Use lock pins with a cold-forged, round head on one end, an annular breakneck groove and annular pull grooves on the other end, and a shank length suitable for the material thickness being fastened

   Provide each fastener with a steel locking collar of proper size for the shank diameter used that when cold-swayed into the locking grooves, forms a head for the grooved end of the fastener after the pull section has been removed. Provide a flanged-type collar, with a tab to retain the collar on the pin during installation, that is a standard product of an established lock-pin-and-collar-fastener manufacturer; mark fasteners with the grade designation and a symbol identifying the manufacturer.

7. **Dimensions.** Bolts and nuts in accordance with ANSI B18.2.3.7M and B18.2.4.6M and Table 815.2.1-2, Bolt And Nut Dimensions.

Table 815.2.1-2
Bolt and Nut Dimensions

Heavy Hexagon Structural Bolts in [mm]				Nut Dimensions, Heavy Hexagon Nuts in [mm]	
Bolt Size D	Width Across Flats F	Height H	Thread Length T	Width Across Flats W	Height H
⅝ [16]	1 1/16 [27]	25/64 [10]	1¼ [31]	1 1/16 [27]	39/64 [17]
¾ [19]	1¼ [34]	15/32 [12]	1⅜ [36]	1¼ [34]	47/64 [20]
⅞ [22]	1 7/16 [36]	35/64 [14]	1½ [38]	1 7/16 [36]	55/64 [23]
1 [25]	1⅝ [41]	39/64 [15]	1⅝ [41]	1⅝ [41]	63/64 [24]
1⅛ [28]	1 13/16 [46]	11/16 [17]	1¾ [44]	1 13/16 [46]	1 7/64 [27]
1¼ [31]	2 [50]	25/32 [19]	2 [49]	2 [50]	1 7/32 [30]

2 Provide hardened circular washers in accordance with ASTM F 436 [ASTM F 436M] and Table 815.2.1-3, Hardened Circular Washer Dimensions.

Table 815.2.1-3
Hardened Circular Washer Dimensions

Circular Washers in [mm]				
Bolt Size D	Maximum Outside Diameter	Minimum Diameter of Hole	Thickness	
			Minimum	Maximum
⅝ [16]	1 5/12 [34]	21/32 [18]	0.122 [3]	0.177 [5]
¾ [19]	1 15/32 [42]	13/14 [22]	0.122 [3]	0.177 [5]
⅞ [22]	1¾ [44]	15/16 [24]	0.132 [3]	0.177 [5]
1 [25]	2 [50]	1 1/16 [26]	0.136 [3]	0.177 [5]
1⅛ [28]	2¼ [56]	1¼ [30]	0.136 [3]	0.177 [5]
1¼ [31]	2½ [60]	1⅜ [33]	0.136 [3]	0.177 [5]

815.2.2 Testing

1. **Bolts.** Proof-load test bolts in accordance with ASTM F 606 [ASTM F 606M], method 1, at least as frequently as specified in ASTM A 325, 9.5.1 [ASTM A 325M, 10.2.4].

   The department requires wedge tests on full-size bolts in accordance with ASTM F 606 [ASTM F 606M], 3.5. Test after galvanizing, when applicable, and as frequently as specified in ASTM A 325, 9.5.1 [ASTM A 325M, 10.2.4].

   When providing galvanized bolts, determine the zinc-coating thickness by measurements taken on the wrench flats or on top of the bolt head.

2. **Nuts.** Proof-load test nuts in accordance with ASTM F 606 [ASTM F 606M], 4.2, at least as frequently as specified in ASTM A 563 [ASTM A 563M] 9.3. For galvanized nuts, test after galvanizing, overlapping, and lubricating.

   When providing galvanized nuts, determine the zinc-coating thickness by measurements taken on the wrench flats.

3. **Washers.** When providing and using galvanized washers, perform hardness testing after galvanizing and after the zinc coating has been removed. Measure the zinc-coating thickness.

4. **Assemblies.** Perform rotational-capacity tests on black or galvanized bolt, nut, and washer assemblies (after galvanizing, for galvanized assemblies) before shipping.

   Ensure that each production lot combination of bolts, nuts, and washers is tested as an assembly and that at least two assemblies are tested per rotational-capacity lot. Assign a rotational-capacity lot number to each combination of lots tested.

   Assemble the bolt, nut, and washer in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device. Ensure a minimum rotation from a snug-tight condition (10 percent of the required installation tension) in accordance with Table 815.2.2-1, Minimum Rotation From Snug Tight Condition.

Table 815.2.2-1
Minimum Rotation From Snug Tight Condition

Minimum Rotation	Bolt Length
240º	≤ 4 times the diameter of the bolt
360º	> 4 diameters up to ≤ 8 diameters of the bolt
480º	> 8 diameters of the bolt

Ensure that the tension reached at the above rotation is at least 1.15 times the required installation tension. Use an installation and turn-test tension in accordance with Table 815.2.2-2, Installation And Turn-Test Tension.

Table 815.2.2-2
Installation and Turn-Test Tension

Diameter in [mm]	Required Installation Tension kip [kN]	Turn-Test Tension kip [kN]
⅝ [16]	19 [94.2]	22 [108]
¾ [19]	28 [147]	32 [169]
⅞ [22]	39 [183]	45 [209]
1 [25]	51 [212]	59 [244]
1⅛ [28]	56 [274]	64 [315]
1¼ [31]	71 [337]	82 [388]

After exceeding the required installation tension above, take and record one reading of tension and torque. Ensure that the torque value does not exceed the following:

$Torque_{max}$ = 0.25 PD, where:

$Torque_{max}$ = measured torque in foot-pounds [newton•meters]

P = measured bolt tension in pounds [kilonewtons]

D = bolt diameter in feet [millimeters]

Bolts too short to assemble in a Skidmore-Wilhelm Calibrator may be tested in a steel joint; compute the maximum torque requirement using a value of P equal to the turn-test tension shown in the table above.

Examine bolts and nuts for stripping or failure; ensure that the nut finger-turns on and off the thread being tested. Assemblies with evidence of stripping fail the test.

815.2.3 Reporting

1 Ensure that required test results, as well as the location and date of testing, are recorded on the appropriate document.

815.2.4 Witnessing

1 Tests need not be witnessed by an inspection agency; ensure that the manufacturer or distributor performing the tests certifies the accuracy of results recorded.

815.2.5 Additional Bolts for Testing

1 Provide additional bolts for testing by the Materials Program in accordance with Table 815.2.5-1, Required Test Bolts.

Table 815.2.5-1
Required Test Bolts

Number of Bolts of Each Length Required for Project	Number of Additional Test Bolts Required
0 to 150	1
151 to 280	2
281 to 500	3
501 to 1200	5
1201 to 3200	8
3201 to 10,000	13
over 10,000	20

815.2.6 Documentation

1 Provide mill test reports (MTR), showing where the material was melted and manufactured for mild steel used in manufacturing bolts, nuts, and washers.

2 For all bolts, nuts, and washers supplied, provide a manufacturer-certified test report (MCTR), showing results for required tests.

3 Ensure that the MCTR provided by the manufacturer performing rotational-capacity tests includes the following:

1. Lot number of each item tested;
2. The rotational-capacity lot number assigned to each combination of lots tested;
3. The results of required rotational-capacity tests;
4. The location and date of testing;
5. The manufacturing location of bolt assembly components; and
6. A statement that the test results on the MCTR meet the requirements.

4 For bolt assembly components, ensure that the distributor-certified test report (DCTR) includes the MCTR; the rotational-capacity test may be performed by a distributor instead of a manufacturer, with results reported on the DCTR.

815.2.7 Shipping

1 Ensure that bolts, nuts, and washers from each rotational-capacity lot are shipped in the same container. If there is only one production-lot number for each size of nuts and washers, they may be shipped in separate containers. Permanently mark each container with the rotational-capacity lot number to allow identification at any stage before installation. Ensure the provision and receipt of two signed copies of the appropriate MTR, MCTR, or DCTR with each shipment.

815.3 Sheet Metal

1 Ensure the provision and use of sheet metal in accordance with ASTM A 924 [ASTM A 924M] and ASTM A 653 [ASTM A 653M], coating designation G90 [Z275].

815.4 Automatically-End-Welded Studs

1 Ensure the provision and use of automatically-end-welded studs in accordance with AASHTO/AWS D1.5 Bridge Welding Code, section 7, and with mechanical properties in accordance with the requirements for type B studs.

815.5 Steel Pipe

1 Ensure the provision and use of steel pipe in accordance with ASTM A 53. Provide grade B for pipe with a nominal diameter greater than 2 in [50 mm]; for smaller diameters, provide type F.

815.6 Bolts and Fasteners

1 Other than high-strength bolts, ensure the provision and use of bolts and fasteners in accordance with ASTM A 307, grade A [ASTM F 568, class 4.6], or SAE, grade 2, with coarse threads.

815.7 Steel Piles

1 For steel piles, provide rolled steel sections made from structural steel in accordance with ASTM A 709 grade 36, 50, or 50W [ASTM A 709M, grade 250, 345, 345W]. Ensure camber and sweep within the allowed mill tolerance.

2 If used, ensure that splicer sections are made of steel meeting the same requirements as the corresponding piles. When specified, provide pile points made of cast steel in accordance with ASTM A 27, grade 65-35 [ASTM A 27M, grade 450-240], or ASTM A 148, grade 90-60 [ASTM A 148M, grade 620-415]; the State Bridge Engineer may approve alternative materials.

815.8 Sheet Piling

1 Provide and use sheet piling made from structural carbon steel in accordance with ASTM A 328 [ASTM A 328M].

815.9 Bridge Railing

1 Ensure the provision and use of structural-tube railing made from structural tubing in accordance with ASTM A 501 or ASTM A 500, grade A or B.

2 If ASTM A 500 structural-tube is used, ensure railing is tested in accordance with ASTM E 436, after galvanizing; ensure a testing temperature of 0 ºF [-18 ºC]. Ensure six specimens from the longest side of the tube are used to determine the percentage shear area; do not use specimens containing a weld. The department will not accept material in which the average percent shear area is less than 50.

3 Provide standard and expansion sleeves made from structural steel in accordance with ASTM A 709, grade 36 [ASTM A 709M, grade 250], and galvanized in accordance with Subsection 501.4.1.25, Galvanizing, and Subsection 815.14, Galvanized Coating.

4 Provide posts made from structural steel in accordance with ASTM A 709 grade 36 [ASTM A 709M, grade 250].

5 For bridge railing, provide anchor bolts in accordance with Subsection 815.18, High-Strength Anchor Bolts.

6 Provide anchor bolts, posts, and railing galvanized or cadmium-coated in accordance with Subsection 501.4.1.25, Galvanizing, and Subsection 815.14, Galvanized Coating.

7 For concrete anchorage, provide and use unpainted, nongalvanized hardware consisting of steel bars in accordance with ASTM A 709, grade 36 [ASTM A 709M, grade 250].

815.10 Bronze Bearing Plates

1 When specified, provide self-lubricating bronze bearing plates made of cast bronze alloy in accordance with AASHTO M 107 (ASTM B 22), Copper Alloy, UNS No. C91100, with contact surfaces finished in the direction of movement to a maximum roughness of No. 125 [3 µm] in accordance with ANSI B 46.1. Ensure that the lubricated surface has trepanned recesses and that hydraulic pressure has been use to press a lubricating compound made of graphite, metallic substance, and binder into the recesses to form dense, nonplastic, lubricating inserts comprising at least 25 percent of the plate's total area. Ensure that steel surfaces in contact with bronze plates are coated during assembly with an approved lubricant. Ensure that the coefficient of friction between contact surfaces does not exceed 0.1.

815.11 Steel Pins and Rollers

1 For pins and rollers with diameters equal to or less than 9 in [230 mm], provide and use in accordance with AASHTO M 169, grades 1016 to 1030, inclusive. Ensure a minimum Rockwell Scale B hardness of 85, or the development of a minimum tensile strength of 72,000 psi [500 MPa] with a minimum yield strength of 36,000 psi [250 MPa].

815.12 Steel Castings

1 For highway-bridge components, provide and use steel castings, of the class specified, in accordance with ASTM A 148 [ASTM A 148M].

815.13 Gray Iron Castings

1 Provide gray iron castings in accordance with ASTM A 48, class No. 35B, true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes and other defects affecting their intended use. Ensure that castings are boldly-filleted at angles, with sharp and perfect arises, and with clean, smooth, uniform surfaces.

815.14 Galvanized Coating

1 As specified, ensure that products made from rolled, pressed, and forged steel shapes, plates, bars, and ⅛ in [3 mm] and thicker strip are zinc (hot-dipped galvanized) coated in accordance with AASHTO M 111.

2 As specified, provide and use iron and steel hardware galvanized in accordance with ASTM A 153 [ASTM A 153M] or ASTM B 633, or cadmium-coated in accordance with ASTM B 766, class 8, type II or III; ensure that type II cadmium coating is bronze or brown.

815.15 Preformed Fabric Pads

1 Provide and use preformed fabric pads made of multiple layers of cotton duck, impregnated and bound with rubber, compressed to uniform thickness, and in accordance with Military Specification MIL-C-882. Ensure the use of enough plies to achieve the specified thickness after compression and vulcanizing and that finished pads withstand compression loads perpendicular to the plane of laminations of at least 10,000 psi [70 MPa] without detrimental extrusion or reduction in thickness.

815.16 Elastomeric Bearing Pads

1 Ensure laminated elastomeric bearings conform with AASHTO M 251, Appendix X1. Ensure the use of grade-4, 50-durometer hardness elastomer.

815.17 Welding Materials

815.17.1 General

1 For manual shielded-metal arc welding, provide and use electrodes in accordance with AASHTO/AWS A5.1 for E 7016, E7018, or E7028 electrodes.

2 For submerged arc welding, provide and use electrodes and fluxes in accordance with AASHTO/AWS A5.17 for flux classifications F7X2-EXXX, F7X4-EXXX, F7X5-EXXX, F7X6-EXXX, or F7X8-EXXX.

3 For flux-cored arc welding, provide and use electrodes in accordance with AWS A5.20 for E7XT-1, E7XT-5, E7XT-6, or E7XT-8 electrodes.

4 The engineer will approve alternative electrodes if the MCTR shows that their mechanical properties, tensile strength, yield strength, elongation, and impact properties in accordance with one of the above-listed classifications.

5 For welding bare, unpainted steel in accordance with ASTM A 709, grade 50W or HPS70W [ASTM A 709M, grade 345W or HPS485W], provide and use electrodes in accordance with Section 4 of AASHTO/AWS D1.5.

6 Provide a classification of electrodes and electrode-flux combinations that produces weld metal with a minimum-impact strength of 20 J, Charpy V-notch, at a temperature of 0 ºF [-18 ºC] or less.

7 Provide certified copies of test reports for all tests specified in AASHTO/AWS A5.1, A5.17, A5.18, or A5.20, whichever is applicable, made on the electrodes or flux-electrode combinations of the same class, size, and brand, manufactured using the same process and materials as those provided. If the electrodes used are of a size for which tests are not required by applicable specifications, provide test reports for electrodes of the size nearest and of the same classification and brand. The tests may be for process qualification or quality control. Ensure that the tests were done less than one year before the manufacture of the electrodes and fluxes provided and that the report includes all pertinent information concerning the required tests.

8 Provide certification that the gas or gas mixture used for flux-cored arc welding is suitable for the intended application and meets the dew point requirement.

9 When galvanizing weldments after welding, provide and use a type or brand of filler metal that will deposit weld metal with a maximum silicon content of 0.4 percent to avoid possible weld disintegration during galvanizing.

10 For submerged-arc welding, provide and use a flux that is nonhygroscopic, dry, and free of foreign contamination.

815.17.2 High Performance Steel

1 For welding steel in accordance with ASTM A 709, grade HPS70W [ASTM A 709M, grade HPS485W], the following apply:

1. Use only submerged-arc and shielded-metal arc processes.
2. Use consumables satisfactory for the lower-strength steel listed in table 4.1 of AASHTO/AWS D1.5 when welding to ASTM A 709, grade 50 or 50W [ASTM A 709M, grade 345 or 345W] steel. Ensure that consumables are in accordance with diffusible hydrogen requirements of the AASHTO/AWS filler-metal specifications optional supplemental moisture-resistance designator, H4 or H8.

3. For fillet and full-penetration welds joining pieces of like-strength steels, provide and use consumables in accordance with the *AASHTO Guide Specifications for Highway Bridge Fabrication* with HPS70W Steel for matching strength welds. To use alternate consumables, submit a request for approval including documentation of successful welding in accordance with AASHTO/AWS D1.5 and diffusible hydrogen tests as described in Article 12.6.2 of AASHTO/AWS D1.5 that conclude the deposited weld metal, under proposed fabrication shop conditions, has a diffusible hydrogen level of H4 or less.

4. Use welding procedures qualified in accordance with Article 5.19 of AASHTO/AWS D1.5. Perform qualification tests for strength, toughness, and ductility, and evaluate results in accordance with Article 5.19 of AASHTO/AWS D1.5. Include ultrasonic testing in accordance with AASHTO/AWS Section 6, Part C and evaluate in accordance with table 9.1 of AASHTO/AWS D1.5. Disregard indications found at the interface of the backing bar.

815.18 High-Strength Anchor Bolts

1 As specified, provide and use cast-in high-strength anchor bolts or threaded anchor rods in accordance with ASTM A 449; supply ASTM A 563 nuts of appropriate grade and finish to match the anchor bolts [AASHTO M 164M or ASTM F 568, class 8.8 , with ASTM A 563M, class 12 nuts].

2 For grouted-in high-strength anchor bolts, provide and use swedge bolts or threaded rod in accordance with ASTM A 193, grade B7; supply nuts in accordance with ASTM A 194 [ASTM A 194M].

3 Ensure that galvanized bolts have an ultimate tensile strength no greater than 150,000 psi [1 034 214 kPa].

815.19 Anchor Bolts Other Than High-Strength

1 Provide and use anchor bolts in accordance with ASTM A 307 [ASTM F 568]; supply nuts in accordance with ASTM A 563 and of a matching grade and finish. Ensure that galvanized bolts are hot-dipped.

815.20 Frames, Grates, and Covers

1 Use cast or fabricated structural designed for an AASHTO HS20 loading.

2 For fabricated grates, use structural steel in accordance with Subsection 815.1, Structural Steel. The department will allow the ⅝-inch [16 mm] diameter cross bars to be fillet welded, resistence welded, or electroforged to the bearing bars.

SECTION 816
Signs and Traffic Devices

816.1 Sheet Aluminum for Sign Panels

1 For sign panels, ensure the provision of sheet aluminum made as follows:

1. Using 5052-H38 or 6061-T6 alloy in accordance with ASTM B 209 [ASTM B 209M];
2. Kept uncontaminated after cleaning and etching and before the application of retroreflective sheeting;
3. Surface-treated with a chemical conversion method;
4. Anodized or chemically-treated by an approved process; and
5. Using chemical immersion baths of adequate capacity for total immersion, maintained within limits of operating-solution strength by reliable control methods.

816.2 Aluminum Alloy Channels and Tubing

1 Ensure the provision and use of aluminum alloy channels and tubing in accordance with ASTM B 221 [ASTM B 221M] for alloy 6061-T6.

816.3 Retroreflectors

1 Ensure the provision and use of a methacrylate lens in accordance with ASTM D 788, grade 8.

2 For delineators or markers, provide retroreflectors consisting of a round, retroreflective unit housed in an embossed frame with a single, grommeted mounting hole. Provide lenses that are:

1. Colorless or of the color specified, with approximately 7 in² [4500 mm²] of retroreflective surface and
2. Fused under heat and pressure around the entire perimeter and the center mounting hole to an opaque back to form a unit permanently sealed against dust, water, and water vapor.

3 Ensure the provision and use of a retroreflector housing made:

1. Of 5052-O aluminum 0.020 in [500 µm] thick;
2. With embossed reinforcement ribs;
3. In diameter, approximately 3¼ in [85 mm]; in depth 0.235 in [6 mm]; and
4. With a $^{3}/_{16}$-inch [5 mm] inside diameter aluminum grommet expanded in the retroreflector mounting hole.

816.3.1 Definitions

1 The department will use the following definitions in reference to retroreflectors:

1. **Entrance Angle.** The angle at the retroreflector face between a line perpendicular to the face and the direction of light incident on the reflector.
2. **Observation Angle.** The angle at the retroreflector face between an observer's line of sight and the direction of light incident on the retroreflector.
3. **Specific Luminance.** The candelas returned at the chosen observation angle by a retroreflector with 1 in² [625 mm²] of retroreflecting surface for each lux of illuminance at the retroreflector; this term will be used in reference to optical testing of retroreflectors for letters, symbols, and accessories.
4. **Specific Intensity.** The candelas returned at the chosen observation angle by a center-mount, 3¼-inch [85 mm] diameter retroreflector for each lux of illuminance at the retroreflector.

816.3.2 Optical Testing

1 Optically test retroreflectors using procedures performed as follows:

1. Position the retroreflector 100 ft [30 m] from a single, uniformly bright light source with an effective diameter of 2 in [50 mm], operated at normal efficiency.

2. Measure the return light using a photoelectric photometer with a minimum sensitivity of 1×10^7 foot-candle [1 µlx/mm] of scale division, with a receiver aperture diameter of ½ in [12 mm], and shielded to eliminate stray light.

3. Maintain a distance, measured between the centers of the return light source and the aperture, of 2.1 in [55 mm] for an observation angle of 0.1 degree; of 3½ in [90 mm] for an observation angle of 0.17 degrees; and of 6.9 in [175 mm] for an observation angle of 0.33 degrees.

4. Spin the retroreflector to average the orientation effect.

2 If using a test distance other than 100 ft [30 m], modify the source and aperture dimensions and the distance between return light source and aperture in the same proportion as the test distance.

3 Ensure that the specific luminance of crystal retroreflectors for cutout letters, symbols, and accessories is in accordance with or exceeds Table 816.3.2-1, Specific Luminance Requirements: Crystal, measured while retroreflectors are spinning.

Table 816.3.2-1
Specific Luminance Requirements: Crystal

Observation Angle (degrees)	Entrance Angle (degrees)	Specific Luminance fc/in² [cd/m²/lx]
0.1	0	14 [2020]
0.1	20	5.6 [810]

4 For yellow reflectors, ensure a minimum specific luminance equal to 60 percent of the value for crystal.

5 Ensure that the specific intensity of retroreflectors for delineators or markers is in accordance with or exceeds Table 816.3.2-2, Specific Intensity Requirements, measured while the retroreflectors are spinning:

Table 816.3.2-2
Specific Intensity Requirements

Observation Angle (degrees)	Entrance Angle (degrees)	Specific Intensity (fc [cd/lx])	
		Crystal	Yellow
0.1	0	119 [11.1]	71 [6.6]
0.1	20	47 [4.4]	28 [2.6]

6 If more than 4 percent of the samples tested fail to reach the above values, test a resample; the engineer will reject the lot if more than 4 percent of the resample fails.

7 Ensure the provision and use of retroflectors that have been tested for adequate sealing against dust and water using procedures performed as follows:

1. Submerge samples in room temperature water and subject to a vacuum of 5 in of mercury [17 kPa] for five minutes.
2. Restore atmospheric pressure, and leave samples submerged for water intake.
3. Examine for the presence of liquid water or fogging inside the reflector.
4. If more than 4 percent of the samples tested fail (exhibit the presence of moisture inside the reflector), test a resample; the engineer will reject the lot if more than 4 percent of the resample fails.

8 Give the engineer three copies of the manufacturer's certification that the retroreflectors provided meet these requirements. When asked, provide at least five samples randomly selected by the engineer from each shipment of each type of retroreflector, at no additional cost to the department.

9 The engineer will approve retroreflectors based on the manufacturer's certification or tests performed on samples as provided in previous paragraphs.

816.4 Retroreflective Sheeting

1 For the type specified, provide and use an encapsulated glass bead, encapsulated prismatic, or nonmetallic, microprismatic reflective material precoated with adhesive backing protected by a treated plastic liner and in accordance with AASHTO M 268 (ASTM D 4956).

816.4.1 Temporary Traffic Control Devices

1 For temporary traffic control, ensure the provision and use of category I and III devices made with type III retroreflective sheeting; ensure that category II reboundable devices are made with reboundable type III retroreflective sheeting.

816.5 Metal Delineator Posts

1 Ensure the provision and use of metal delineator posts of the shape specified, rolled from structural steel, rerolled rail steel, or new billet steel with a minimum yield strength of 30,000 psi [210 MPa], minimum ultimate tensile strength of 50,000 psi [340 MPa], and a weight [mass] of at least 1 lb/ft [1.5 kg/m]. Ensure that posts have been cleaned and painted with two coats of baked, black enamel.

2 To attach retroreflectors to posts, provide an open-end blind rivet. For rivet expansion, provide a cadmium-plated steel, break-stem-type mandrel that leaves the mandrel head in the rivet body.

3 When specified, paint the top 6 in [150 mm] of posts with a white or silver retroreflective liquid coating consisting of crystal retroreflective elements suspended in a solvent-dispersed vehicle and with a specific intensity in accordance with Table 816.5-1, Specific Intensity Requirements.

Table 816.5-1
Specific Intensity Requirements

Observation Angle (degrees)	Entrance Angle (degrees)	Specific Intensity (fc/ft² [cd/lx])
0.2	0	0.85 [9.1]
0.2	15	0.85 [9.1]

816.6 Roadway Sign Supports

1 For roadway signs, ensure the provision and use of steel parts, including posts, galvanized in accordance with Subsection 815.14, Galvanized Coating, and Subsection 501.4.1.25, Galvanizing. Ensure the provision of steel pipe in accordance with ASTM A 53 [ASTM A 53M], schedule 40, grade B, and of steel plates and shapes in accordance with ASTM A 36 [ASTM A 36M].

2 For sign posts made of tubular-steel, ensure the use of cold-rolled sheet steel of the gauge specified and in accordance with ASTM A 653 [ASTM A 653M] and ASTM A 924 [ASTM A 924M], grade A, or of hot-rolled carbon sheet steel of the gage specified and in accordance with ASTM A 570 [ASTM A 570M] and with a minimum yield of 60,000 psi [414 MPa]. Ensure that all cold-rolled sheet steel, including connecting hardware, is hot-dipped galvanized in accordance with ASTM A 653 [ASTM A 653M] and ASTM A 924 [ASTM A 924M], coating designation G-90 [Z275]; if welding after galvanization, zinc-coat corner welds after scarfing.

3 Ensure that post tubing made of hot-rolled carbon sheet-steel is triple-coated with an in-line application of hot-dipped zinc (galvanization). Ensure that the inside surface receives a double in-line application of a full, zinc-based organic coating. If welding occurs after galvanization, zinc-coat corner welds after scarfing.

816.7 Overhead Sign Supports

1 For overhead signs, ensure the provision and use of structural steel shapes and plates in accordance with ASTM A 36 [ASTM A 36M]. Use steel pipe in accordance with ASTM A 53 [ASTM A 53M]—grade B for pipe with a nominal diameter greater than 2 in [50 mm] and type F for smaller diameters. The department will allow the use of pipe with the chemical and mechanical properties of ASTM A 36 [ASTM A 36M] and the dimensional tolerances of ASTM A 53 [ASTM A 53M].

816.8 Bolts and Fasteners

1 For use with traffic signs and devices, ensure the provision of:

1. Bolts and fasteners in accordance with ASTM A 307 or SAE grade 2;
2. High-strength bolts, nuts, and washers in accordance with Subsection 815.2, High Strength Bolts and Fasteners;

3. Counter-sunk, flat-head elevator bolts for plywood sign panels;

4. Coverings over bolt heads on signs of the same material and color as the sign; and

5. Sign bolts galvanized or plated in accordance with Subsection 815.14, Galvanized Coating.

816.9 Plywood Sign Panels and Barricades

1 For sign and barricade panels, ensure the provision and use of high-density, exterior-grade, A-A, 60-60, overlaid fir plywood, of the thickness specified, and in accordance with US Department of Commerce product standard PSI74.

816.10 Treated-Timber Sign Posts

816.10.1 General

1 Ensure that timber posts for signs are treated, and certificates and reports thereof (including boring reports) submitted, in accordance with Section 817, Structural Timber and Lumber.

816.10.2 Dimensional Timber Posts

1 Ensure the provision and use of rough-sawn wood cut from live, growing trees of Lodgepole Pine, Ponderosa Pine, Douglas Fir, or Southern Yellow Pine, graded in accordance with Subsection 817.1, Structural Timber and Lumber, and supplied in accordance with Table 816.10.2-1, Dimensional Timber Post Grades.

Table 816.10.2-1
Dimensional Timber Post Grades

Post Size	Grade
4 in × 4 in [100 mm × 100 mm]	No. 1 Structural Light Framing
4 in × 6 in [100 mm × 150 mm]	No. 1 Structural Joists and Planks
6 in × 6 in [150 mm × 150 mm] and larger	Select Structural Posts and Timbers

816.10.3 Round Timber Posts

1 Ensure the provision and use of posts cut from sound, seasoned Lodgepole Pine, Ponderosa Pine, Douglas Fir, or Southern Yellow Pine then air-dried or artificially seasoned, with no reverse crooks, and sufficiently straight that a line drawn between the geometric centers of the top and bottom does not fall outside the body of the post. Provide machine-peeled posts, with no outer bark and no remaining strip of inner bark wider than 2 in [50 mm] or longer than 3 in [75 mm].

2 Ensure that the sum of the diameter of all knots larger than ½ in [12 mm] in any 12-inch [300 mm] section of post does not exceed 8 in [200 mm]. Ensure that posts are free of rot, insect-damaged holes larger than ⅛ in [3 mm], and checks wider than ½ in [12 mm]. Ensure posts are tapered so that no difference in diameters exceeds 1¼ in [30 mm] over a length of 10 ft [3 m].

3 Ensure that shakes measure no more than one-half the post diameter, that shakes on the butt surface are not within 2 in [50 mm] of the side surface, and there is no more than a one-half twist in the grain in any 20-foot [6 m] length of post.

4 Ensure that top and butt surfaces of posts are square. Ensure that 3-inch [75 mm] posts have a gain, measured from the top of the post, not exceeding ¼ in [6 mm] per 3 ft [1 m] of length; ensure that larger posts have a continuous gain, for the entire post length, not exceeding ¾ in [19 mm]. Ensure that post sizing is in accordance with Section 817, Structural Timber and Lumber.

SECTION 817
Structural Timber and Lumber

817.1 Structural Timber and Lumber

1 Ensure the provision and use of structural timber and lumber as specified, including species and grade. When specifying surfaced lumber, the department uses nominal sizes in accordance with American Lumber Standards.

2 Ensure the provision and use of timber and lumber that has been graded before shipment and in accordance with the current standard grading and dressing rules of the West Coast Lumber Inspection Bureau (WCLIB), WWPA, or other agencies approved by the Board of Review of the American Lumber Standards Committee in accordance with US Department of Commerce product standard PS-20. Provide redwood in accordance with grading requirements of the California Redwood Association for "Construction Heart."

3 For treating timber and lumber, ensure the use of a facility and method that has been approved by the department, unless assay reports for each charge of material are supplied in addition to certifications, treating reports, and boring reports. The department does not require treatment of redwood.

4 Ensure that:

1. Treatment is performed in accordance with American Wood-Preservers' Association (AWPA) standards C1 and C14; apply standard C14 for the retention rate;
2. Products not listed in C14 are treated in accordance with applicable standards;
3. The preservative is approved by the AWPA for ground contact;
4. Handling and care are in accordance with AWPA Standard M4; and
5. Only one kind of preservative is used for any particular item on a project (e.g., wood guardrail posts, wood fence posts, wood sign posts, etc.).

5 Ensure that millwork, adzing, framing, cutting, and boring has been completed before pressure treatment. If field cutting and boring is allowed and performed after treatment, ensure that resulting cuts and holes are thoroughly swabbed, sprayed, or brushed with two coats of a preservative approved by the AWPA for field use or repair; treat damaged surface areas the same way. Ensure that treatment reports, boring reports, and assay reports submitted to the department are representative of each shipment.

6 Ensure the provision and use of timber and lumber that has been inspected before shipment, that a certificate of inspection is given to the engineer, and that each piece inspected and certified is marked accordingly; wood to be treated may be unmarked. Ensure that untreated lumber has been seasoned to a moisture content of 20 percent or less before shipment.

7 Certification or grade marking does not constitute acceptance; the engineer will reject material not meeting specifications upon delivery.

8 Stack wood stored at the job site to ensure proper ventilation and elevated off the ground; the engineer may reject wood damaged because of improper storage.

9 Provide rough-sawn timber or lumber in accordance with Table 817.1-1, Dimensional Requirements: Rough-Sawn Timber or Lumber.

10 Provide posts in accordance with Subsection 816.10, Treated-Timber Sign Posts.

Table 817.1-1
Dimensional Requirements: Rough-Sawn Timber or Lumber

Nominal Thickness/Width in [mm]	Allowable Thickness/Width	
	Minimum(1) in [mm]	Maximum in [mm]
1 [25]	⅞ [22]	1⅛ [29]
2 [50]	1⅝ [41]	2¼ [57]
3 [75]	2⅝ [68]	3⅜ [86]
4 [100]	3⅝ [92]	4⅜ [111]
5 [125]	4⅝ [117]	5⅜ [137]
6 [150]	5⅝ [143]	6⅜ [162]
7 [175]	6⅝ [168]	7⅜ [187]
8 [200]	7⅜ [187]	8½ [216]

(1) If the dimension is thickness, 20 percent of the length of the item may have a thickness $^{1}/_{32}$ in [0.8 mm] smaller than the indicated minimum tolerance for rough-sawn lumber; ensure that the remaining 80 percent of the item length meets specified minimum thickness.

SECTION 818
Mailbox Posts and Mounting Hardware

818.1 Mailbox Post and Mounting Hardware

1 Ensure the provision and use of mailbox posts and mounting hardware in accordance with Table 818.1-1, Mailbox Post and Hardware Mounting Requirements.

Table 818.1-1
Mailbox Post and Hardware Mounting Requirements

Item	Size	Material Type	Surface Finish
U-Bolt Clamps		Commercial	
Hardware		Commercial	ASTM A 153 [ASTM A 153M], ASTM A 275 [ASTM A 275M]
Single, double, multiple supports	2 in [50 mm] OD 14 gage	ASTM A 513	ASTM A 275 [ASTM A 275M], ASTM A 653 [ASTM A 653M], ASTM A 924 [ASTM A 924M]
Socket	12 gage	ASTM A 569 M	Dip-coated with rust-inhibiting primer; Fed Spec TT-P-636
Wedge	12 gage	ASTM A 569 M	ASTM A 275 [ASTM A 275M], ASTM A 653 [ASTM A 653M], ASTM A 924 [ASTM A 924M]
Mounting bracket and angle	14 gage	ASTM A 366 M	ASTM A 275 [ASTM A 275M], ASTM A 653 [ASTM A 653M], ASTM A 924 [ASTM A 924M]
Adapter plate	12 gage	ASTM A 366 M	ASTM A 275 [ASTM A 275M], ASTM A 653 [ASTM A 653M], ASTM A 924 [ASTM A 924M]
Anti-twist plate	16 gage	ASTM A 366 M	
Cantilever pipe, galvanized. Pressure testing not required		ASTM A 53 type F, Schedule 40	ASTM A 275 [ASTM A 275M], ASTM A 653 [ASTM A 653M], ASTM A 924 [ASTM A 924M]
Screw fittings may be steel or malleable iron. Pressure testing not required.		ASTM A 858M or ASTM A 47 [ASTM A 47M] grade 22010	ASTM A 153 [ASTM A 153M] class C or D

SECTION 819
Grout

819.1 Grout

819.1.1 Sand-Cement Grout

1 For sand-cement grout, provide and use grout composed of portland cement in accordance with Subsection 801.1, Portland Cement, sand in accordance with Subsection 803.3, Aggregate for Mortar, and only enough water to allow placing and packing; ensure a proportion of cement to sand, measured by volume, of 1:2. Mix approximately 45 minutes before use.

819.1.2 Nonshrink Grout

1 For nonshink grout, provide and use a product in accordance with ASTM C 1107. Do not add aluminum.

819.2 Epoxy Resin Grout

1 For epoxy resin grout, provide and use a product in accordance with AASHTO M 235, type IV, grade 2; use grade 3 for horizontal holes and vertical and overhead applications. Provide a class of grout suitable for the temperature of the concrete at the time of use. The engineer may approve the use of other polymer adhesives.

SECTION 820
Hydrated Lime

820.1 General

1 For hydrated lime, provide and use a product analyzed in accordance with ASTM C 25 and in accordance with Table 820.1-1, Chemical Composition for Hydrated Lime.

Table 820.1-1
Chemical Composition for Hydrated Lime

Component	Percent (Nonvolatile Basis)
Calcium Oxide (CaO)	7.0, max.
Active Lime Content, Calcium Hydroxide ($CaOH_2$) + Calcium Oxide (CaO)	90.0, min.
Carbon Dioxide (CO_2)	2.5, max.
Magnesium Oxide (MgO)	2.5, max.
Combined Iron and Aluminum Oxides (Fe_2O_3 and Al_2O_3)	1.5, max.
Silica (SiO_2) and Insoluble Matter	3.0, max.
Free Water Content	3.0, max.

820.2 Soil Stabilization

1 For use in soil stabilization, provide and use hydrated lime in accordance with AASHTO M 216 [AASHTO M 216M], except as noted in Subsection 820.1, General.

820.3 Anti-Stripping Additive for Plant Mix Pavement

1 As an anti-stripping additive to plant mix pavement, ensure the use of hydrated lime of which no less than 99 percent passes through a No. 30 [600 µm] sieve and 95 percent through a No. 200 [75 µm] sieve, when tested by wet sieving methods in accordance with ASTM C 110, section 4.

SECTION 821
Geocell

821.1 Geocell

1 Construct geocell of polyethylene or high density polyethylene having a depth of 4 in [100 mm], an expanded cell length of 8 in to 9 in [200 mm to 230 mm] and perforated sides. Ensure perforations that are in staggered, horizontal rows. Provide geocell meeting the requirements of Table 821.1-1, Geocell Properties.

Table 821.1-1
Geocell Properties

Property	Test Method	Value
Sheet Thickness	ASTM D 5199	50 mil [1.27 mm]
Density	ASTM D 1505	58.7 - 60.6 lb/ft^3 [0.94 - 0.97 g/cm^3]
Environmental Stress Crack Resistance (ESCR)	ASTM D 1693	2,000 hour min.
Carbon Black Content	ASTM D 1603	1.5 - 2.5%
Short Term Peel Strength	U.S. Army Corps of Engineers Technical Report, GL-86-19, Appendix A	225 lb [1000 N] min.

SECTION 822
Rockfall Mesh

822.1 Wire Mesh

1 Provide rockfall mesh that is hexagonal, non-raveling, woven, double-twist, hot-dipped, zinc-coated galvanized wire, with the size of the mesh opening being 3¼ in × 4½ in [83 mm × 114 mm], nominal. Match the color of the PVC sheath with the surrounding rock slope and as approved by the engineer. Selvedge or bind perimeter edges of wire mesh to prevent unraveling of the mesh. Use wire with a minimum strength at least equal to the mesh for the selvedge and with a diameter greater than that of the mesh wire and as recommended by the manufacturer.

2 Ensure rockfall mesh meets the requirements listed in Table 822.1-1, Rockfall Mesh Properties.

Table 822.1-1
Rockfall Mesh Properties

Property	Test Method	Nominal Value
Tensile Strength	ASTM A 975	60,000 psi [414 MPa]
Galvanized Wire Diameter	ASTM A 975	0.120 in [3.05 mm]
Zinc Coating	ASTM A 975	0.85 oz/ft^2 [260 g/m^2], min.
Galvanized Wire Diameter (For PVC Coated Wire)	ASTM A 975	0.106 in [2.7 mm]
Zinc Coating (For PVC Coated Wire)	ASTM A 975	0.80 oz/ft^2 [243 g/m^2], min.
PVC Coating Thickness	ASTM A 975	0.02 in [0.56 mm]

822.2 Lacing and Fasteners

1 Provide and use fasteners for connecting edges and ends of mesh rolls at overlaps in accordance with the requirements of ASTM A 975.

2 Ensure lacing and fasteners meet the requirements listed in Table 822.2-1, Lacing Wire and Fasteners.

Table 822.2-1
Lacing Wire and Fasteners

Property	Test Method	Nominal Value
Galvanized Wire Diameter (for Lacing Wire)	ASTM A 975	0.087 in [2.2 mm]
Galvanized Wire Diameter (for Fasteners)	ASTM A 975	0.118 in [3.0 mm]
PVC Coating Thickness	ASTM A 975	0.02 in [0.56 mm]

822.3 Anchors

1 For driven and grouted anchors, provide 1 in [25 mm] diameter × 6 ft [1.8 m] long, grade 60 [400] threaded bars in accordance with ASTM A 615 [ASTM A 615M]; epoxy coat, under shop conditions, in accordance with AASHTO M 284 (ASTM A 775)[AASHTO M 284M (ASTM A 775M)] for corrosion protection. Provide spin adapters for grouted anchors to facilitate installation by rotation without damaging the threads. When specified for grouted anchors, use ¾ in [19 mm] diameter zinc-coated steel structural wire strand in accordance with ASTM A 603, class A; splay 4 in [100 mm] of the wire rope end.

822.4 Grout

1 Use nonshrink cement grout in accordance with Subsection 819.1.2, Nonshrink Grout, to grout drilled anchors.

2 Provide resin grout in cartridge form and with thixotropic and viscous properties to allow mixing of the materials by rotation of the anchor without the mixture running out of the hole or into the joints after mixing. Use resin grout in accordance with Table 822.4-1, Resin Grout Properties.

Table 822.4-1
Resin Grout Properties

Property	Value
Ultimate compressive strength	14,000 psi [96.5 Mpa], min.
Ultimate tensile strength	2,495 psi [17.2 MPa], min.
Ultimate shear strength (when fully cured)	5,005 psi [34.5 MPa], min.

3 Provide resin cartridges a maximum of 12 in [300 mm] in length and individually identified as to their respective gel times. Ensure gel time and size of cartridges are as recommended by the manufacturer for the drill hole and anchor size used. Store resin grout as recommended by the manufacturer.

822.5 Top Support Wire Rope

1 Provide wire rope ½ in [12 mm] in diameter, zinc-coated steel structural wire strand, in accordance with ASTM A 603, class A.

822.6 Hardware

1 Use heavy duty, spherical seating type nuts in accordance with ASTM A 563 [ASTM A 563M]. Provide flat or beveled washers as required in accordance with ASTM F 436M.

2 Provide steel bearing plates in accordance with ASTM A 709 [ASTM A 709M], grade 36 [250]; use ⅜-inch [10 mm] flat steel square plates with a side dimension of at least 8 in [200 mm].

3 Use lightweight wire rope thimbles weighing approximately 13.9 lb [6.3 kg] per hundred. Use dropped forged steel or cast steel wire rope clips. Ensure thimbles and wire rope clips are galvanized in accordance with ASTM A 153 [ASTM A 153M].

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