2009
Oklahoma Department of Transportation
Transportation Commission

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PREFACE

These Special Provisions, with the exception of Section 100, are generally written in the imperative mood and active voice. In sentences using the imperative mood, the subject, "the Contractor", is implied. Reference to the Contractor is also implied in this language by the use of "shall", "shall be", or similar words and phrases. In Material specifications, the subject may also be the supplier, fabricator, or manufacturer supplying material, products, or equipment for use on the project.

Wherever "directed", "required", "prescribed", or other similar words are used, the "direction", "requirement", or "order" of the Engineer/Resident Engineer is intended. Similarly, wherever "approved", "acceptable", "suitable", "satisfactory", or other similar words are used, the words mean "approved by", "acceptable to", or "satisfactory to" the Engineer. The word "will" generally pertains to decisions or actions of the Engineer.

PURPOSE, INTENT, AND INTERPRETATION OF SPECIFICATIONS

The purpose of these Specifications is to establish, where applicable, minimum acceptable standards or a range for acceptable results. It is the intent of these Specifications that the Contractor be fully and exclusively responsible for producing an acceptable end product.

In producing this end product, the Contractor shall exercise control of the project. Department of Transportation personnel, except where specifically provided for herein, will make inspections for the State to document that an acceptable product is being produced.

Interpretation of these Specifications will be done in such a manner as to allow the Contractor to control his/her project to the greatest degree possible in producing an end result product which is in all respects acceptable. These Specifications should not, however, be interpreted in any manner which allows a Contractor to produce an unacceptable product or endanger the traveling public. An acceptable end result product is the essence of the Contract. Only projects in substantial conformance with the Plans and Specifications will be accepted by the Department of Transportation.

In order to avoid cumbersome and confusing repetition of expressions in these specifications, it is provided that whenever anything is, or is to be, done, if, as, or, when, or where "contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered necessary, deemed necessary, permitted, reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected or condemned," it shall be understood as if the expression were followed by the words "by the Engineer or to the Engineer".

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GENERAL PROVISIONS

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SECTION 101
GENERAL INFORMATION, DEFINITIONS AND TERMS

101.01 PURPOSE, INTENT, AND INTERPRETATION OF SPECIFICATIONS

The purpose of these Specifications is to establish, where applicable, minimum acceptable standards or a range for acceptable results. It is the intent of these Specifications that the Contractor be fully and exclusively responsible for producing an acceptable end product.

In producing this end product, the Contractor shall exercise control of the Project. The Contractor may deviate from any method required by these Specifications if the following conditions are met:

- Such deviation will produce an end product substantially similar to the end product that would have resulted from the method required by these Specifications; and
- The Department approves of such deviation.

Oklahoma Department of Transportation (Department) personnel, except where specifically provided for in these Specifications, will make inspections for the State to document that the Contractor is producing an acceptable product.

The Department will interpret these Specifications to allow the Contractor to control the Project to the greatest degree possible in producing an end result product that is in all respects acceptable. These Specifications should not, however, be interpreted in any manner that allows a Contractor to produce an unacceptable product or endanger the traveling public. An acceptable end product is the essence of the Contract. The Department will only accept the Work performed by the Contractor if the Work substantially meets the Contract requirements as defined by the Contract documents. The Department presumes that references in these Specifications to manuals and standardized industrial guides are references to the latest published edition, unless otherwise specified.

The titles or headings of the sections and subsections of these specifications are intended for the convenience of reference and shall not have any bearing on their interpretation.

101.02 ACTIVE VOICE, IMPERATIVE MOOD

The Department has rewritten this edition of the *Standard Specifications for Highway Construction* with an emphasis on the active voice. In a sentence written in the active voice, someone acts on something. For example: "The Resident 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.

This edition of the 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 these Standard Specifications, the Department is stating its requirements or directions for the 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 an award of a contract, imperative statements are directed to the bidder(s). After a contract has been awarded, imperatives are directed to the Contractor.

The Department will identify parties other than the bidder or Contractor to whom it gives a responsibility in these 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.

101.03 ABBREVIATIONS AND ACRONYMS

Where the following abbreviations and acronyms are used in these Specifications, Contracts, Bid Forms, or on Plans, they indicate the following expressions:

Table 101:1
Abbreviations and Acronyms

Short Form	Long Form
AAA	American Arbitration Association
AAN	American Association of Nurserymen
AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AGC	Associated General Contractors of America
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron & Steel Institute
ANSI	American National Standards Institute
ARA	American Railway Association
AREA	American Railroad Engineering Association
ARTBA	American Road and Transportation Builders Association
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASTM	American Society of Testing and Materials
ATSSA	American Traffic Safety Services Association
AWPA	American Wood Preservers Association
AWWA	American Water Works Association
AWS	American Welding Society
CFR	Code of Federal Regulations
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FAST Guide	Field Acceptance Sampling & Testing Guide
FHWA	Federal Highway Administration
FSS	Federal Specifications and Standards (General Services Administration)
IES	Illuminating Engineering Society of North America
IMSA	International Municipal Signal Association
ITE	Institute of Traffic Engineers
MUTCD	Manual on Uniform Traffic Control Devices for Streets and Highways
NCHRP	National Cooperative Highway Research Program
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
ODEQ	Oklahoma Department of Environmental Quality
ODOT	Oklahoma Department of Transportation

Table 101:1
Abbreviations and Acronyms

Short Form	Long Form
OPDES	Oklahoma Pollution Discharge Elimination System
OSHA	Occupational Safety and Health Administration
SAE	Society of Automotive Engineers
UL	Underwriter's Laboratory
USACE	United States Army Corps of Engineers
USFWS	United Stated Fish & Wildlife Services

101.04 MEASUREMENT SYMBOLS

Where the following measurement symbols are used in these Specifications, Contracts, Bid Forms, or on Plans, they indicate the following expressions:

Table 101:2
Dual-Unit Measurement Symbols

SI (metric)		Physical Characteristic	U.S. Customary (English)	
Symbol	Unit Name		Unit Name	Symbol
nm	nanometer		microinch	µin
µm	micrometer		mil (0.001 inch)	mil
mm	millimeter	**Length**	inch	in
cm	centimeter		foot	ft
m	meter		yard	yd
km	kilometer		mile	mi
—	—		square inch	in²
mm²	square millimeter		square foot	ft²
m²	square meter	**Area**	square yard	yd²
km²	square kilometer		square mile	mi²
ha	hectare		acre	acre
			pint	pt
mL	milliliter		quart	qt
L	liter	**Volume**	gallon	gal
m³	cubic meter		cubic inch	in³
—	—		cubic foot	ft³
—	—		cubic yard	yd³
g	gram		ounce	oz
kg	kilogram	**Mass (weight)**	pound	lb
—	metric ton		ton, short (2,000 lb)	ton
°C	degree Celsius	**Temperature**	degree Fahrenheit	°F
ms	millisecond		millisecond	ms
sec	second	**Time**	second	sec
min	minute		minute	min
hr	hour		hour	hr
km/h	kilometers per hour	**Speed**	miles per hour	mph
Pa	pascal			
kPa	kilopascal	**Pressure**	pound-force per square inch	psi
MPa	megapascal			
W	watt		watt	W
kW	kilowatt	**Power, energy and electrical**	kilowatt	kW
mA	milliampere		milliampere	mA
A	ampere		ampere	A
V	volt		volt	V
VA	voltampere		voltampere	VA

Table 101:2
Dual-Unit Measurement Symbols

SI (metric)		Physical Characteristic	U.S. Customary (English)	
Symbol	**Unit Name**		**Unit Name**	**Symbol**
Ω	ohm	**Power, energy and electrical**	ohm	Ω
Hz	hertz		hertz	Hz
J	joule		joule	J
lm	lumen		lumen	lm
lx	lux		footcandle	fc
cd	candela		—	—
—	—		horsepower	hp
N	newton	**Force**	pound-force	lbf
kN	kilonewton		1,000 pounds-force	kip
N/mm	Newton per millimeter	**Load**	pound per linear inch	pli
N•m	Newton meter	**Torque**	pound-force foot	lbf•ft
Pa•s	pascal second	**Viscosity, dynamic**	centipoises	cP
			poise	P
m^2/s	meter squared per second	**Viscosity, kinematic**	centistokes	cSt
H	Henry	**Inductance**	Henry	H
ppm	parts per million	**Concentration**	parts per million	ppm
L/s	liter per second	**Flow**	gallon per minute	gpm
dB	Decibel	**Sound**	decibel	dB

Table 101:3
Engineer's Estimate Pay Unit Symbols

Pay Unit	Symbols	
	English	**Metric**
Acre	AC	—
Calendar day	CD	CD
Day	DAY	DAY
Dollar	DOL	DOL
Each	EA	EA
Each group	EAGP	EAGP
Foot drilled	F DR	—
Gallon	GAL	—
Hectare	—	HA
Hour	HOUR	HOUR
Kilogram	—	KG
Kiloliter	—	KL
Kilometer	—	KM
Kilotonne meter	—	KT.M
Kilowatt-hour	KWH	KWH
Liter	—	L
Pound	LB	—
Linear foot	LF	—
Luminaire day	LMDY	LMDY
Lump sum	LSUM	LSUM
Meter	—	M
Meter drilled	—	M DR
Square meter	—	M2
Cubic meter	—	M3
Thousand feet board measure	KFBM	—

Table 101:3
Engineer's Estimate Pay Unit Symbols

Pay Unit	Symbols	
	English	Metric
1,000 gallon	KGAL	—
Thousand ton-feet	KTFT	—
Sign day	SD	SD
Square foot	SF	—
Station	STA	STA
Square yard	SY	—
Metric ton	—	T
Track mile	TKMI	—
Ton per mile	TM	—
Ton	TON	—
Ton foot	TONF	—
Track foot	TRKF	—
Track meter	—	TRKM
Vertical foot	VF	—
Vertical meter	—	VM

101.05 DEFINITIONS

A. Acceptance Date. The date on which the **Contractor** completes and delivers documents, certificates, proofs of compliance, and final estimates to the **Resident Engineer**. (See Subsection 105.17.C, "Final Acceptance.")

B. Addendum. A revision to the **Proposal Forms** developed by the **Department** after **Bid Notice** and before opening of **Bid Proposals**.

C. Award. The **Commission**'s selection of the lowest, **Responsive Bid** from a **Responsible Bidder**.

D. Base Course. — See **Pavement Structure**.

E. Bid Bond. — See **Bond**.

F. Bid Form (Schedule of Items). The approved form on which **Bidders** are to provide **Bid Item Unit Prices** in their **Bid Proposals**.

G. Bid Item. An item of work on the **Bid Form**, for which a **Bidder** shall provide a **Bid Item Price**.

H. Bid Item Price. The amount a **Bidder** provides in its **Bid** for performing the work represented by the quantity of a **Bid Item** on the **Bid Form**.

I. Bid Item Unit Price. The amount a **Bidder** provides in its **Bid** for performing each unit of a **Bid Item**.

J. Bid Notice. A formal announcement by the **Department** which uniformly and equally notifies the public and prospective **Bidders** of the intent of the Department to **Award** a public construction contract in accordance with the Public Competitive Bidding Act of 1974 (61 O.S. § 104). The Bid Notice of a project will contain its location, the type and extent of work which will be required and the date, time, and place of the **Bid Opening**.

K. Bid Opening (Letting). The opening of the **Bid Proposals** submitted by **Bidders** on the date and time defined by the **Department** in the **Bid Notice**.

L. Bid Price. The total of all **Bid Item Prices** for a bid submitted by a **Bidder**.

M. Bid Proposal. The written offer from the **Bidder** submitted on the **Bid Form** or electronic media presenting **Bid Prices** for **Work** and **Materials** necessary to complete the proposed **Project**.

1. **Standard Proposal**. The offer of the **Bidder** to perform the **Work** described in the **Plans** and **Specifications** within the **Contract Time**, and to provide the labor and **Materials** at prices quoted by the Bidder.

2. **A+B Proposal**. Outlines the **Bid Price** (element "A") and the **Bidder's** estimated construction time (element "B"). The **Department** will assign a value to each day of the construction time. The sum of the assigned values multiplied by the number of days bid is added to the **Bid Price**. The combined sums are used to rank the **Bid Proposals**. Rarely, a third element (C) is included to account for time needed to complete a key element of the **Project**.

N. Bidder. An individual or legal entity submitting a **Bid Proposal** for the **Work**.

O. Bituminous/Asphaltic. Containing or treated with the brownish-black heavy ends of petroleum source, generally used as a cementitious material.

P. Bond. A guaranty issued by a **Surety** and submitted by a **Bidder** to ensure fulfillment of the **Contract**, coverage of **Department** overhead, or quality of the **Work** and **Materials**. The Department requires the following Bonds:

1. **Bid Bond (Proposal Guaranty)**. A guaranty to ensure execution of the **Contract**. A certified check, cashier's check, or irrevocable **Letter of Credit** for 5 percent of the **Bid Price** to ensure the **Bidder** will enter into the **Contract** if the Bidder's is awarded the Contract. The Proposal Guaranty repays the **Department** for republishing notices to Bidders, expenses incurred by the defaulting Bidder, and the difference between the bid of the defaulting Bidder and the Bidder to whom the Contract is awarded. Total expenses must not exceed the amount of the Proposal Guaranty if the Bidder fails to execute the Contract or fails to provide Bonds and insurance to the Department.

2. **Maintenance Bond**. A bond of at least the total **Contract Price** to protect the **Department** from defective **Work** and **Materials** for one year after final acceptance of the **Contract**.

3. **Performance Bond**. A bond of at least the total **Contract Price**, which ensures prompt completion of the **Project**.

4. **Statutory and Payment Bond**. A bond of at least the **Contract Price** that guarantees the **Contractor** will pay all expenses the Contractor or the **Subcontractor** incurs including the following:

   - State and local taxes accrued as a result of the **Contract**
   - **Liquidated Damages** provided by the **Contract** and assessed by the **Department**
   - Overpayment of **Progressive Estimates** that result in a balance due to the Department (required by the Statutes of the State of Oklahoma).

Q. Bridge. A **Structure** and supports erected over a depression or obstruction with a passageway for carrying traffic. A Bridge has an opening of more than 20 ft [6.1 m] between undercopings of abutments or extreme ends of

openings for multiple boxes, measured along the center of the **Roadway**. It may include multiple pipes where the distance between openings is less than half of the smaller contiguous opening.

1. **Bridge Length**. The distance along the line of survey stationing back-to-back of backwalls of abutments, or end-to-end of the bridge floor, but at least the total clear opening of the **Structure**.
2. **Bridge Roadway Width**. The width of the **Structure** measured at right angles to the center of the **Roadway** between the bottoms of curbs or between the inner faces of the parapet or railing.
3. **Substructure**. The section of a **Bridge** below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with the back-walls, wing-walls, and wing protection railings.
4. **Superstructure**. The entire structure of the **Bridge**, except the **Substructure**.

R. Bridge Engineer. A **Department** engineer responsible for engineering decisions related to the design and construction of **Bridges**.

S. Calendar Day. — See **Contract Time**.

T. Change Order. A written order to the **Contractor** for additional **Work**, changes in quantities, changes in the price of **Contract Pay Items**, and additions or modifications to the **Contract**.

U. Channel. A natural or artificial watercourse.

V. Commission. The Transportation Commission of the **State** as constituted by State law and charged to administer the affairs of the **Department** acting directly, or through the **Director**.

W. Completion Date. The date on which the **Project** and any exceptions are completed. (See Subsection 105.17.B, "Project Completion.")

X. Construction Limits. That portion of real property, as defined by the **Plans**, in which the **Contractor** is authorized to perform contractually required activities. It is constrained laterally by the slope stakes and linearly by the **Project** stationing. The Contractor may be allowed to work or stockpile materials outside the construction limits when allowed by the **Engineer**.

Y. Contract. The written agreement between the **Department** and the **Contractor** that sets the performance of the **Work**, the basis of payment and other obligations of the parties.

The Contract includes the **Bid Notice**, **Bid Proposal**, **Contract Form**, **Bonds**, **Specifications**, **Supplemental Specifications**, **Special Provisions**, **Plans**, the **Work Order**, and any **Change Orders** or **Supplemental Agreements** that are required to complete the **Project**.

Z. Contract Amount. The amount of the original **Contract**, agreed to by the **Department** and **Contractor**, including any Department-approved adjustments.

AA. Contract Time. The number of **Working Days** or **Calendar Days** allotted for completing the **Work**, including authorized time extensions; or a date by which the Contractor shall complete the Work.

1. **Calendar Day**. Any day shown on the calendar beginning and ending at midnight. In these Specifications, when the term "day" is used the implied meaning is a **Calendar Day**.
2. **Fixed Completion Date**. The date by which the **Project** is to be completed.
3. **Working Day**. Every day shown on the calendar, excluding Saturdays, Sundays and **Holidays**, during weather and other conditions that allow construction to proceed for at least six hours with workers engaged in the **Work**. The **Department** will consider Saturdays, Sundays, and Holidays, on which workers engage in regular work requiring the presence of an **Inspector**, to be working days.

AB. Contractor. The individual or legal entity contracting with the **Department** for performance of the **Work** on the **Project**.

AC. Control of Access. The condition where an owner's or occupant's right to access, light, air, or view his or her abutting land in connection with a **Highway** is fully or partially controlled by public authority.

1. **Full Control of Access**. The authority to control access used to give preference to through-traffic by providing access connections with selected **Public Roads** only and prohibiting crossings at grade or direct private driveway connections.
2. **Partial Control of Access**. The authority to control access used to give preference to through-traffic so that, in addition to connections with selected **Public Roads**, there may be some crossings at grade and some private driveway connections.

AD. 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.

AE. Culvert. Any **Structure** under the **Roadway** with a clear opening of 20 ft [6.1 m] or less, measured along the center of the Roadway.

AF. Delay. A temporary suspension of all or a portion of the **Work**. The various Delays are as follows:

1. **Excusable Delay**. A **Delay** caused by the **Department** or an event beyond the **Contractor**'s control that impact the **Work** and are critical to the progress and completion of the **Project**. Acts of suppliers, fabricators or **Subcontractors** are considered under the Contractor's control (exceptions in Subsection 108.07.D(1), "Administration and Extension of Contract Time, General") and will not be considered as an excusable delay or for an extension of **Contract Time**.
2. **Non-excusable Delay**. A **Delay** to the **Project** or milestone date that was within control of the Contractor for which no monetary compensation or time extension will be granted.
3. **Compensable Delay**. An **Excusable Delay** for which the **Contractor** may be entitled to additional monetary compensation.

4. **Non-compensable Delay**. An **Excusable Delay** for which the **Contractor** may be entitled to an extension of time but no additional monetary compensation.

AG. Department. The Department of Transportation of the **State** authorized by Article XVI Section 1 of the Constitution of the State as provided by enactment of the Oklahoma Legislature.

AH. Differing Site Conditions. Subsurface or latent physical conditions at the site that meet one of the following criteria:

- Differ materially from those shown on the **Plans,**
- Differ materially from those normally encountered or recognized as inherent in the **Work**, or
- Are unknown physical conditions of an unusual nature.

AI. Director. The executive officer appointed and authorized by the **Commission** to direct and control the **Department**.

AJ. Disincentive Provision. — See **Incentive Provision/Disincentive Provision**.

AK. Easement. A grant by an owner to use property for a certain purpose.

AL. Engineer. The Chief Engineer of the **Department** and the assistants or representatives authorized by the **Director** acting within the scope of their assigned duties or authority.

AM. Equipment. Machinery, tools, and apparatus necessary for performing the **Work** as required by the **Contract**.

AN. Estimates. An electronically generated report containing quantities of **Materials** placed and **Work** performed and detailing compensation paid to the **Contractor**. The two types of estimates include:

1. **Progressive Estimate**. A record of **Materials** placed and **Work** performed during a period of time and detailing compensation paid to the **Contractor** for those Materials and Work. (See Subsection 109.06, "Progress Payments.")
2. **Final Estimate**. A record generated after the **Project** has been completed, containing audited quantities of **Materials** used, and integrating additions and subtractions from final quantities of **Work** to establish a payment or collection from the **Contractor** to reflect a final **Contract Price**. (See Subsection 109.08, "Final Payment.")

AO. FAST Guide. Field Acceptance Sampling & Testing (FAST) Guide. Consists of guidelines defining minimum sampling and testing frequencies of **Materials**, conducted on **Projects** for acceptance and Independent Assurance. The **Department's** Materials Division will develop and implement the FAST Guide.

AP. Final Estimate — See **Estimates**.

AQ. Final Stabilization. When all earth-disturbing activities are complete and permanent erosion and sediment controls are established and functional. The stabilized site is protected from erosion from water-flow and rain. Unpaved areas, except graveled **Shoulders**, crushed aggregate **Base Course,** or other areas not covered by permanent **Structures** are protected by a uniform

blanket of perennial vegetation (at least 70 percent native background cover) or equivalent stabilization measures including riprap, geotextiles, gabions, or paved ditches. (See Section 220, "Management of Erosion, Sedimentation, and Storm Water Pollution Prevention and Control.")

AR. Fixed Completion Date. — See **Contract Time**.

AS. 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.

AT. Holiday. Any day proclaimed a holiday by Executive Order of the Governor.

AU. Incentive Provision/Disincentive Provision. **Contract** provisions allowing adjustments to the **Contract Price** for each day the **Work** is completed ahead or behind specified milestone dates or the **Completion Date**.

1. **Incentive Payments**. Additional money for the **Contractor** for each day **Work** is completed before specified milestone dates or the **Completion Date**. The **Department** will determine the maximum number of days it will pay incentives based on lane rental amounts and other factors.
2. **Disincentive Assessment**. An assessment to deduct money owed a **Contractor** for failure to complete **Work** before specified milestone dates or the **Completion Date**. The **Department** will determine the deduction amount based on lane rental cost formulas, defined as, the cost to the traveling public per increment of time for losses attributable the failure of the Contractor to have a facility or a designated portion fully available for use by the given date.

AV. Inspector. An authorized representative assigned by the **Resident Engineer** to inspect the **Work**.

AW. Laboratory. The official testing laboratory of the **Department** or any other testing laboratory designated by the **Director** or **Engineer**.

AX. Letter of Credit. An irrevocable letter of credit used in lieu of a **Bond** for the benefit of the **State**. (See Subsection 103.05, "Bonding Requirements.")

AY. Letting. — See **Bid Opening**.

AZ. Liquidated Damages. Monetary damages charged to the **Contractor** at a specified rate when **Work** is not completed within the **Contract Time,** to recover a portion of cost incurred by the **Department** for additional engineering, inspection, and overhead for continued supervision of the **Project** after the Contract Time expires. See Subsection 108.09, "Failure to Complete on Time.")

BA. Lot. A specific quantity of **Work** or **Materials**.

BB. Maintenance Bond. — See **Bond**.

BC. Major and Minor Contract Items. Items considered Major or Minor, under the terms of the **Contract**, are based on the percent value of the original **Contract Price**. **Projects** that are awarded as either mandatory or optional

tied projects shall have quantities of similar bid items combined for determining Major or Minor Contract items.

1. **Major Items**. The following schedule will determine Major Items:

Table 101:4
Major Item Values Per Contract Amount

Contract Amount, *$*	**Major Item as Percent of Contract Amount**
≤1,000,000	≥5%
>1,000,000 – ≤4,000,000	≥$50,000 + 2.0% of the contract amount over $1,000,000
>4,000,000 – ≤8,000,000	≥$110,000 + 1.0% of the contract amount over $4,000,000
>8,000,000	≥150,000 + 0.5% of the contract amount over $8,000,000

2. **Minor Items**. All items less than the above percentages will be considered Minor Items, except when added quantities cause the cost to exceed the above percentages.

BD. Manufacturer Recommendations. Instructions, directions, or procedures provided by the manufacturer of a product (material, equipment, etc.) for the proper use of the product.

BE. Materials. Substances used in the construction of the **Project** and its appurtenances.

BF. Materials Division. An internal division within the **Department** responsible for the design, testing, and approval of **Materials** to be used in the **Work**.

BG. Materials Engineer. A **Department** engineer responsible for engineering decisions related to design, testing, and approval of **Materials**.

BH. Notice of Intent (NOI). The OPDES General Permit application to start earth-disturbing activities of at least one acre for storm water discharges. (See Section 220, "Management of Erosion, Sedimentation, and Storm Water Pollution Prevention and Control.")

BI. Notice to Proceed. Written notice to the **Contractor** to begin **Work**. When applicable, the notice will include the start date of the **Contract Time**.

BJ. Notice of Termination (NOT). The OPDES General Permit application indicating the end of earth-disturbing activities and the attainment of final stabilization. (See Section 220, "Management of Erosion, Sedimentation, and Storm Water Pollution Prevention and Control.")

BK. Partial Acceptance. Acceptance of a part of the **Contract** as determined by the **Resident Engineer**. (See Section 105.17, "Project Completion and Acceptance.")

BL. Partial Acceptance Date. The date on which the **Resident Engineer** determines a part of the **Contract** to be acceptable. (See Section 105.17, "Project Completion and Acceptance.")

BM. Partial Completion. Completion of a part of the **Contract**, as requested by the **Contractor** and determined by the **Resident Engineer**. (See Section 105.17, "Project Completion and Acceptance.")

BN. Partial Completion Date. The date on which the **Resident Engineer** determines a part of the **Contract** to be complete. (See Section 105.17, "Project Completion and Acceptance.")

BO. Pavement Structure. The combination of **Subbase**, **Base Course**, and **Surface Course** placed on a **Subgrade** to support and distribute the traffic load to the **Roadbed**.

1. **Surface Course**. Layer(s) of a **Pavement Structure** designed to accommodate the traffic load. The top layer, sometimes called the "Wearing Course," resists skidding, traffic abrasion, and disintegrating climate effects.
2. **Base Course**. Layers of specified **Materials** placed on a **Subbase** or a **Subgrade** to support a **Surface Course**.
3. **Subbase**. Layers of specified **Materials** thickness placed on a **Subgrade** to support a **Base Course**.
4. **Subgrade**. Compacted soils (treated or untreated) upon which the **Pavement Structure** is constructed.

BP. Pay Item. A specific unit of **Work** recorded in the **Contract**.

BQ. Performance Bond. — See **Bond**.

BR. Plans. Approved **Contract** drawings showing the location, type, dimensions, and details of **Work** required. The Plans include the following:

1. **Standard Plans**. Detailed drawings approved for repetitive use.
2. **Plan Notes**. Insertions on **Standard Plans** to facilitate design considerations. Whenever a conflict in Plan Notes appears, the **Contractor** shall notify the **Resident Engineer** before starting the affected **Work**. The Resident Engineer will determine the applicability of the Plan Notes in question.
3. **Working Drawings**. Supplemental design sheets or similar data that the **Contractor** is required to submit to the **Resident Engineer**, such as shop drawings, bending diagrams for reinforcing steel, and plans for erection, false work, framework, and cofferdams.
4. **Work Plans**. Supplemental procedures or data developed by the **Contractor** as the method for completing the **Work**.

BS. Prequalification. The process of qualifying a prospective **Bidder** before issuing the **Bid Documents**, in accordance with the rules, regulations, policies, and procedures of the **Commission**.

BT. Prequalification Questionnaire. The approved form of the **Department** where the prospective **Bidder** provides information regarding financial condition, experience, the **Equipment** to be used, and the ability to finance and perform the **Work**.

BU. Profile Grade. The trace of a vertical plane intersecting the top surface of the proposed **Surface Course** and usually along the longitudinal centerline of the

Roadbed. Profile Grade means either elevation or gradient of the trace according to the context.

BV. Progressive Estimate. — See **Estimates**.

BW. Project. The specific section of the **Road,** proposed Road, or other facilities together with all appurtenances and construction to be performed under the **Contract**.

BX. Proposal Forms. The documents and information available to **Bidders**, including the **Plans**, for creating and submitting a **Bid Proposal** for the **Work**.

BY. Proposal Guaranty. — See **Bid Bond**.

BZ. Resident Engineer. The direct representative of the **Department** with the authority to oversee all aspects of the construction. The **Resident Engineer** will serve as the point of contact for the **Contractor** during the **Project**. The Department representative may or may not be a licensed professional engineer and may be a consultant retained by the Department. (See Subsection 105.01, "Authority and Duties of the Resident Engineer.")

CA. Responsive Bid. A bid that meets all requirements of the **Bid Notice**.

CB. Responsible Bidder. A **Bidder** that the **Department** determines has the ability to perform the **Work**.

CC. Right-of-Way. A general term denoting land, property, or an interest therein, acquired for **Highway** purposes for the **Project**.

CD. Road (Highway or Street). A general term denoting a public way for vehicular travel, including the entire area within the **Right-of-Way**. The following are types and parts of the Road:

1. **Divided Highway**. A **Highway** with separated **Roadways** for traffic in opposite directions.
2. **Expressway**. A divided arterial **Highway** for through traffic with **Full** or **Partial Control of Access** and generally with **Grade Separations** at intersections.
3. **Freeway**. An **Expressway** with **Full Control of Access**.
4. **Frontage Road**. A **Road** constructed on **Department**-owned **Right-of-Way**, adjacent and parallel to but separate from the **Highway**, that connects to the Highway for service to abutting property and for **Control of Access**.
5. **Grade Separation**. A **Structure** carrying **Highway** traffic over or under another **Highway**, **Street**, or any railroad tracks.
6. **Interchange-Collector Distributor Road**. A **Road** constructed on a **Department**-owned **Right-of-Way**; parallel to the mainline that collects and distributes traffic between **Ramps** where the mainline is not connected to any crossroads.
7. **Local Road**. A **Road** with one connection to the Highway constructed on **Department**-owned **Right-of-Way** to provide access to property abutting or adjacent to the **Highway**.

8. **Median**. The part of a **Divided Highway** that separates the **Traveled Ways** of traffic.

9. **Parkway**. An arterial **Highway** for non-commercial traffic, with **Full** or **Partial Control of Access**, and usually located within a park or a ribbon of park-like development.

10.Public Road. A **Road** constructed on **Department**-owned **Right-of-Way** to connect other **Public Roads** or **Streets**, but not connected or allowing access to the **Highway**.

11.Ramp. A connecting **Roadway** between two intersecting **Highways**, at a Highway separation, or a **Road** connecting the Highway with other Roads.

12.Roadbed. The graded portion of a **Highway** with top and side slopes, prepared as a foundation for the **Pavement Structure** and **Shoulders**.

13.Roadside. The area adjoining the outer edge of the **Roadway** and large areas between **Divided Highways**.

14.Roadway. The part of the **Right-of-Way** between the outer edges of the **Shoulders**.

15.Shoulder. The part of the **Roadway** contiguous with the **Traveled Way**, designed for emergency use and lateral support of **Base** and **Surface Courses**.

16.Sidewalk/Bicycle Path. The part of the **Right-of-Way** constructed for pedestrian use, bicycle use, or both.

17.Speed Change Lane. An auxiliary lane, including tapered areas, for the acceleration or deceleration of vehicles entering or leaving the **Highway**. Speed Change Lanes are described as Acceleration Lanes, Deceleration Lanes, or Median Lanes.

18.Traveled Way. The part of the **Roadway** for the movement of vehicles, excluding **Shoulders**.

CE. Roadside Development. Those items necessary to preserve or replace landscape **Materials**, and features that include plantings or ground cover to preserve and enhance the appearance and stability of the **Highway**, **Right-of-Way**, or acquired **Easements**, for scenic improvements.

CF. Shut Down Order. A written order issued by the **Resident Engineer** to the **Contractor** instructing the Contractor to cease all or a specific part of the **Work**. The Contractor shall not resume work prohibited by the **Shut Down Order** until the Resident Engineer issues a written authorization rescinding the Shut Down Order.

CG.Specifications. The provisions and requirements for the performance of **Work**.

1. **Standard Specifications**. The book of **Specifications** approved for general application and repetitive use.
2. **Supplemental Specifications**. The book of approved additions and revisions to the **Standard Specifications**.
3. **General Use Special Provisions**. Revisions or amendments to the **Standard** and **Supplemental Specifications** approved for general use.

4. **Project Specific Special Provisions**. Revisions or amendments to the **Standard** and **Supplemental Specifications** applicable to an individual **Project** and designated with the identifying project number.

CH. State. The State of Oklahoma.

CI. Statutory and Payment Bond. — See **Bond**.

CJ. Structure. A **Bridge**, **Culvert**, catch basin, drop inlet, retaining wall, cribbing, manhole, end-wall, headwall, building, sewer, service pipe, under-drain, foundation drain, and other features that may be encountered in the work and not classified.

CK. Subbase. — See **Pavement Structure**.

CL. Subgrade. — See **Pavement Structure**.

CM. Subgrade Treatment. Chemical treatment of **Subgrade** soils or aggregates to modify or stabilize.

1. **Modification**. Chemical treatment of **Subgrade** soils or aggregates by incorporating materials that will increase load-bearing capacity in order to provide a sound, working platform for paving **Equipment**. Modification does not provide structural value to the pavement section.
2. **Stabilization**. Chemical treatment of **Subgrade** soils or aggregates by incorporating materials in order to provide structural value to the pavement section.

CN. Subcontractor. A legal entity approved by the **Department** that the **Contractor** by written agreement, employs to perform a designated segment of **Work**. The Subcontractor is responsible for supplying personnel, **Equipment,** and **Materials** required for completing the subcontracted segment of the Work.

CO. Superintendent. The **Contractor's** authorized representative in charge of the **Work**.

CP. Supplemental Agreement. A written agreement, signed by the **Department** and the **Contractor**, to add compensation for **Materials** and time not included in the **Plans** bid by the Contractor and which the **Resident Engineer** deems necessary to improve the **Project**.

CQ. Surety. The insurance company or other body authorized under the laws of the **State** to issue **Bonds** to insure the **Contractor's** performance of the **Contract**.

CR. Surface Course. — See **Pavement Structure**.

CS. Traffic Engineering Division. An internal division within the **Department** responsible for the design and construction of traffic control devices to be used in the **Work**.

CT. Unbalanced Bid. A **Bid Proposal** that contains unbalanced **Bid Item Unit Prices** based on one of the following characteristics:

1. **Mathematically**. A bid containing lump sum or unit **Bid Items** that do not reflect reasonable estimated costs, a reasonable proportionate share of the **Bidder's** anticipated profit, overhead costs, and other indirect costs.

2. **Materially**. A bid that generates reasonable doubt that the **Award** to the **Bidder** submitting a Mathematically Unbalanced Bid will result in the lowest ultimate cost to the **Department**.

CU. Unilateral Change Order. A **Change Order** issued by the **Resident Engineer** that the **Contractor** does not agree with or sign, or that is administrative in nature and does not require the acknowledgement of the Contractor.

CV. Value Engineering. The formal technique by which the **Contractor** may suggest methods for performing the requirements more economically and share in the resulting savings, without impairing essential functions or characteristics.

CW. Work. All resources, including labor, **Materials**, **Equipment**, and incidentals, necessary to complete the **Project** in accordance with the **Contract** requirements.

CX. Working Day. — See **Contract Time**.

SECTION 102
BIDDING REQUIREMENTS AND CONDITIONS

102.01 PRE-QUALIFICATION

The Department requires pre-qualification of prospective bidders as a prerequisite for bidding, unless prohibited by law or waived by the Department.

The Department will perform bidder pre-qualification in accordance with the most current issue of the Oklahoma Administrative Code. Copies of the Code and Pre-qualification Questionnaire are available from:

The Office Engineer
Oklahoma Department of Transportation
200 N.E. 21st Street
Oklahoma City, Oklahoma 73105

102.02 NOTICE TO PROSPECTIVE BIDDERS

The Department will publish a Bid Notice to notify the public and prospective bidders of the intent to award a public construction contract in accordance with Section 104 of the Oklahoma Public Competitive Bidding Act of 1974 (61 OS §101 et seq.). The Bid Notice will provide the following information:

- The location and description of the proposed work,
- How to access the Proposal Forms, Plans, and Specifications,
- The requirement for a Proposal Guaranty, and
- The date, time, and location of the Bid Opening.

The Bid Notice will become part of the Contract.

102.03 CONTENTS OF PROPOSAL FORMS

The Proposal Forms include the following information:

- The location and description of the construction,
- A schedule of items,
- Estimated quantities for the items,
- A timeline for work completion,
- The Proposal Guaranty amount,
- The date, time, and location of the Bid Opening,
- Special Provisions, and
- Addenda as issued.

The Department considers all documents attached to, or referenced in, the Proposal Forms (including the Plans, Standard Specifications, Supplemental Specifications, and Special Provisions) to be part of the Proposal Forms.

The Department will require prospective bidders to pay for each copy of the Proposal Forms and each set of Plans in the amount published in the Bid Notice.

102.04 REFUSAL OF PROPOSALS

The Department may refuse to issue Proposal Forms to, or to receive or open Proposals from, a prospective bidder for the following reasons:

- The bidder lacks competency, financial stability, or adequate machinery, plant, and other equipment listed in the Pre-qualification Questionnaire in accordance with Subsection 102.01, "Pre-qualification."
- The Department determines that the prompt completion of additional work might be hindered or prevented because of a bidder's uncompleted work on another Department contract.
- The bidder fails to pay, or satisfactorily settle, bills due for labor and material on any open Department contract by the Bid Opening.
- The bidder fails to comply with pre-qualification regulations.
- The bidder defaults under a previous Department contract.
- The bidder performs unsatisfactory on previous or current Department contracts.
- The bidder has failed to execute and submit the Final Estimate on a previous Department contract.
- The bidder has been indicted for or convicted of a felony involving moral turpitude or offenses against the public contracting laws (federal or state) which may, as the Department determines, affect the bidder's ability to perform future work. The Department will consider a plea of guilty or nolo contendere as equivalent to a conviction.
- The bidder is currently suspended or debarred by the Department or another government agency.
- The bidder has failed to comply with Disadvantaged Business Enterprise requirements of a previous Department contract.
- The bidder fails to pay subcontractor or release subcontractor retainage on a previous or current project in accordance with Subsection 109.11, "Payment to Subcontractors."
- The bidder has failed to maintain insurance on a previous Department contract.

- The bidder has failed to provide skilled and qualified supervision or workers on a previous Department contract.
- The bidder has made a misrepresentation or false statement, or has failed to conform to any requirement contained in the bidder's unsworn statement under penalty of perjury on a previous Department contract.
- The bidder has failed or refused to cooperate or has impeded review of the bidder's records on a previous or current Department contract by the Department, State auditors, or Federal authorities whose duties require access to such records.

102.05 INTERPRETATION OF QUANTITIES AND BID PROPOSAL

The quantities in the Proposal Forms are estimates only, to be used by the Department for the purpose of comparing Proposals, and the Department reserves the right to increase, decrease, or eliminate estimated quantities of work or materials in accordance with Section 104, "Scope of Work." The Department will pay for the actual quantities of work performed and accepted or materials provided as required by the Contract in accordance with Section 109, "Measurements and Payment."

102.06 EXAMINATION OF PLANS, SPECIFICATIONS, SPECIAL PROVISIONS, AND THE WORK SITE

Each bidder is responsible for examining the following before submitting a Proposal:

- Site of the proposed work,
- Proposal Forms,
- Plans,
- Standard Specifications,
- Supplemental Specifications, and
- Special Provisions.

If a bidder chooses to not perform site investigations and the Department awards the Contract to that bidder, the bidder will be responsible for all site conditions that would have been discovered had the bidder performed a reasonable site investigation.

Do not take advantage of any apparent error or omission in the Proposal Forms. Upon discovering an error or omission, immediately notify the Department. The Department will make corrections to accurately describe the intent of the Proposal Forms.

The Department may perform boring and subsurface investigations to determine design criteria. If the Department has performed these, bidders may inspect boring logs and other records of subsurface investigations relevant to the currently advertised project at the following address during normal business hours:

Department of Transportation, Office Engineer
200 N.E. 21st Street
Oklahoma City, Oklahoma 73105

Do not rely on information from the Department's boring and subsurface investigations to assess the difficulty of the work described in the Proposal Forms or to describe the actual conditions that may be encountered. Do not substitute the Department's investigations for bidder investigation, interpretation, and judgment. The Department considers submission of a Proposal as evidence that the bidder understands and is satisfied with the work conditions and the requirements of the proposed Contract.

The Department will not be bound by statements or representations concerning conditions or description of the work unless included in the Proposal Forms, Plans, Standard Specifications, Supplemental Specifications, Special Provisions, or related Contract documents. Oral explanations or instructions given by Department employees or agents before the award of the Contract are not binding.

For requests for explanation of Department intent of the Proposal Form, Plans, Standard Specifications, Supplemental Specifications, Special Provisions, or related Contract documents, allow the Department time to reply to all prospective bidders before submission of Proposals. The Department will issue explanations as addenda to the Proposal Forms, and will provide addenda to all prospective bidders (Plan holders) by certified mail or facsimile before the Bid Opening. Acknowledge receipt of addenda on the Proposal Forms in the space provided.

102.07 PREPARATION OF PROPOSAL

Submit the Proposal in the format required by the Bid Notice. For each item on the Proposal Forms, type or write (in ink) the unit price and the product of the unit price and estimated quantity on the Proposal Forms in the space provided. Show the total Proposal amount by adding the products of the unit prices and the estimated quantities. Acknowledge any change to a unit price, the product of a unit price and quantity, or the total Proposal amount with the initials of the person signing the Proposal, adjacent to each change.

If a discrepancy occurs on the Proposal, between the unit price and the product of the unit price and quantity, the Department will use the unit price. If a unit price or the product of a unit price and quantity is omitted for any item listed on the Proposal Forms, the Department will consider the Proposal non-responsive and will reject the Proposal. If there is a discrepancy between the submitted electronic media and written Proposal, the Department will use the written Proposal. If the Department requires a printout of electronic media and a discrepancy occurs between the printout and the electronic media, the Department will use the printout.

An individual, all members of a partnership, a duly authorized officer of a corporation, or all members of a joint venture shall sign the Proposal in black or blue ink. For Proposals submitted by a corporation, show the name of the corporation and business address. For Proposals submitted by the internet bidding process, the Department will require an electronic signature only. Include a Non-Collusive Bidding Certification with the Proposal in accordance with Subsection 102.16, “Non-Collusive Bidding Certification.”

102.08 NONRESPONSIVE PROPOSALS

The Department will consider a proposal nonresponsive and may reject it for any of the following reasons:

- The bidder submits a Proposal on an unapproved form (or format, if computer-generated), or the form is altered, incomplete, or disassembled.
- The bidder submits a Proposal using a form other than the latest approved Proposal Form.
- The Department determines that Proposal irregularities (such as unauthorized additions and conditional or alternate bids) may tend to make the Proposal incomplete, indefinite, or ambiguous.

- The Proposal does not contain a unit price for each item listed, except for authorized alternate items.
- The Proposal is mathematically or materially unbalanced. The Department considers a Proposal mathematically unbalanced if that Proposal contains items with lump sums or unit prices that do not reflect reasonable estimated costs plus reasonable proportionate share of the bidder's anticipated profit, overhead costs, and other indirect costs. The Department considers a Proposal materially unbalanced if that Proposal creates a reasonable doubt that award to the bidder submitting a Mathematically Unbalanced Bid will result in the lowest total cost to the Department.
- The Proposal is not properly signed.
- The Proposal is not typed or completed in ink.
- The bidder fails to provide a properly executed Proposal Guaranty, or irrevocable Letter of Credit.
- The bidder fails to sign the unsworn statement made under penalty of perjury.
- The Proposal fails to comply with any material requirement of the Bid Notice.
- The bidder fails to properly comply with Disadvantaged Business Enterprise Requirements or to properly list eligible disadvantaged businesses if participation in accordance with the Proposal Forms.

102.09 PROPOSAL GUARANTY

Submit a Proposal Guaranty or irrevocable Letter of Credit with the Proposal in the amount of at least 5 percent of the Bid Price, unless otherwise specified in the Proposal Forms, made payable, or subject to forfeiture, to the Department.

102.10 DELIVERY OF PROPOSAL

Proposals shall be either:

- Placed in a sealed envelope plainly marked with identifying information as required. Addressed to the Department in care of the official in whose office the Proposals are to be received. Proposal data may be delivered electronically by compact disk or diskette as provided for in the current Department procedures. The title and address of the official designated to receive Proposals is: Office Engineer, 200 N.E 21st Street, Oklahoma City, Oklahoma 73105. In the event of a conflict between electronic media and the written submission, the written submission shall be binding.
- Delivered by electronic submission over the internet as provided by the current Department procedures.

File Proposals before the time and at the place specified in the Bid Notice and Proposal Forms. If the Department receives a Proposal after the time specified in the Bid Notice, the Department will return the unopened Proposal to the bidder.

102.11 WITHDRAWAL OF PROPOSAL

The bidder may withdraw its Proposal with an authorized representative's notarized written request any time before the established bid opening time. The Department will return requests to withdraw a proposal to the bidder unread, if received after the Bid Opening.

102.12 COMBINATION BIDS

The Department may issue Proposal Forms for combined projects, separate projects, or both. The Department reserves the right to recommend awards on combination Proposals or separate Proposals most advantageous to the Department. The Department will not consider combinations of Proposals other than those specifically advertised by the Department.

102.13 PUBLIC OPENING OF PROPOSALS

The Department will publicly open and read Proposals on the date and at the hour and place specified in the Bid Notice, and in the presence of the Director or representative.

102.14 REJECTION OF PROPOSALS

The Department may reject a Proposal if in the opinion of the Department the best interests of the people of the State of Oklahoma would be best served by doing so. The Department may reject a Proposal in accordance with Subsection 102.04, "Refusal of Proposals," Subsection 102.08, "Nonresponsive Proposals," and the following:

- A bidder submits more than one Proposal for the same proposed Contract, under the same or different name.
- Currently having one or more Department projects in Liquidated Damages.
- Failure to repay the Department for overpayments made on a current or previous Department contract.

102.15 (VACANT)

102.16 NON-COLLUSIVE BIDDING CERTIFICATION

Include with the Proposal the following statement subscribed or affirmed by the bidder as true under the penalties of Law. Sign, notarize, and submit the Non-Collusive Bidding Certification with the Proposal. Use the form included in the Proposal, which will be in substantially the following form:

Non-Collusive Bidding Certification

STATE OF OKLAHOMA
COUNTY OF _____

A. For purposes of competitive bids, I certify:

1. I an the duly authorized agent of _____, the bidder submitting the competitive bid to which this statement is attached, for the purpose of certifying the facts pertaining to the existence of collusion among bidders and between bidders and state officials or employees, as well as facts pertaining to the giving or offering of things of value to government personnel in return for special consideration in the letting of any contract pursuant to the bid to which this statement is attached;
2. I am fully aware of the facts and circumstances surrounding the making of the bid to which this statement is attached and have been personally and directly involved in the proceedings leading to the submission of such bid; and
3. Neither the bidder nor anyone subject to the bidder's direction or control has been a party to the following:
   a. Any collusion among bidders in restraint of freedom of competition by agreement to bid a fixed price or to refrain from bidding;
   b. Any collusion with any state official or employees as to quantity, quality, or price in the prospective contract, or as to any other terms of such prospective contract; and
   c. Any discussions between bidders and any state officials concerning exchange of money or other thing of value for special consideration in the letting of a contract.

B. I certify, if awarded the contract, whether competitively bid or not, that neither the Contractor nor anyone subject to the Contractor's direction or control has paid, given, or donated or agreed to pay, give, or donate to any officer or employee of the State of Oklahoma any money or other thing of value, either directly or indirectly, in procuring the contract to which this statement is attached.

Certified this _____ day of _____, 20___.

_____
(Signature)

_____
(Print Name)

_____
(Position in Company)

The Department will not award a contract to a bidder that has not complied with the statements in the Non-Collusive Bidding Certification.

When the bidder submits an electronic bid, the electronic media will prescribe the certifications.

The following do not constitute a disclosure within the meaning of Part 1 of the Non-Collusive Bidding Certification:

- The bidder has published price lists, rates, or tariffs covering items being procured.
- The bidder has informed prospective customers of proposed or pending publication of new or revised price lists for such items.
- The bidder has sold the same items to other customers at the same prices being bid.

SECTION 103
AWARD AND EXECUTION OF CONTRACT

103.01 CONSIDERATION OF PROPOSALS

The Department will publicly open and read the Proposals. For each submitted Proposal, the Department will review and verify the product of the unit price and estimated quantity for each item and the total Proposal amount. The Department will compare its estimate for each item with the products of the unit price and estimated quantities in each Proposal, compare acceptable Proposals, and publicly announce the results.

The Commission reserves the right to promote the State's best interest by:

- Rejecting any or all Proposals,
- Waiving an administrative error that would void an otherwise valid award,
- Re-advertising for new Proposals, or
- Proceeding to do the work by other procurement methods.

The Department may deem as nonresponsive and reject a Proposal that fails to fully comply with all requirements of the Bid Notice and Proposal Forms.

103.02 AWARD OF CONTRACT

With the recommendation of the Director, the Commission will award the Contract to the lowest responsible bidder with a responsive Proposal in accordance with the Department's requirements. The Commission will award the Contract within the time period allowed by law.

103.03 CANCELLATION OF AWARD

The Commission may cancel the Contract award at any time before the execution of the Contract in accordance with Subsection 103.09, "Failure to Execute Contract." The Department and Commission will not incur any liability for this action.

For federal-aid Projects, concurrence and funding by the Federal Agency is required before the Department will execute the Contract. If these requirements are not met, the Commission may unilaterally rescind the award of the Contract, even after execution of the Contract. If the Commission rescinds the award, the Department will return the Proposal Guaranty to the successful bidder, and release both parties from obligations and liabilities created by the Contract.

The Department may cancel the award of a Contract if the Contractor:

- Fails to timely provide Bonds or irrevocable Letter of Credit, or

- Fails to provide proper evidence of project specific insurance.

103.04 RETURN OF PROPOSAL GUARANTIES

The Department will return Proposal Guaranties to unsuccessful bidders immediately after the selection of the lowest responsible and responsive bidder.

The Department will return the successful bidder's Proposal Guaranty after the Contract and bonds have been signed by the Contractor and received and executed by the Department.

103.05 BONDING REQUIREMENTS

Return the signed Contract to the Department with the following:

- A Performance Bond,
- A Statutory and Payment Bond, and
- A Maintenance Bond, if required by the Contract.

The successful bidder may submit a single irrevocable Letter of Credit instead of the Bonds described above on any Department Contract. Submit an irrevocable Letter of Credit on the form prescribed by the Department of Central Services with the State identified as the beneficiary. The Letter of Credit must be issued by a financial institution insured by the Federal Deposit Insurance Corporation, or the Federal Savings & Loan Insurance Corporation.

The successful bidder shall obtain the Department's approval of the Surety. The Surety shall provide bonds in compliance with the rules, regulations, policies, and procedures of the Commission, addressing the Department's terms for the bonds, executed by the Surety, and accompanied by valid and acceptable Powers of Attorney. The Department of Central Services will prescribe the form of the Letter of Credit.

103.06 (VACANT)

103.07 EXECUTION OF CONTRACT

The Contract shall be signed in black or blue ink by the individual, all members of a partnership or joint venture, or a duly authorized officer of the corporation, to whom the Contract was awarded. The successful bidder shall return the signed Contract to the Department, within the time limit specified in the Proposal Forms. The Department will execute the Contract within 14 working days after receiving the signed Contract from the successful bidder, and will return a copy of the executed Contract to the successful bidder.

The Department will not allow construction to begin until the Contractor receives the Notice to Proceed and notifies the designated Resident Engineer.

103.08 APPROVAL OF CONTRACT

The Contract will not be binding upon the Department or Commission until executed by the Director or authorized designee, approved as to form and legality by the General Counsel or authorized designee, and delivered to the Contractor.

103.09 FAILURE TO EXECUTE CONTRACT

The Commission will rescind the Contract award if the successful bidder fails to do the following:

- Comply with any of the requirements of the Proposal Forms,
- Sign the Contract,
- Provide project specific certificates of insurance, or
- Provide the Bonds, or irrevocable Letter of Credit, required by law.

If the Commission rescinds the award, the Department may require forfeiture of the Proposal Guaranty.

SECTION 104
SCOPE OF WORK

104.01 PURPOSE OF CONTRACT

The purpose of the Contract is to provide details for the construction and completion of the Work. The Contractor is responsible for providing all labor, materials, equipment, and incidentals required to complete the work in accordance with the Contract. No alterations based upon the increase or decrease in pay item quantities may be entered into that increase the length or extent of a project by more than 25 percent.

104.02 SPECIAL WORK

As necessary, the Department may prepare Special Provisions describing work included in the Proposal Forms. The Department will consider Special Provisions attached to or incorporated by reference in the Proposal Forms to be part of the Contract.

104.03 DIFFERING SITE CONDITIONS

During the progress of the work, if subsurface or latent physical conditions are encountered at the site differing materially from those indicated in the Contract or if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the work provided for in the Contract, are encountered at the site, the party discovering such conditions shall promptly notify the other party in writing of the specific differing conditions before the site is disturbed and before the affected work is performed.

Upon written notification as provided in Subsection 104.06, “Notification of Differing Site Conditions, Changes, and Extra Work,” the Resident Engineer will investigate the conditions, and if it is determined that the conditions materially differ and cause an increase or decrease in the cost or time required for the performance of any work under the Contract, an adjustment, excluding anticipated profits, will be made and the Contract modified in writing accordingly. The Resident Engineer will notify the Contractor of the determination whether or not an adjustment of the Contract is warranted.

No Contract adjustment which results in a benefit to the Contractor will be allowed unless the Contractor has provided the required written notice as specified in Subsection 104.06, “Notification of Differing Site Conditions, Changes, and Extra Work.”

No Contract adjustment will be allowed under this clause for any effects caused on unchanged work.

If the Contractor has provided written notification of differing site conditions as provided in Subsection 104.06, “Notification of Differing Site Conditions, Changes, and Extra Work,” and the Resident Engineer determines that differing site conditions exist, payment will be made in accordance with Subsection 109.04, “Differing Site Conditions, Changes, and Extra Work,” and adjustments to Contract Time will be made as provided in Subsection 108.07, “Administration and Extension of Contract Time.”

104.04 SIGNIFICANT CHANGES IN THE CHARACTER OF WORK

The Engineer reserves the right to make, in writing, at any time during the work, such changes in quantities and such alterations in the work as are necessary to satisfactorily complete the Project. Such changes in quantities and alterations shall not invalidate the Contract nor release the Surety, and the Contractor agrees to perform the work as altered.

If the alterations or changes in quantities significantly change the character of the work under the Contract, whether such alterations or changes are in themselves significant changes to the character of the work or by affecting other work cause such other work to become significantly different in character, an adjustment, excluding anticipated profit, will be made to the Contract. The basis for the adjustment shall be agreed upon prior to the performance of the work. If a basis cannot be agreed upon, then an adjustment will be made either for or against the Contractor in such amount as the Engineer may determine to be fair and equitable.

If the alterations or changes in quantities do not significantly change the character of the work to be performed under the Contract, the altered work will be paid for at the unit price as bid by the Contractor.

The term “significant change” shall be construed to apply only to the following circumstances:

- When the character of the work as altered differs materially in kind or nature from that involved or included in the original proposed construction; or
- When a major item of work, as defined in Subsection 101.05.BC, is increased in excess of 125 percent or decreased below 75 percent of the original Contract quantity. Any allowance for an increase in quantities shall apply only to that portion in excess of 125 percent of original Contract item quantity, or in case of a decrease below 75 percent, to the actual amount of work performed.

If directed changes require additional time to complete the Project, adjustments in the Contract Time will be made as provided by Subsection 108.07, “Administration and Extension of Contract Time.”

Payment for changed major item quantities or altered work will be made as provided in Subsection 109.03, “Payment for Increased or Decreased Quantities,” or Subsection 109.04, “Differing Site Conditions, Changes, and Extra Work,” as appropriate.

104.05 SUSPENSION OF WORK ORDERED BY THE RESIDENT ENGINEER

The Resident Engineer may suspend all or any portion of the work for any reason during performance of the Contract. Suspension of all or any portion of the work will be done by written Shut Down Order to the Contractor.

If the performance of all or any portion of the work is suspended or delayed by the Resident Engineer in writing for an unreasonable period of time (not originally anticipated, customary, or inherent to the construction industry) and the Contractor believes that additional compensation, Contract Time, or both is due as a result of such suspension or delay, the Contractor shall submit to the Resident Engineer in writing a request for adjustment within 7 calendar days of receipt of the notice to resume work. The request shall set forth the reasons and support for such adjustment.

Upon receipt, the Resident Engineer will evaluate the Contractor's request. If the Resident Engineer agrees that the cost and/or time required for the performance of the Contract has increased as a result of such suspension and the suspension was caused by conditions beyond the control of and not the fault of the Contractor, its suppliers, or subcontractors at any approved tier, and not caused by weather, the Resident Engineer will make an adjustment (excluding profit) and modify the Contract in writing accordingly. The Contractor will be notified of the Resident Engineer's determination whether or not an adjustment of the Contract is warranted.

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

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

If the Contractor has submitted a request for adjustment within the time prescribed and the Resident Engineer determines that an adjustment is warranted, payment will be made as provided in Subsection 109.04, "Differing Site Conditions, Changes, and Extra Work," and adjustments to Contract Time will be made as provided in Subsection 108.07, "Administration and Extension of Contract Time."

104.06 NOTIFICATION OF DIFFERING SITE CONDITIONS, CHANGES, AND EXTRA WORK

The Contractor shall notify the Resident Engineer of alleged changes to the Contract due to the following before beginning or continuing with the affected work:

- Differing site conditions,
- Altered work beyond the original Work,
- Department action that changed the Contract requirements, or
- Extra work.

The Contractor shall discontinue performance of affected work and not incur additional expenses on alleged changes to the Contract, unless otherwise directed by the Resident Engineer in writing.

A. Verbal and Written Notice of Intent to File Claim

The Contractor shall immediately notify the Resident Engineer verbally of the alleged differing site condition, change, or extra work and submit the following

information to the Resident Engineer in a written Notice of Intent to File Claim within 7 calendar days of encountering the alleged change or action:

- The date of occurrence and the nature and circumstances of the occurrence that constitute a change;
- Name, title, and activity of each Department representative knowledgeable of the alleged change;
- Identify any documents and the substance of any oral communication involved in the alleged change;
- Basis for a claim of accelerated schedule performance;
- Basis for a claim that the work is not required by the Contract; and
- Particular elements of Contract performance for which compensation is requested including:
  - Pay item(s) that have been or may be affected by the change;
  - Labor, materials, or both that will be added, deleted, or wasted by the change, and equipment that will be idled or added;
  - Existing or anticipated delays and disruptions in Contract performance, procedure, or sequence;
  - Adjustments to Contract prices, delivery schedules, staging, and Contract Time estimated due to the alleged change; and
  - Estimate of the time within which the Department must respond to the notice to reduce project cost, delay, or disruption.

The Contractor's failure to provide both verbal and written notices to the Resident Engineer constitutes the Contractor's waiver of the right to file claims resulting from an alleged change.

B. Contract Work Continuation and Claim Response

After notifying the Resident Engineer, the Contractor shall not begin work affected by the alleged change. Continue diligent prosecution of unaffected work required by the Contract.

The Resident Engineer will investigate the Notice of Intent to File Claim. Within 10 calendar days after receipt of the notice, the Resident Engineer will respond in writing to the Contractor for the following purposes:

- Confirm that a change occurred and, if necessary, direct the Contractor's further performance;
- Deny that a change occurred and, if necessary, direct the Contractor's further performance; or
- Advise the Contractor that the notice did not include adequate information, and identify additional required information and the date for its submission for further review by the Resident Engineer. The Resident Engineer will review the additional information and respond to the Contractor within 10 calendar days after receipt of the amended notice.

The Resident Engineer will not adjust the Contract for claims of increased costs or time extensions for delay resulting from the Contractor's failure to submit the additional requested information.

104.07 MAINTENANCE OF TRAFFIC

The Contractor shall keep all roads open to all traffic as shown on the Plans. If required by the Contract, or approved by the Resident Engineer, the Contractor may detour traffic on an approved detour route. The Contractor shall maintain the section of the Project used by traffic in a safe and accommodating condition. The Contractor shall provide, erect, and maintain barricades, warning signs, delineators, striping, flaggers, and pilot cars in accordance with the traffic control plan, the MUTCD, and Section 880, "Construction Signing and Traffic Control."

The Contractor shall maintain the road improvements, including all temporary approaches or crossings and intersections with trails, roads, streets, businesses, parking lots, residences, garages, farms, and other necessary features, at no additional cost to the Department. The Department will not require the Contractor to perform snow and ice removal during winter work suspensions. The Department will pay for providing, installing, and maintaining traffic control in accordance with Section 880, "Construction Signing and Traffic Control."

The Department will provide additional compensation for the following maintenance activities:

A. Maintenance of Traffic During Suspension of Work

(1) Suspensions Ordered by the Resident Engineer

The Contractor shall construct and open Project sections and temporary roadways to traffic as agreed between the Contractor and the Resident Engineer during the suspension period.

During the suspension period, the Department will maintain the temporary roadway and Project sections.

When work resumes, the Contractor shall replace or restore any work or materials lost or damaged because of traffic's temporary use of the Project, and remove work or materials used for the Project's maintenance. The Contractor shall complete the Project as if the work had been continuous and without interference. The Department will pay for additional work caused by the suspension and beyond the Contractor's control at contract unit prices or as extra work.

(2) Other Suspensions of Work

If the Resident Engineer suspends work for the following reasons, the Contractor shall incur all costs for maintenance of the roadway to accommodate traffic during the suspension period, excluding snow and ice removal:

- Seasonal or climatic conditions;
- The Contractor's failure to correct conditions unsafe for the workers or the general public;
- The Contractor's failure to implement direction from the Resident Engineer; or
- Other reasons caused by the Contractor.

B. Maintenance Directed by the Resident Engineer

The Department will pay for directed special maintenance for the benefit of traffic, not otherwise required by the Contract, by contract unit prices or in accordance with

Subsection 104.04, "Significant Changes in the Character of Work." The Resident Engineer will determine the special maintenance work.

104.08 RIGHTS IN AND USE OF MATERIALS FOUND ON THE WORK

The Resident Engineer may authorize the Contractor to use material found in the excavation suitable for completing work items. The Department will pay the Contractor for the removal of material at the corresponding contract unit price and for the placement of material at the corresponding contract unit price.

The Department will not charge the Contractor for the material used on the Project. The Contractor shall replace the removed material with material approved by the Resident Engineer and compact replacement material to the density for roadway embankment construction in accordance with the Contract requirements, at no additional cost to the Department. The Department will not allow the Contractor to excavate or remove material within the right-of-way, but outside the grading limits without the Resident Engineer's written approval.

Unless otherwise required by the Contract, the Contractor may temporarily use material from structure removals in the erection of the new structure. Do not cut or damage temporarily used material without approval of the Resident Engineer.

104.09 REMOVAL AND DISPOSAL OF SALVAGED MATERIALS, STRUCTURES, AND OBSTRUCTIONS

Unless otherwise required by the Contract, all salvaged material shall become the property of the Contractor. Ownership of salvaged materials implies the responsibility to dispose of the salvaged material in accordance with all applicable local, state, and federal rules and regulations. The Department will not allow the Contractor to bury or otherwise dispose of material within the Project or on any publicly owned property without the Resident Engineer's prior written approval.

104.10 FINAL CLEAN UP

The Resident Engineer will not assign a Completion Date until the Contractor completes the work and removes from the right-of-way all machinery, equipment, surplus and discarded materials, rubbish, and temporary structures. Remove stumps or portions of trees, cut all brush and weeds within the right-of-way, and leave the Project and borrow pits in a neat condition as approved by the Resident Engineer. Do not dispose of cleared material on property adjacent to the right-of-way. Dispose of all waster generated on the Project in accordance with all applicable local, state, and federal rules and regulations.

Finish all areas or slopes in a neat condition, approved by the Resident Engineer. Repair any areas, slopes, or turf damaged by operations, at no additional cost to the Department. The Resident Engineer will not assign a Completion Date until the Contractor achieves Final Stabilization, as determined by the Resident Engineer, in accordance with the requirements of the Contract. The Department considers the cost of final cleanup as incidental to other relevant Contract Items.

104.11 RESTORATION OF SURFACES OPENED BY PERMIT

The Department reserves the right, at any time, to allow construction or reconstruction of any utility service within the Project, or to grant permits to public utility companies for utility service construction or reconstruction or to authorities of the municipality where the Project is located. The Contractor is not entitled to any damages from the Department, except in accordance with Subsection 108.07, "Administration and Extension of Contract Time," for delay due to utility service construction or reconstruction by a third party. The Contractor shall make repairs, in accordance with Contract requirements, to work due to utility service access, and the Resident Engineer will direct and the Department will pay for work in accordance with Subsection 104.04, "Significant Changes in the Character of Work," or as otherwise required by the Contract.

The Department may issue permits to individuals, firms, or corporations wanting to place a utility, construct a driveway, make a curb-cut, or otherwise access the Department's highway right-of-way. The Contractor shall allow parties with a permit to access the highway right-of-way.

104.12 CONTRACTOR'S RESPONSIBILITY FOR WORK

Until the Resident Engineer assigns a Completion Date, the Contractor is responsible for the Work, including change order work. The Contractor shall protect the work against damage from all causes whether from the execution or non-execution of the work, except as described in Subsection 104.07.B(1), "Suspensions Ordered by the Resident Engineer."

The Contractor shall rebuild, repair, restore, and make good all losses or damage to any portion of the permanent or temporary work occurring before the Resident Engineer assigns a Completion Date (at no additional cost to the Department), except damage to permanent work caused by the following:

- Acts of God,
- Acts of a public enemy,
- Acts of governmental authorities, or
- Damage by a third party to permanent work completed by the Contractor and paid and placed in to service by the Department.

These damage exceptions shall not apply if the Contractor does not take reasonable precaution or exercise sound engineering and construction practice in performing the work.

If the Contractor experiences delays to the performance of the work as a result of damage by others, the Resident Engineer will evaluate a time extension in accordance with Subsection 108.07, "Administration and Extension of Contract Time." If permanent work is damaged by a third party and the Contractor recovers payment from the third party, the Department will not pay the Contractor for the same damages.

The Department considers the Contractor responsible for correcting or replacing any defective work or materials in accordance with Subsection 105.12, "Removal of Unacceptable and Unauthorized Work," and any damage resulting from the Contractor's operations or negligence.

The Contractor shall provide a competent supervisor experienced in the Project scope

of work and trained in accordance with all applicable local, state, and federal laws and regulations. Delegate authority to the supervisor to make binding decisions on behalf of the Contractor and to provide labor, equipment, and material required for effective Project work progress. The Department expects the supervisor to be available full time for contact and communication on the Project.

104.13 ENVIRONMENTAL PROTECTION

The Contractor shall comply with all local, state, and federal laws and regulations controlling pollution of the environment. Avoid pollution of streams, lakes, ponds, and reservoirs with fuels, oils, bitumens, chemicals, or other harmful materials and pollution of the atmosphere from particulate and gaseous matter within the Project and Contractor operated off site facilities. Avoid impacts to listed endangered species, threatened species, and the critical habitats of both.

The Department will not allow fording of streams unless otherwise approved by the Resident Engineer and performed in a manner that minimizes stream siltation.

For work areas or pits located in or adjacent to streams, the Contractor shall separate the work from the main stream by dike or barrier to keep sediment from entering the stream. Exercise care during the construction and removal of barriers located in or near streams to minimize siltation of the stream.

The Contractor shall treat water from aggregate washing or other work resulting in sediment by filtration, settling basins, or other means to reduce the sediment concentration of the discharge to no more than that of the stream or lake receiving the discharge.

The Contract shall address other requirements for temporary and permanent erosion, sedimentation, and storm water pollution controls in accordance with Chapter 200, “Earthwork and Roadside Development.”

104.14 CONTRACTOR’S RESPONSIBILITY FOR UTILITY PROPERTY AND SERVICES

For Contractor work areas adjacent to properties of railroad, telephone, power companies, other utilities or facilities located within the Project, the Contractor shall not begin work until completing Contract required arangements for the protection of the properties or facilities. Avoid damage to these properties or facilities that could result in considerable expense, loss or inconvenience.

The Contractor shall cooperate with owners of underground or overhead utility lines during utility removal or relocation operations to allow these utility operations reasonable progress, minimal duplication of work, and avoidance of unnecessary service interruptions.

The Contractor shall comply with the Underground Facilities Damage Prevention Act (63 O.S. § 142.1 et. seq.), including amendments. Obtain copies from the Resident Engineer.

For interruptions to water or utility services from accidental breakage, or for exposed or unsupported lines, the Contractor shall immediately notify the proper authority. The Contractor shall cooperate with the proper authority to promptly restore service. The Department will not allow an interruption to water service to continue after working

hours. Maintain access to fire hydrants for the Fire Department at all times and do not stockpile material within 15 ft [4.6 m] of a fire hydrant.

The Contractor shall verify the location of all water services, water mains, sanitary sewers and other utilities shown on the Plans. Damage to these facilities from Contractor operations is the responsibility of the Contractor in accordance with the Underground Facilities Damage Prevention Act (63 O.S. § 142.1, et seq.).

104.15 VALUE ENGINEERING PROPOSALS BY THE CONTRACTOR

A. General

Cost savings from Value Engineering Proposals (VEP) offered by the Contractor and approved by the Department shall be shared equally between the Contractor and the Department.

Do not anticipate the Department's approval of a VEP in submitting a Proposal. Contract unit prices shall reflect Contract requirements. If the Department rejects a VEP, complete the Project at the contract unit prices.

If the Department determines that the time for review and response is insufficient, as indicated in the Contractor's submittal in accordance with Subsection 104.15 C, "Submittal of Proposal," the Department will promptly notify the Contractor. The Department will evaluate the need for a non-compensable delay adjustment to the Contract, if the Department's additional review and response time affects the Contractor's schedule.

The Contractor shall have no claim against the Department for compensable or non-compensable delay to the Contract based on the Department not responding within the time indicated in the submittal in accordance with Subsection 104.15.B, "Submittal of Conceptual VEP," and Subsection 104.15 C, "Submittal of VEP," if the Department requires additional information from the Contractor to complete the review.

The Department considers as valid, a VEP that could produce a savings to the Department without impairing essential functions and characteristics of the facility, including but not limited to, service life, economy of operation, ease of maintenance, desired appearance, and safety.

To avoid unnecessary costs in preparing a VEP, the Contractor may submit a Conceptual VEP to the Resident Engineer for the Department's review. This review need not address the total economics of the proposal, nor the specific engineering design(s).

B. Submittal of Conceptual VEP

Submit a conceptual VEP with the following material and information:

1. A statement identifying the submittal as a conceptual VEP.
2. A brief description of the difference between the Contract requirements and the proposed change with the cooperative advantages and disadvantages, including:

    2.1. Effects on service life,
    2.2. Economy of operations,
    2.3. Ease of maintenance,

2.4. Desired appearance, and
2.5. Safety.

3. An estimate of the Contract costs and quantities compared to the new costs and quantities generated by the VEP.
4. A statement establishing the date that the Department must respond to the conceptual VEP to obtain the maximum cost reduction for the Contract.
5. A statement estimating the impact of the VEP on the Contract completion time.
6. A description of any previous use or testing of the alternative means or methods proposed, and the conditions and results.

If the Department rejects the conceptual VEP, the Contractor shall not pursue the matter any further. If the Department approves the conceptual VEP, the Contractor may proceed with the VEP. Approval of the conceptual VEP will not obligate the Department to approve the VEP.

C. Submittal of VEP

Submit a VEP with the following material and information:

- A statement identifying the submittal as a VEP.
- A brief description of the difference between the Contract requirements and the proposed change, and the cooperative advantages and disadvantages, including:
  - Effects on service life,
  - Economy of operations,
  - Ease of maintenance,
  - Desired appearance, and
  - Safety.
- A complete set of plans and specifications prepared and sealed by an Oklahoma registered Professional Engineer that show the proposed revisions relative to the original Contract features and requirements.
- A complete analysis indicating the Contract costs and quantities to be replaced by the VEP compared to the new costs and quantities generated by the VEP.
- A statement establishing the date that the Department must execute a Change Order adopting the VEP to obtain the maximum cost reduction for the Contract.
- A statement estimating the impact of the VEP on the Contract completion time.
- A description of any previous use or testing of the alternative means or methods proposed, and the conditions and results. If previously submitted on another Department project, indicate the date, project number, and the action taken by the Department on the VEP.

D. Conditions

The Department will consider the Contractor's VEP that meets all of the following conditions:

- The VEP applies only to the Contract referenced in the VEP and becomes the property of the Department. The VEP shall contain no restrictions imposed by the Contractor on the VEP's use or disclosure. The Department retains the right to use, duplicate, and disclose any data necessary from the VEP and use an accepted VEP on other projects without obligation to the Contractor. The Department will not deny the Contractor's rights provided by law for patented material or process.

- If the Department is already considering certain revisions to the Contract or has approved Contract changes that the Contractor subsequently incorporates in a VEP, the Department will reject the VEP with no obligation to the Contractor.
- The Contractor shall have no claim against the Department for additional costs or delays resulting from the Department's rejection of a VEP, including but not limited to, development costs, loss of anticipated profits, increased material, or labor costs.
- The Department will determine if a VEP qualifies for consideration and evaluation. The Department may reject any VEP that requires excessive time or costs for review, evaluation, or investigation, or that is not consistent with the Department's design policies and criteria for the Project.
- The VEP shall not include experimental features, but proven features used under similar conditions on other projects or locations approved by the Department.
- The Department will not consider VEP that include options already required by the Contract.
- The cost savings generated by the VEP must be sufficient to warrant the additional cost of the Department's review and evaluation of the VEP.
- The Department will not consider a VEP that changes the type or thickness of the pavement structure.
- The Contractor may submit a VEP for an approved subcontractor. Subcontractors may not submit a VEP, except through the Contractor.
- The Contractor shall promptly provide additional information to the Department for evaluation of the VEP. The Department will reject a VEP if the Contractor does not promptly submit additional information. For a VEP with design changes, the additional information may include results of field investigations and surveys, design calculations, and field change sheets.

The Resident Engineer will reject all or any portion of work performed for an approved VEP, if the work yields unsatisfactory results. The Resident Engineer will direct the removal of rejected work and require the Contractor to proceed with work in accordance with the original Contract requirements. The Resident Engineer will not pay for work performed for the VEP or for removal of unsatisfactory work. If the Resident Engineer approves modifications to the VEP to adjust to field conditions, the total amount payable for the VEP work will be limited to the amount of the removed Contract units in accordance with the original Contract requirements. The Contractor shall have no claim against the Department for additional costs or delays resulting from the Department's rejection of work or limitation of payment for work.

E. Payment

If the Department approves a VEP, the Resident Engineer will authorize a Change Order with the changes and payment requirements. The Department will pay the Contractor as follows:

1. For revised work, by changes in quantities of Contract pay items, new agreed pay items, or both, in accordance with the Contract.
2. For savings, the Department will pay the Contractor 50 percent of the VEP savings, calculated as the difference between the cost of the revised work and the cost of the related work required by the original Contract at contract unit prices. The Department will pay the 50 percent Value Engineering cost savings

to the Contractor in a lump sum as soon as savings have been earned and quantities calculated.

3. If requested by the Contractor, the Department may consider payment to the Contractor for a maximum of one-half of the Contractor's cost of development, design, and preparation of the VEP. If approved, the Department will add this amount to the lump sum payment for savings.

104.16 RAILROAD-HIGHWAY GRADE CROSSINGS

For work on railroad right-of-way or on right-of-way occupied jointly by the highway and railroad, the Contractor shall take precautions to ensure the safety of railroad operations. The Contractor and the Contractor's Surety shall indemnify and save harmless the railroad company and Department from all actions or claims of any character, name, or description brought for or on account of any injuries or damages received or sustained by any person, persons, or property resulting from any act, omission, neglect or misconduct of the Contractor or the Contractor's employees in the performance of the work.

104.17 RAILROAD-HIGHWAY GRADE SEPARATION STRUCTURES AND APPROACHES

A. General

The construction of grade separation structures and approaches is a joint undertaking of the Department and the railroad company whose tracks are crossed, and representatives of the railroad company shall have full authority to make inspections of the work as it progresses.

Unless otherwise required by the Contract for the Project or by a separate Right-of-Entry Agreement between the Contractor and the railroad company, the Contractor shall provide written notification to the railroad company identified by the Contract requirements, at least 10 working days before beginning work on the railroad company's property. In addition, notify the railroad company 48 hours in advance of beginning construction of falsework over, or of construction of piers adjacent to, the railroad company tracks.

During all work affecting the railroad company, the Contractor shall cooperate to the fullest extent possible. The Contractor shall plan and execute the work creating the least interference with the traffic and operations of the railroad company. The Department requires the Contractor to provide a clear area for the maintenance of railroad traffic during construction, kept free at all times of any falsework, equipment, material, or other obstructions. Unless otherwise shown on the Plans, or on a separate Right-of-Entry Agreement between the Contractor and the railroad company, provide a minimum vertical clearance of 22 ft [6.6 m] above the top of the highest rail and a minimum horizontal clearance of 8½ ft [2.6 m] on each side of the centerline of the tracks, measured at right angles to the tracks. The Contractor shall not disrupt the track drainage system. The Department will not allow equipment or material to remain in the track ditches and obstruct the flow of water. The Contractor shall immediately remove any material spilled into the ditches.

If the railroad company allows the Contractor, by written agreement, to encroach on the clearances specified in this subsection, the Contractor shall take precautions and

erect and maintain telltales or warning devices required by the railroad company, at no additional cost to the Department.

If the Contractor is required or elects to haul material across the railroad company's tracks, the Contractor shall arrange with the railroad company for necessary private crossings and provide for the installation, maintenance, use, and protection of crossings, at no additional cost to the Department.

The Contractor shall ensure the safety of the railroad operations through the Project. The Contractor shall prepare, and submit for approval by the Department and the railroad company, detailed plans for all falsework over the tracks, or caissons, or sheeting for piers, or abutments adjacent to or under the tracks before beginning work. After obtaining approval of the detailed plans from the Department's Bridge Engineer and the railroad company, the Contractor may construct the falsework, sheeting, or caissons in accordance with the approved detailed plans. The Department neither accepts, nor assumes, any liability for defects or errors in the Plans by approval of the Contractor's detailed plans. The Department makes no warranty, either expressed or implied, as to the accuracy or fitness of the Contractor's detailed plans.

The Contractor is responsible to the railroad company for all damage to railroad property resulting from the Contractor's operations, and may be subject to additional conditions required in the railroad company's Right-of-Entry Agreement. The Department will not pay the Contractor's Final Estimate until the Contractor provides the Resident Engineer satisfactory evidence, in the form of a photocopy, of a letter sent by the Contractor to the railroad company by certified mail notifying the railroad company of completion of the work required by the Contract. The letter shall indicate that the railroad company has 30 calendar days to notify the Contractor and the Department of potential claims. Upon completion of the work, the Contractor shall remove all equipment, unused materials, rubbish, and temporary structures, and leave the premises in a condition satisfactory to the railroad company and the Department.

If included in the Contract requirements, certain construction operations may necessitate the suspension of railroad traffic. Avoid any disruptions of train schedules by performing and completing work as quickly as possible. Before beginning work, the Contractor shall advise and obtain approval from the railroad company and the Department of the proposed method, the amount and character of equipment, and the probable time required to complete the work. The Department's approval shall not relieve the Contractor of the responsibility for the safety of the work method or equipment or the completion of the work as required by the Contract.

B. Overpass (Highway Overhead Bridge)

The Department will provide a vertical clearance of 50 ft [15 m], measured from the base of the rail, for telegraph, telephone, and signal services. If the Contractor requires more clearance, the Contractor shall provide additional clearance, at no additional cost to the Department.

C. Underpass (Railroad Overhead Bridge)

The Department will provide a vertical clearance of 30 ft [9 m], measured from the base of the rail, for telegraph, telephone, and signal services crossing over the proposed construction. If the Contractor requires more clearance, the Contractor shall provide additional clearance, at no additional cost to the Department.

D. Railroad Company Requirements

The railroad company may, as a condition for working on or over railroad right-of-way, impose both vertical and horizontal clearance requirements. The railroad company's specific clearance requirements for working on or over railroad right-of-way will be contained in the Right of Entry Agreement between the Contractor and the railroad company.

104.18 RAILROAD FLAGGING

The Contractor shall reimburse the railroad company directly for the cost of all railroad flagging required and provided by the railroad company for work on railroad property. The Contractor shall include the cost of flagging in the contract unit prices for other relevant pay items unless a pay item for *Railroad Flagging* is included in the Proposal Forms.

The Department will not pay the Contractor's Final Estimate until the Contractor provides satisfactory evidence, in the form of a notarized certificate that the Contractor reimbursed the railroad company for flagging services provided by the railroad company.

SECTION 105
CONTROL OF WORK

105.01 AUTHORITY AND DUTIES OF THE RESIDENT ENGINEER

The Resident Engineer will decide questions about the following issues:

- Quality and acceptability of materials provided by the Contractor,
- Quality and acceptability of work performed by the Contractor,
- Rate of work progress,
- Interpretation of the Contract requirements, or
- Compliance of work with the Contract requirements.

A. Suspension of Work

The Resident Engineer may suspend part or all of the work if the Contractor fails to do the following:

- Correct conditions unsafe for the project personnel or public,
- Perform requirements of the Contract, or
- Respond to directives from the Resident Engineer.

The Resident Engineer may also suspend part or all of the work based on the following:

- Periods of unsuitable weather,
- Conditions the Resident Engineer considers unsuitable for the prosecution of the work, or
- Any other condition or reason the Resident Engineer determines in the Department's best interest.

B. Appeal Process

For disagreements with any decision of the Resident Engineer, appeal the decision in accordance with established dispute resolution procedures specified in Subsection 105.18, "Claims for Adjustment," and the Special Provisions.

C. Engineering Details

The Resident Engineer is responsible for implementing the Project's engineering details and is responsible for inspection and documentation of the work and ensuring work in accordance with Contract requirements. The authority of the Resident Engineer includes:

- Making binding decisions based on Contract requirements on behalf of the Department;
- Selecting and delegating authority to the Department's representative on the Project;
- Rejecting defective materials or workmanship; and
- Suspend work not in compliance with Contract requirements.

D. Removal of Contractor Staff

The Resident Engineer may direct the Contractor to remove any of the Contractor's or subcontractors' supervisors, foremen, or other employees for any of the following reasons:

- Failure or refusal to follow directives from the Resident Engineer,
- Safety violations,
- Poor workmanship, or
- Other causes.

The Resident Engineer will direct removal by written notice to the Contractor, effective upon the Contractor's receipt of the notice.

105.02 PLANS AND WORKING DRAWINGS

A. General

The Department will provide plans showing details of all structures, lines, grades, typical sections, and a summary of pay items listed on the Proposal Forms.

Prepare working drawings and work plans, as required by the Contract and as needed, to adequately control, construct, and inspect the work. When applicable, working drawings shall include the following:

- Traffic control drawings,
- False work drawings,
- Coffer dam drawings,
- Steel sheet piling drawings,
- MSE retaining wall drawings,
- Post tensioned concrete structure drawings,
- Pre-stressed concrete member shop drawings,
- Pre-cast structure drawings (excluding pipe),
- Structural steel shop drawings
- Structural steel transportation drawings,
- Anchor bolt layouts,

- Erection drawings, or
- Any combination of these items.

When applicable, work plans shall include the following:

- Stress sheets for post tensioning,
- Painting plans,
- Plans for drilling shafts,
- Mix designs,
- Plans for pile hammers,
- Other equipment lists,
- Quality control plans, or
- Site specific erosion control plans.

The Contractor shall keep and make available one set of plans, approved working drawings, and work plans on the Project for the duration of the Project.

The Department will review working drawings and work plans before the Contractor performs any work shown on those drawings or plans. Do not make changes or deviations from the reviewed working drawings or work plans without prior approval by the Resident Engineer. The Department's reviews do not relieve the Contractor of responsibility for the successful completion of the work.

The Department considers the cost of providing work drawings and work plans to be included in the contract unit prices of the relevant pay items.

B. Submissions

The Contractor shall submit working drawings and work plans to the appropriate Design Division. The Engineer will review working drawings and work plans and return to the Contractor. If returned for correction, the Contractor shall correct and resubmit. Unless otherwise required by the Contract, for the Engineer's review, allow at least six weeks per submission of railroad structures and at least four weeks per submission of all other structures. Submit complete sets of working drawings and work plans, except if submitting corrections or revisions. The Engineer will not review partial sets of working drawings or work plans without prior approval.

Submit working drawings and work plans with a transmittal letter including the following:

- Project number,
- Job/piece number,
- County,
- Structure number,
- A list of enclosed working drawing sheets, and
- A list of changes, when applicable.

C. Working Drawing Requirements

The Contractor shall use drafting and lettering on working drawings clearly legible under field conditions and when microfilmed. Orient working drawings similar to the drawings shown on the Plans.

The Contractor shall use sheets no larger than 24 in × 36 in [610 mm × 920 mm] for drawings. Include a title block in the lower right hand corner of each page. The title block shall include the following:

- Project number,
- Job/piece number,
- County,
- Location description,
- Structure number,
- Sheet number,
- Contractor's name, and
- The name of the supplier, fabricator, or manufacturer supplying material, product, or equipment to the Project, when applicable.

Provide a space 2 in wide × 3 in high [50 mm × 75 mm] near the title block for the approval stamp. For revisions of previously approved drawings, list all revisions and include a description of each revision near the title block on each sheet.

Place the initials of the drafter and checker on each revised working drawing sheet and the date completed. The drafter and checker shall be two separate individuals qualified in drafting and checking the required Contract item details.

On the working drawings, the Contractor shall describe all materials intended for use on the Project, including the specifications for materials and other unique characteristics and ordering information.

Working drawings, including necessary calculations, and changes to the Project design shall bear the seal and signature of a State of Oklahoma registered professional engineer proficient in the relevant design field. Use the following matrix to determine if working drawings require approval, signature, and seal of a State of Oklahoma registered professional engineer. If specific Standard Specifications apply to required working drawings and the Standard Specifications differ from those in the following matrix, follow the requirements of the specific Standard Specifications:

Table 105:1
Working Drawing Approval Guide

Working Drawings for:	Requires Registered Professional Engineer's Signature, Seal, and Date	Requires Department Approval
Alternate or optional designs submitted by Contractor	Yes	Yes
Supplementary fabrication and shop drawings for structural items	No, unless shown on the Plans	See applicable item
Contractor proposed temporary facilities that affect the public safety not shown on the Plans	Yes	Yes

105.03 CONFORMITY WITH PLANS AND SPECIFICATIONS

Work performed and materials provided shall be uniform in character and meet the dimensions and material requirements within Contract required tolerances. If a maximum or minimum tolerance value or both as specified in the Contract, control the production and processing of material and work performance to ensure the statistically consistent quality of the finished product.

To assure compliance with these requirements, provide quality control personnel as necessary. The Contractor shall be responsible for the process control of all material during handling, blending, mixing, and placing operations to produce an acceptable product. The Resident Engineer will not direct to the Contractor or producer to set dials, gauges, scales, or meters. However, the Resident Engineer may advise the Contractor about operations or sequence of operations that will result in noncompliance with Contract requirements.

If material provided, work performed, or the finished product does not conform with the Contract, but meets the design purpose, the Resident Engineer will determine the conditions that the material, work, or product will be approved, unless Contract requirements address this determination. If the Resident Engineer makes the determination, the Resident Engineer will document the basis of approval by Change Order. The Change Order will include an adjustment in the contract unit price for material, work, or product necessary to support the Resident Engineer's determination.

For temporary pavements, quality characteristics of materials and construction will be measured, except for smoothness. The Department will withhold deductions for deficiencies the same as those for permanent pavements. Upon removal of temporary pavements, if no significant failures occurred in these pavements during required use, the Resident Engineer will release deductions withheld for deficiencies. If failure occurs, the cause of failure need not be associated with deficiencies for the Resident Engineer to deny release of deductions withheld. The Contractor is responsible for maintenance and reconstruction of the temporary pavement during required use, if necessary.

If the material, work performed, or the finished product does not conform with the Contract requirements and results are unsatisfactory, the Resident Engineer will direct the Contractor to remove and replace, or otherwise correct, the material, work, or product at the Contractor's expense.

If the Contract allows the acceptance of material or work not in compliance with the minimum requirements, the Resident Engineer will use pay adjustment factors for the material or work included in the applicable measurement and payment section of the Contract.

105.04 COORDINATION OF PLANS, SPECIFICATIONS, AND SPECIAL PROVISIONS

These Plans, Standard Specifications, Supplemental Specifications, Special Provisions, and all supplementary documents are essential parts of the Contract and a requirement in one is as binding as if in all. The Department intends them to be complementary and to describe and provide a complete Contract. In case of discrepancy between these Contract documents, the order of precedence is as follows:

For Dimensions:	**For Information:**
Project Plans	Project Specific Special Provisions
Standard Plans	Project Plans
Calculated	General Use Special Provisions
Supplemental Specifications	Standard Plans
Standard Specifications	Supplemental Specifications
Scaled	Standard Specifications
External Technical Documents	External Technical Documents

Oral changes received at pre-bid conferences are not binding. Binding changes must be received by the Contractor in writing and issued by the Department as addenda to the Proposal Forms.

The Contractor shall not take advantage of any apparent error or omission in the Contract. If the Contractor discovers an error or omission, the Contractor shall promptly notify the Engineer so the Department can make corrections and interpretations necessary to fulfill the intent of the Contract. If plan notes appear to be in conflict or require clarification, contact the Engineer for resolution before starting work.

105.05 COOPERATION BY CONTRACTOR

The Department will provide the Contractor at least two sets of Plans and one copy of the Contract. Make one set of Plans, Standard Specifications, Supplemental Specifications, and Special Provisions available on the Project for the duration of the Contract.

The Contractor shall continually manage and facilitate the work on the Project and shall cooperate with the Resident Engineer, Inspectors, and contractors on other Department projects.

105.06 COOPERATION WITH UTILITIES

The Department will identify utility items to be relocated or adjusted by the utility owner, others, or the Contractor as required by the Contract.

Utility facilities and appurtenances located within the Project will be shown on the Plans and will be relocated or adjusted at the utility owners' expense, unless otherwise required by the Contract. The locations of utilities, especially for underground installations, are provided by the utility owners and may not be exact. The Contractor shall employ work procedures that account for the possible inaccuracy of these representations.

The Contractor shall cooperate with utility owners in the removal and relocation of underground or overhead utility facilities to minimize interruption to utility service and duplication of work by the utility owners.

The Contractor shall use work procedures to identify and protect utility facilities or appurtenances that will remain in place during construction.

The Department will notify utility agencies, utility companies, and pipeline owners affected by the Contract work and will provide for necessary adjustments of utility fixtures and appurtenances within or adjacent to the construction limits by the time limits listed in the Proposal Forms or before the Notice to Proceed, whichever occurs first. The Contractor may request a waiver of these requirements to facilitate beginning work, if Project conditions can accommodate a waiver.

If the Contractor interrupts utility services due to breakage within the Project, the Contractor shall notify and cooperate with the affected utility authorities until service has been restored. Do not start work around fire hydrants until the local fire authority approves plans for continued service.

If the Contractor's carelessness or omissions cause damage to utilities, the Contractor shall not repair the utilities but shall be financially responsible for the repair of the utilities to a condition similar or equal to that existing before the damage occurred.

Notify the Resident Engineer if utility facilities or appurtenances, not included in the Contract, are encountered. The Resident Engineer will determine if adjustment or

relocation of the utility is necessary to accommodate construction and will arrange for additional work necessary to continue the Project with the utility owner or the Contractor.

105.07 COOPERATION BETWEEN CONTRACTORS

The Department reserves the right to perform other work within or near the Project.

If the Commission awards separate contracts within the same Project limits, the respective Contractors shall minimize interference with the progress or completion of the work being performed by the other contractors. Contractors working on the same Project shall coordinate operations to facilitate prompt completion of the Contract work. The Department may declare in default Contractors failing to cooperate with other contractors.

The Contractor shall minimize interference with the operations of contractors under other contracts on the same Project by:

- Properly arranging the work,
- Timely placing and disposing the material being used,
- Joining work with that of the others in an acceptable manner, and
- Performing work in proper sequence to that of the other contractors.

At Contract required grade separations, bridge structures, or both, the grading contractor shall immediately start fills and grading operations at abutments and shall complete the fills adjacent to abutments without delay.

At Contract required grade separation structures with roadway excavation through the structure location, the grading contractor shall immediately start excavation and grading operations at these locations and shall complete this work without delay. Perform excavation at these locations as shown on the underpass Plans. Do not extend excavation work beyond the width shown on the underpass Plans.

The bridge contractor shall complete the bridge boxes and the backfills around the bridge boxes to the lower of the top of the box or to the natural ground line as soon as possible after the Contract Notice to Proceed. The grading contractor shall complete the roadway fills over the bridge boxes.

If the grading contractor completes the roadway fills (except for those over bridge boxes) before the bridge contractor completes the bridge boxes, the bridge contractor shall complete the roadway fills over the bridge boxes to the typical section and subgrade line shown on the Plans.

Each contractor is responsible for all work performed under the respective Contract and shall save and hold harmless the Department, its officers, agents and employees from any and all damages or claims arising from the Contractor's conduct and experience and based on inconvenience, delay or other loss because of the presence of other contractors working with the Project.

105.08 CONSTRUCTION STAKES, LINES AND GRADES

The Contract requirements will establish if the Contractor shall provide construction stakes, lines, and grades, in accordance with Section 642, "Construction Staking."

105.09 (VACANT)

105.10 DUTIES OF THE PROJECT INSPECTORS

The Department will authorize Project Inspectors to inspect the Work. Inspection may involve any part of the Work, including the preparation, fabrication, or manufacturing of the materials to be used. Project Inspectors are not authorized to alter or waive the Contract requirements.

105.11 INSPECTION OF WORK

The Contractor shall allow the Department access to the work and provide information and assistance required to make a complete and detailed inspection and documentation of the materials and the work. Inspections may be made by the Resident Engineer or authorized representative, the FHWA or other federal agencies, the ODEQ or other state agencies, counties, cities, and other public or private entities having supervisory, regulatory, or financial interest in the Project.

The Contractor shall make a reasonable good faith effort to perform all work, and incorporate materials into the work, in the presence of a Department representative. If a Department representative is unavailable for inspection or is otherwise absent at the time of the work, the Contractor shall document efforts to contact the Project Inspector. If the Contractor fails to provide good faith effort or document the work not inspected by the Department, the Department may require the Contractor to remove and replace the work at no additional cost to the Department. If a Department representative is given a written notice that the work was to be performed 24 hr in advance and an inspection has not been performed, the Contractor is exempt from any removal or replacement expenses.

At any time before acceptance of the work, the Contractor shall remove or uncover portions of the finished work as directed by the Resident Engineer. After inspection, the Contractor shall restore those portions of the work in accordance with the Contract requirements. If the exposed or inspected work meets Contract requirements, the Department will pay the cost of uncovering or removing, and the cost of replacing the removed work in accordance with Subsection 104.04, "Significant Changes in the Character of Work." If the exposed or examined work does not meet Contract requirements, the Contractor shall replace the removed or uncovered work with material meeting the Contract requirements at no additional cost to the Department.

For Contract work funded by another unit of government or political subdivision or any railroad company, representatives from that entity may inspect the work. These inspections are a Contract requirement, but do not make the unit of government, political subdivision, or railroad company a party to this Contract.

105.12 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK

The Department will consider work not performed in accordance with the Contract requirements unacceptable, unless accepted under the provisions of Subsection 105.03, "Conformity with Plans and Specifications." Work determined unacceptable by the Resident Engineer before the final acceptance shall be removed and replaced by the Contractor at no additional cost to the Department.

The Department will not pay for the following work until the Resident Engineer approves:

- Work performed contrary to the Resident Engineer's direction;
- Work performed beyond the Project limits, or
- Work performed without approval from the Resident Engineer.

The Contractor shall perform corrective work to meet the Contract requirements at no additional cost to the Department. If the Contractor does not perform corrective work directed by the Resident Engineer, the Resident Engineer may have unacceptable work removed and replaced by others and deduct the cost of that work from the amount of money due the Contractor.

105.13 LOAD RESTRICTIONS

The Contractor shall observe legal load restrictions if hauling materials on public roads outside the limits of the Project. A special permit does not relieve the Contractor from liability for damage resulting from moving material or equipment.

The Contractor shall not exceed legal load limits within the Project limits, unless approved in writing by the Resident Engineer. Do not operate equipment or use haul loads that cause damage to structures, roadway, or other construction. Do not store materials on any bridge deck that are in excess of the bridge design load. Provide weight and axle load information on all equipment used on the project if requested by the Resident Engineer. Obtain written permits from the Resident Engineer before crossing any bridges with equipment or other device exceeding 20,000 lb per axle. For any load, equipment, or material stored or crossing the bridge(s) provide analysis for review and approval prepared by a Professional Engineer registered in Oklahoma. Examples include, bur are not limited to: material transfer devices, milling machines, haul trucks, pavers, and conveyors. Based on the condition of the bridges on the Project, permits may require emptying the device before crossing, keeping the device's wheels on top of the bridge beams, or transporting the device on vehicles with more axles to distribute the load. Keep permits in Project records.

The Resident Engineer may restrict hauling material over any completed work within the Project limits. The Resident Engineer will not allow loads on hydraulic cement concrete construction before the minimum curing time or specified strength is obtained, in accordance with Subsection 504.04.H, "Load on Decks and Approach Slabs."

105.14 MAINTENANCE DURING CONSTRUCTION

The Contractor shall continuously and effectively perform and maintain the work until the Project is accepted. The Resident Engineer will immediately notify the Contractor of noncompliance with these Contract requirements. If the Contractor does not remedy the unsatisfactory maintenance within 24 hr of the notice, the Resident Engineer will maintain the Project by others and will deduct the cost of that maintenance from the amount of money due the Contractor.

If the Contract includes the placing material on, or using a previously constructed subgrade, base course, pavement or structure, the Contractor shall maintain the previously constructed work during construction operations.

The Department will consider the cost of maintenance work during construction and before the Project is accepted to be included in the contract unit price for the relevant pay item.

105.15 OPENING SECTIONS OF PROJECT TO TRAFFIC

The Resident Engineer may direct certain sections of work opened to traffic before completion or acceptance of the work. Opening these sections to traffic does not constitute acceptance of the work or waiver of the Contract requirements. On opened sections, the Department will compensate the Contractor for the cost of maintaining the roadway in accordance with Subsection 109.04, "Differing Site Conditions, Changes, and Extra Work." The Department will execute a change order to compensate the Contractor for additional expenses and time, if the section opening is not due to the fault of the Contractor.

If the Contractor is late in completing features of the work in accordance with the Contract or progress schedule, the Resident Engineer will give written notice establishing a time period for completing these features. If the Contractor fails to complete these features or make a reasonable effort to complete the work in accordance with the written notice, the Resident Engineer may direct all or a portion of the project opened to traffic. The Contractor shall not be relieved of liability or responsibility for maintaining the work and shall perform the remaining construction operations with minimum interference to traffic at no additional cost to the Department.

The Contractor shall repair damage to the Project, not caused by traffic or from slides, at no additional cost to the Department. Before removal of slides, the Resident Engineer will determine a removal approach and provide to the Contractor.

105.16 FURNISHING RIGHT-OF-WAY

Before construction begins, the Department will secure right-of-way and will ensure that it is available for the Contractor's unrestricted operations, except as otherwise required by the Contract.

105.17 PROJECT COMPLETION AND ACCEPTANCE

A. Substantial Completion

Substantial completion is defined as follows:

- All pavement markings and safety appurtenances have been installed,
- Traffic has been placed in its final lane configuration, and
- No further lane closures will be necessary to perform remaining Contract work.

For projects not opened to traffic, substantial completion occurs if the project is available for a subsequent project or the designated use. The Department may identify project specific features or requirements in the Contract requirements.

B. Project Completion

After the Contractor has completed the Work, the Resident Engineer will make an inspection. If all work is completed in accordance with the Contract requirements, any change order(s), or applicable supplemental agreements, the Resident Engineer will assign a Completion Date and relieve the Contractor of all construction site responsibilities.

If the inspection discloses work not completed in accordance with the Contract requirements, any change order(s), or applicable supplemental agreements, the Resident Engineer will give written notice to the Contractor of the noncompliant work found in the inspection. The Resident Engineer will not declare the Project complete

until the Contractor addresses the noncompliant work to the satisfaction of the Resident Engineer.

C. Final Acceptance

Final acceptance occurs after the Contractor executes and submits all documents, certificates, proofs of compliance, and the Final Estimate. When the Contractor submits and the Resident Engineer accepts all Contract required project documentation and the Final Estimate, the Resident Engineer will assign an Acceptance Date. Final payment will not be due to the Contractor until the Acceptance Date has been assigned. In accordance with Statutes and regulations, the Acceptance Date will govern the payment of any interest or monies due the Contractor.

D. Partial Completion

At any time during the Project, if the Contractor or a subcontractor completes a part of the Contract, the Contractor may request the Resident Engineer make a final inspection of that part. If the Resident Engineer finds that part completed in accordance with the Contract requirements, any change orders, or applicable supplemental agreements, the Resident Engineer may assign a Partial Completion Date and relieve the Contractor of further responsibility for that part. The decision to declare Partial Completion is the sole responsibility of the Resident Engineer. A Partial Completion decision by the Resident Engineer does not void or alter any terms of the Contract.

E. Partial Acceptance

The Contractor may request the Resident Engineer inspect a part of the project. Partial Acceptance may occur for a designated part of the Contract if the Resident Engineer assigns it a Partial Completion Date, determines final quantities for the designated part of the Contract, and the Contractor submits and the Resident Engineer accepts all required material certifications and documentation. Once the Resident Engineer assigns a Partial Acceptance Date and submits a progressive estimate, the Contractor shall be relieved of further responsibility for that Contract part. Once the Resident Engineer determines audited final quantities for a designated part of the Contract work and the Department pays for that work, those audited final quantities will not be revised or adjusted. If, after Partial Acceptance, the Contractor or a subcontractor damages the accepted work part, the Contactor shall repair or replace the damaged work in accordance with the Contract requirements and to the satisfaction of the Engineer at no additional cost to the Department.

105.18 CLAIMS FOR ADJUSTMENT

The Contractor may submit a claim for Contract adjustment after the Resident Engineer has received, reviewed, and denied a Contractor request for compensation, time, or both.

If the Contractor considers additional compensation due for work or material not covered in the Contract, or considers additional time due for completion of Contract requirements, the Contractor shall submit a written “Notice of Intent to File Claim” (Notice) to the Resident Engineer in accordance with Subsection 104.06, “Notification of Differing Site Conditions, Changes, and Extra Work.” The Contractor shall submit the Notice before beginning work not covered by the Contract, work caused by a change of

plan, or continuing work that has been altered by changes in methodology, location, or differing site conditions directed by the Resident Engineer.

The Department requires the Contractor to submit this Notice (no exceptions) before the submission of a claim and before beginning or continuing affected work. If the Contractor fails to submit a Notice within the time and in the manner specified in Subsection 104.06, "Notification of Differing Site Conditions, Changes, and Extra Work," the Contractor waives any claim for additional compensation. The Notice will allow the Department to evaluate options mitigating the impact of the claim.

The Resident Engineer will respond to the Notice in accordance with Subsection 104.06.B, "Contract Work Continuation and Claim Response." The Contractor shall cooperate with the Resident Engineer and provide information during the period of notification, review, and evaluation to resolve the Contract issue and avoid, if possible, further claim process actions.

If the Contractor does not give written notice and does not allow the Resident Engineer the opportunity to keep strict account of actual costs, the Contractor waives any claim for additional compensation. Notice by the Contractor, and cost accounting by the Resident Engineer shall not be construed as substantiating the validity of the claim. Within 90 days after completion of the work for which extra compensation or time has been requested, the Contractor shall submit to the Resident Engineer specific cost information justifying the request for additional compensation. Place this information on the latest edition of the Department's form entitled "Cost Breakdown for Support of Supplemental Agreement." If the Contractor does not submit a fully documented claim to the Resident Engineer within 90 days, the Department will not allow any extra compensation or additional time.

A. Requirements for Contractor Claims

Submit claims in sufficient detail to allow the Resident Engineer to determine the basis for entitlement and the resulting costs. The Department will not accept a claim against a unit price-based Contract for additional costs, lost profits, or for any other compensation, based on a total cost or modified total cost calculation that would result in a total cost-plus or a total unit cost compensation. For the purpose of these specifications, the Department considers the terms "total cost claim" or "modified total cost claim" to include all work required by the Contract, or any portion, unit, part or parts of the work required by the Contract, however such portion, unit, part or parts of the work may be identified, categorized or isolated from remaining work and any claim for compensation for all work on the Contract or for any portion, unit, part or parts of the work of the Contract using any form, technique, method or mode which results in a "total cost" figure, sum or result from cost computation.

Provide the following minimum information with each claim submitted:

- Detailed factual statement of the claim providing all necessary dates, locations, and items of work affected by the claim. (See the required format for a factual statement at the end of this list.)
- The date actions resulting in the claim occurred or conditions resulting in the claim became evident.
- A copy of the written "Notice of Intent to File a Claim," filed by the Contractor for the specific claim.

- The name, title, and activity of each Department employee knowledgeable about facts that gave rise to such claim.
- The name, title, and activity of each Contractor employee knowledgeable about facts that gave rise to such claim.
- The specific Contract requirements that support the claim, and a statement why the requirements support the claim.
- A weekly listing of all construction equipment in use or held in standby condition, as approved by the Resident Engineer, due to the work that is the subject of the Claim including the type, make, model and year of manufacture. The listing will reflect hours that equipment was in use or standby condition due to the work that is the subject of the claim. No equipment costs will be allowed on a claim for those periods of time that the Contractor failed to file the equipment listing.
- The identification of any relevant documents relating to the claim.
- A statement that the additional compensation or extension of time is based on the provisions of the Contract or on an alleged breach of Contract.
- For time extension claims, the specific days sought and the basis for the claim for time as determined by an analysis of the Contractor's Progress Schedule provided to the Department in accordance with Subsection 108.03.A, "Activities Schedule Chart (ASC) and Written Narrative (WN)," or Subsection 108.03.B, "Critical Path Progress Schedule," before starting the Work.
- The amount of additional compensation sought and a breakdown of that amount in accordance with Subsection 109.04, "Differing Site Conditions, Changes, and Extra Work."

Failure to submit a claim before the Department makes final payment on the Contract shall constitute a waiver of all claims.

The detailed factual statement shall include the following minimum information:

(1)Introduction

The purpose of the introduction is to present a general background in sufficient detail to provide an overview of the claim.

(2)Contract Requirements

The purpose of the Contract requirements is to establish what provisions in the Contract documents that the Contractor relied on to prepare the bid and schedule to perform the work. This section establishes what Contract provisions the Contractor relied on and provides the basis for measurement of the differences between what the Contractor anticipated and what actually occurred. The Contractor shall establish a right under the Contract on which the Contractor relied to provide a basis for the Contractor's claim.

(3)Contractor's Schedule

The purpose of this section is to provide an opportunity to demonstrate that the Contract element(s) identified in Subsection 105.18.A(2), "Contract Requirements" were critical to its scheduled completion of the Contract requirements. The Contractor shall demonstrate in this section that its reliance on the above-identified Contract requirements was reasonable for establishing the Contractor's Progress Schedule, the means, and methods which he/she planned to perform the work. The Contractor's Progress Schedule used to support this subsection shall be the

schedule provided to the Department in accordance with Subsection 108.03.A, "Activities Schedule Chart (ASC) and Written Narrative (WN)," or Subsection 108.03.B, "Critical Path Progress Schedule," before start the Work. Estimated cost for performance of required contract work may be supported by either bid documents used in bidding the project or by empirical data from the Contractor's performance on previously completed projects.

(4) Variations in the Contract Requirements Encountered on the Project

The purpose of this section is to allow the Contractor to clearly demonstrate that the actual conditions and circumstances encountered in building the Project differed materially from the requirements of the Contract.

(5) Effects of the Variations

The purpose of this section is to allow the Contractor to explain how the changes in conditions and circumstances impacted the Contractor's plan and affected the Contractor's work.

B. Required Certification of Claims

The claim submittal shall include a written certification, under oath, by the Contractor and any subcontractor presenting a claim through the Contractor, attesting to the following:

- The claim is made in good faith.
- Supportive data is accurate and complete to the Contractor's (subcontractor's) best knowledge and belief.
- The amount of the claim accurately reflects the Contractor's (subcontractor's) true cost incurred.
- The amount of the claim has been adjusted and reduced to reflect change orders related to the claim for which the Contractor (subcontractor) has previously been compensated.

In complying with this requirement, the Contractor and any subcontractor presenting a claim through the Contractor shall use the Department's Certificate of Claim form as follows:

Certificate of Claim

Under the penalty of law for perjury or falsification, the undersigned,

_____,
(Name)

_____,
(Title)

_____,
(Company)

hereby certifies that the claim for extra compensation and time, if any, made herein for work on this Contract is a true, accurate, and complete statement of all actual costs incurred and time sought, and is fully documented and supported under the Contract between the parties. I further certify that I am authorized to submit this Claim on behalf of _____ and to bind this company as to this matter. This claim has been adjusted and reduced to reflect change orders related to this claim for which this company has previously been compensated.

The above information is true and correct to the best of my knowledge

_____
(Authorized Signature)

_____
(Social Security No. or Federal ID No.)

WARNING
IT IS A FELONY TO MAKE OR PRESENT A FALSE, FICTITIOUS, OR FRADULENT CLAIM FOR PAYMENT OF PUBLIC FUNDS. THE STATE OF OKLAHOMA WILL PROSECUTE AND CONVICTION MAY RESULT IN CRIMINAL PENALITIES. (21 O.S.§§358, 359)

State of Oklahoma)
) §:
County of _____)

On the _____day of _____, 20 ____, before me personally appeared _____ to me known to be the person(s) named herein and who executed the foregoing document and acknowledge to me that _____ voluntarily executed the same. My commission expires the _____ day of _____, 20___.

_____ (seal)
(Notary Public)

C. Documentation of Claims

The Department will assess claims for additional compensation for differing site conditions, changes in the character of work, or for extra work and will determine their value in accordance with Subsection 109.04, "Differing Site Conditions, Changes, and Extra Work." The Department will evaluate claims for extension of Contract Time in accordance with Subsection 108.07, "Administration and Extension of Contract Time."

D. Review of Request for Additional Compensation or Time

The Resident Engineer will review and respond in writing to the Contractor's request for additional compensation or time within the following time periods:

- For claims in the amount of $100,000 or less, 45 calendar days from the receipt of the Contractor's claim including all required supporting documentation;
- For claims in an amount of more than $100,000, 90 calendar days from the receipt of the Contractor's claim including all required supporting documentation.

The Resident Engineer and the Contractor may agree in writing to an extension of the Department's review time limits required above.

If the Resident Engineer does not issue a written response to the Contractor's claim within the required time period, the Contractor may proceed as if the claim had been formally denied, in accordance with the currently adopted dispute resolution procedure included in the Contract.

If no agreement is reached between the Contractor and the Department within 15 calendar days after the Department's response to the Contractor, the Contractor may proceed as if the claim had been formally denied, in accordance with the currently adopted dispute resolution procedure included in the Contract.

Nothing in this section shall be construed as establishing any claim contrary to the terms of Subsection 104.06, "Notification of Differing Site Conditions, Changes, and Extra Work," or Subsection 108.07, "Administration and Extension of Contract Time."

SECTION 106
CONTROL OF MATERIAL

106.01 SOURCE OF SUPPLY AND QUALITY REQUIREMENTS

The Contractor shall provide material meeting the quality requirements of the Contract. Notify the Resident Engineer of proposed sources of materials before delivery to the Project. The Resident Engineer may conditionally approve material at the supply source. If the Resident Engineer finds that conditionally approved material incorporated into the work does not produce acceptable results, the Contractor shall remove and replace or otherwise correct the material, as approved by the Resident Engineer, at no additional cost to the Department. Use new materials unless otherwise required by the Contract.

A. Material Acceptance

The Department will evaluate acceptance of material in accordance with one of the following processes:

- Sampling and testing in accordance with Subsection 106.03, “Samples, Tests, and Cited Specifications.”
- Materials Certification in accordance with Subsection 106.04, “Materials Certifications.”
- Approved Products List (APL) as established and maintained by the Department's Materials Engineer.

The process required for evaluation of a specific material is designated in the FAST Guide.

B. Buy America

Follow the “Buy America” provisions as required by Title 23 Code of Federal Regulations § 635.410. Except as expressly provided herein, all manufacturing processes of steel or iron provided under this Contract shall occur in the United States, including the application of:

- Coating,
- Galvanizing,
- Painting, and
- Other coating that protects or enhances the value of steel or iron products.

The following are exempt, unless processed or refined to include substantial amounts of steel or iron material, and may be used regardless of source in the domestic manufacturing process for steel or iron material:

- Pig iron,
- Processed, pelletized, and reduced iron ore material, or
- Processed alloys.

The requirements do not prevent a minimal use of foreign steel if the cost of such materials does not exceed 0.1 percent of the total Contract amount, or $2,500, whichever is greater. The Contractor shall submit to the Resident Engineer the origin and value of any foreign material used.

The Contractor shall submit a certification stating that all manufacturing processes involved with the production of steel or iron materials occurred in the United States.

106.02 LOCAL MATERIAL SOURCES

The Department may designate possible sources of local material in the Contract. The Contractor shall determine the amount of equipment and work required to produce a material that meets the Contract requirements. Consider variations in material quality within source deposits usual and expected. The Resident Engineer may direct selection of material from specific locations within a source deposit. The Resident Engineer will reject locations of source deposit that do not meet the Contract requirements.

The Department may acquire designated sources material and use the property for plant site, stockpiles, and haul roads, as required by the Contract. For material from sources not designated by the Contract, acquire the rights to purchase and use of the material, and assume all costs for exploring and developing the sources, as well as hauling and placing the material on the Project. The Resident Engineer will not allow use of material from sources not designated in the Contract until testing indicates that the material is of equal or better quality than the designated source. The Resident Engineer may make conditional acceptance of the material.

Locate borrow pits, gravel pits, and quarry sites no closer than 500 ft [150 m] from the right-of-way of any road or highway on the State or County System to limit visibility from roads, unless otherwise approved by the Resident Engineer. Following completion of the work, leave the site, as well as any pits and quarry sites, in a neat and presentable condition in accordance with Subsection 104.10, “Final Clean Up.”

106.03 SAMPLES, TESTS, AND CITED SPECIFICATIONS

The Resident Engineer will inspect, test, and approve material before its incorporation in the work. The Resident Engineer will perform sampling and testing at frequencies in accordance with the FAST Guide. Unless otherwise specified, tests will be performed using the most recent cited standard methods or specifications of the Department, AASHTO, ASTM, or other referenced authority. For differing test procedures, the Resident Engineer will use the following order of precedence:

- The Department’s Standard Materials Test Methods,
- AASHTO, and
- ASTM.

Unless otherwise required by the Contract, the Department will perform tests at its own expense.

For acceptance testing, samples will be taken and tested by certified technicians, registered by the Oklahoma Highway Construction Materials Technician Certification Board. Lab tests will be performed by labs qualified and approved by the Department's Materials Engineer.

The Resident Engineer may inspect, test, or reject material before or during its incorporation into the work. The Resident Engineer will address unacceptable material in accordance with Subsection 105.03, “Conformity with Plans and Specifications.” The Resident Engineer may retest material, and reject material that does not meet the requirements of the Contract, even if the material was previously tested and conditionally

approved at the source of supply. The Resident Engineer will provide copies of test results to the Contractor upon request.

The Contractor is responsible for quality control of material during construction, and shall not rely on the Department's acceptance testing for this purpose. If required by the Contract, the Contractor shall submit a formal Quality Control Plan to the Resident Engineer.

106.04 MATERIAL CERTIFICATIONS

A. Description

The requirements and procedures for the issuance and distribution of material certifications are designated in the FAST Guide. Materials not addressed specifically by the FAST Guide will be handled in accordance with the Contract requirements.

B. General Requirements

The Contractor is responsible for obtaining all certifications and delivering to the Contract required destinations.

Ensure a responsible representative of the company that issues the certification signs the material certification. Ensure the title of the signer is clearly shown beneath the signature.

Provide all certifications in duplicate with each copy showing the following information:

- Project number,
- Name of Contractor,
- Identification markings on shipment (if applicable), and
- For Type A certifications required by the FAST Guide, the quantity of material.

C. Types of Certifications

Unless otherwise required by the Contract, provide one of the following types of certification:

1. **Type A**: Manufacturer prepared certification consisting of a certified report detailing tests conducted by a laboratory approved by the Department on samples obtained from the lot(s) of material in the shipment.
2. **Type B**: Manufacturer prepared certification showing the limits of test values as determined by a Department approved manufacturer's laboratory, a qualified commercial laboratory, or another approved laboratory.
3. **Type C**: Manufacturer prepared certification certifying that the material in the shipment conforms to the same formula or is essentially the same as the material previously approved by the Department's Materials Engineer.
4. **Type D**: Manufacturer prepared certification stating that the material meets the Contract requirements, listed by specification reference number, section reference, or other appropriate identification approved by the Resident Engineer.
5. **Type E**: Fabricator prepared certification covering a composite item (e.g. signs, overhead sign structures, etc.) incorporating two or more materials previously approved on an individual basis, but that lose their identities when incorporated into the composite item. The Fabricator is responsible for the following:

- Identifying all material used in the fabrication;
- Certifying that all materials used in the fabrication of the item in question were previously approved by the Department for use; and
- Maintaining test reports and other pertinent identifying records of the individual items incorporated into the composite item until approved by the Resident Engineer.

D. Distribution of Certifications

The Contractor shall submit certifications to the Resident Engineer with another copy mailed to:

Materials Engineer
Oklahoma Department of Transportation
200 Northeast 21st Street
Oklahoma City, Oklahoma 73105

E. Basis of Acceptance

If one of the above types of certification is required by the FAST Guide, the Resident Engineer may accept the material on the basis of a certification provided the following:

- All Contract requirements have been met, and
- The Resident Engineer's visual inspection at the destination shows satisfactory workmanship and condition of the material.

The Contractor shall mark all material provided by certification with a lot number, heat number, order number, or other identification matching those numbers listed on the certification. Do not incorporate any material accepted by certification into the work until the Resident Engineer approves of the certification.

The Department's Materials Engineer will evaluate Type A and Type B Certification for compliance with the Contract requirements and forward approved copies to the Resident Engineer. The Resident Engineer will evaluate and approve other types of certifications.

The Resident Engineer may accept materials listed on the Approved Products List without further certification.

106.05 PLANT INSPECTION

The Engineer may inspect manufacturing plants for compliance with specified manufacturing methods. The Engineer may also inspect material at the manufacturing plant or source and will obtain material samples for testing compliance with material quality requirements in the Contract.

Ensure the following when plant inspection is made by the Engineer:

- Cooperation and assistance of the supplier and Contractor.
- Full access at any time to areas where the relevant materials are manufactured or produced.
- Use of a building by the Inspector, located conveniently near the plant in accordance with Subsection 106.06, "Field Office Laboratory," if required by the Contract.
- Adequate safety measures.

- Crushing or screening facilities equipped with automatic or semi-automatic mechanical sampling device.

For fabricated structural steel members or precast concrete walls and bridge elements requiring Department inspection and approval at a manufacturing plant or source of supply located more than 500 mi [800 km] from Oklahoma City, Oklahoma, pay the additional expense of inspection over the cost of providing the same inspection at Oklahoma City. For all other fabricated items (i.e. epoxy coated reinforcing steel, reinforced concrete pipe and boxes, etc.) requiring Department inspection and approval at a manufacturing plant or source of supply located more than 300 mi [480 km] from Oklahoma City, Oklahoma, pay the additional expense of inspection over the cost of providing the same inspection at Oklahoma City. The Department will calculate miles traveled based on the most recent edition of the "Rand McNally Road Atlas" or an equivalent (such as Mapquest). If applicable, the Department will also calculate vicinity mileage. The Department will calculate travel expenses in accordance with the current Department's Administrative Order # B-310-1-(1) for State Travel Expenses-Reimbursement, plus the current contract price for the inspector's travel time. Contact the Department's Materials Engineer to obtain the current contract prices and contact the supplier to determine the fabrication time, to allow the Department to estimate inspection expenses.

The Department may retest material previously tested and conditionally approved at the source, and may reject all materials that, when retested, do not meet the Contract requirements.

106.06 FIELD OFFICE OR LABORATORY

Provide and maintain, for each Field Office or Laboratory required by the Contract, a Resident Engineer approved weatherproof building or trailer in accordance with Section 640, "Field Office or Laboratory."

106.07 FOREIGN MATERIAL

Unless otherwise specified in the Contract, perform all testing within the United States in the presence of the Engineer, at the discretion of the Department. If required by the Contract, provide and pay for any required sampling and testing that the Department cannot perform. For materials or processes requiring tests performed or witnessed at a foreign source, reimburse the Department for all inspection expenses incurred in accordance with Subsection 106.05, "Plant Inspection."

Provide a certificate of compliance with each lot of foreign material, in accordance with Subsection 106.04, "Materials Certifications." If required for the material, attach mill test reports to the certificate of compliance. Provide steel or iron in accordance with Subsection 106.01.B, "Buy America."

For structural materials requiring mill test reports, the Department will only accept material from those foreign or domestic manufacturers having previously established adequate in-plant quality control to assure delivery of uniform material meeting Contract requirements. The Department will determine adequacy of quality control by its review of detailed written proof submitted by the fabricator or through a plant inspection by the Department.

The Department will not accept structural materials that do not have certificates of compliance and, if required, mill test reports.

106.08 STORAGE AND HANDLING OF MATERIAL

Store and handle materials to preserve their quality and fitness for the work.

A. General

Store and handle materials to preserve their quality and fitness for the work. Transport bulk materials in vehicles constructed to prevent loss or segregation after loading and measuring. Store materials to facilitate prompt inspection. Materials will be subject to inspection and retesting before incorporation in the work in accordance with Subsection 106.03, "Samples, Tests, and Cited Specifications."

The Department will allow the use approved portions of the right-of-way for storing materials and the Contractor's plant and equipment. Provide additional storage space as necessary at no additional cost to the Department. Do not use private property for storage without prior written permission of the owner or lessee. If requested, provide copies of such written permission to the Resident Engineer.

Restore storage and plant sites on the right-of-way to their original condition at no additional cost to the Department.

B. Delivering and Stockpiling Aggregates

Handle all aggregates to preserve their quality, gradation, and fitness for the work. The provisions for transporting aggregates shall be such to assure a continuous and adequate supply of material to the work.

Build up aggregate stockpiles to ensure the delivery of acceptable materials to the plant or Project. Do not stockpile aggregates from different sources and different gradations together.

The gradation requirements, for the individual stockpiles and proportioning from the stockpiles, is the responsibility of the Contractor. The Department will consider aggregates that have become segregated or mixed with earth or other foreign material, to be unacceptable, and will not allow their use in the work until the Contractor integrates the aggregate piles or removes all earth and foreign materials.

106.09 UNACCEPTABLE MATERIAL

Material that does not meet the Contract requirements will be addressed in accordance with Subsection 105.03, "Conformity with Plans and Specifications."

106.10 DEPARTMENT-PROVIDED MATERIAL

Provide all material necessary to complete the work, except Department-provided material as required by the Contract.

The Department will deliver, or make available, Department-provided material to the Contractor at the locations specified in the Contract.

Include in the contract unit price for the relevant pay item the cost of handling and placing all Department-provided material once made available.

The Contractor is responsible for the Department-provided material made available. The Department will make deductions for material shortages or deficiencies, damage, or demurrage charges.

106.11 GUARANTEES AND WARRANTIES

Obtain and assign to the Department manufacturer and producer warranties or guarantees for items, materials, and equipment consistent with those provided as customary trade practice. Warrant or guarantee, for six months after Department and local government acceptance, mechanical and electrical equipment and material, light bulbs excepted, free from any defects or imperfections in workmanship and material. Repair or replace malfunctions or defects that develop during the six-month period at no additional cost to the Department.

Supply manuals for equipment included in the Project, providing the following information:

- Operational procedures,
- Complete nomenclature,
- Wiring diagrams,
- Schematics showing test voltages or procedural methods,
- Functional description of circuits,
- Parts lists,
- Cross reference to standard part numbers,
- Flow diagrams, and,
- Testing procedures and other pertinent data, if required by the Contract.

The provisions of this section are additional to, and run concurrent with, any maintenance or warranty bonds required by the Contract.

SECTION 107
LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

107.01 LAWS, RULES, AND REGULATIONS TO BE OBSERVED

The Contractor shall observe the following, and the effects of the following on individuals engaged or employed on the project or the conduct of the work on the project:

- Federal and State laws;
- Local laws and ordinances; and
- Regulations, orders, and decrees of bodies or tribunals having jurisdiction or authority.

The Contractor shall protect and indemnify the Department and its representatives against any claim or liability arising from the violation of any of the above bulleted items, whether violated by the following parties or any of their employees:

- Contractor,
- Subcontractors,
- Suppliers of materials or services, or
- Other companies engaged by the Contractor.

The Contractor shall comply with federal, State, and local laws, rules, and regulations that set forth unlawful employment practices including that of discrimination because of race, religion, color, sex, or national origin, and that define actions required for Affirmative Action and Minority (Disadvantaged) Business programs.

If the Contractor discovers any discrepancy or inconsistency between the Contract and any law, ordinance, regulation, order or decree, except as noted in Subsection 107.04, "Federal Aid Participation," the Contractor shall immediately submit written notification to the Resident Engineer.

107.02 PERMITS AND LICENSES

The Department does not require the Contractor to obtain work permits or licenses from local governmental agencies for operations related to the prosecution of the work within the project right-of-way. The Contractor shall contact all local governmental agencies with jurisdiction within the project limits to determine if local stormwater permits are required.

107.03 PATENTED DEVICES, MATERIALS, AND PROCESSES

If the Contractor uses designs, devices, materials, or processes covered by letters of patents, copyrights, or trademarks, the Contractor shall provide a suitable legal agreement with the patentee or owner.

The Contractor and Surety shall indemnify and save harmless the Department, the State and any political subdivision, and any affected third party from any and all claims (including costs, expenses, and damages the Department may be obliged to pay) for infringement on such patents, copyrights, or trademarks during the prosecution of the work or after completion of the project.

107.04 FEDERAL AID PARTICIPATION

If any Contract provision on a federal-aid project conflicts with federal laws, rules, or regulations, the federal requirements shall prevail, take precedence, and be in force over and against any conflicting provision.

For federal-aid projects, the Department will administer the Contract but the appropriate officials of the federal government shall have the right to inspect and approve the work without the federal government becoming party to the Contract.

107.05 PUBLIC CONVENIENCE AND SAFETY

The Contractor shall minimize obstructions to traffic in accordance with Subsection 104.07, "Maintenance of Traffic," provide for the safety and convenience of the public, and protect property adjacent to or near the project. The Contractor may not close any public road unless approved or directed by the Resident Engineer.

The Contractor shall not sever or remove existing fence or make alteration to fences required by the Contract until approved by the Resident Engineer. Temporary fences, when required to control livestock, shall be suitable for the purpose intended. The Contractor shall provide temporary fences used for the convenience of the Contractor at no additional cost to the Department.

If the Contractor does not comply with these requirements, the Resident Engineer may issue a Shut Down Order, and may do such work as necessary for the safety of the public.

The cost for any work performed by the Department will be deducted from any monies due the Contractor.

107.06 BARRIERS, BARRICADES, AND WARNING SIGNS

The Contractor is responsible for the following:

- Providing, erecting, and maintaining barriers, barricades, lights, temporary signals, signals, signs, warning signs, and other traffic control and safety devices to control and direct traffic;
- Taking necessary precautions to protect the work and safety of the public;
- Protecting highway sections closed to traffic using effective barriers and barricades;
- Clearly delineating obstructions to the normal flow of traffic during darkness;
- Erecting warning signs in advance of operations that may interfere with the use of the road by traffic, and at locations where new work crosses or coincides with an existing road;
- Placing and maintaining warning signs in accordance with the traffic control plan and the Contract; and
- Not dismantling or removing barriers, barricades, lights, temporary signals, signals, signs, warning signs, or other traffic control and safety devices without prior direction or approval by the Resident Engineer.

Ensure barriers, barricades, lights, temporary signals, signs, warning signs, and other traffic control and safety devices are in accordance with the MUTCD and Section 880, “Traffic Control.”

107.07 USE OF EXPLOSIVES

If using, handling, loading, transporting, or storing explosives or blasting agents, the Contractor shall follow all applicable laws and ordinances, including the Oklahoma Explosives and Regulation Act, 63 OS 2001, Section 121.1 et seq. and corresponding rules and regulations of the Oklahoma Department of Mines, the State Fire Marshall, and the Department of Public Safety.

If the use of explosives is necessary for the prosecution of the work, the Contractor shall exercise care to protect life, property, and completed work. The Contractor shall assume all risks and be solely responsible for all damages resulting from the use or storage of explosives on the project.

The Contractor shall store explosives in a secure manner and clearly mark all storage places with the phrase, “Dangerous Explosives.” If no local laws or ordinances apply, the Contractor shall store explosives in accordance with Occupational Safety and Health Act (OSHA) regulations, and no closer than 1,000 ft [300 m] from any place of human occupancy.

The Contractor shall provide, in advance, written notification to the Resident Engineer, adjacent property owners, and public utilities and railroads having facilities adjacent to the site of the work, of its intentions to use explosives including the location, date, time, and approximate duration of the blasting. The Department requires the Contractor to provide this notification, sufficiently in advance of the blasting, to allow the property owners and utility and railroad companies to take any steps, as they may deem necessary, to protect their property from damage.

The Contractor shall erect suitable warning signs to alert the public on all roads in the immediate vicinity of blasting operations. The signs shall include instructions to turn off all portable radio transmitters, cellular telephonic devices, and any other electronic transmitting device while in the vicinity. The Department considers "vicinity" to be the total length of the blast area plus one additional mile from each end of the blast area. If necessary or required by the Contract, the Contractor shall control traffic using flaggers and guards in the blasting danger zone.

107.08 PROTECTION AND RESTORATION OF PROPERTY AND LANDSCAPE

The Contractor shall preserve public and private property during the prosecution of the work and not move, disturb, or damage land monuments and property marks until directed by the Resident Engineer.

The Contractor is responsible for damage to public or private property resulting from any of the following:

- Acts, omissions, neglect, or misconduct in the Contractor's method of performing the work,
- Defective work or materials, or
- Non-performance of the Contract.

The Contractor is responsible for restoring damaged property to a condition similar or equal to that existing before the damage occurred, at no additional cost to the Department.

107.09 PROTECTION OF ARCHEOLOGICAL AND UNMARKED HUMAN BURIAL SITES

The Contractor shall observe all laws and regulations when establishing off-site facilities, including plant sites, borrow pits, waste areas, haul roads, storage sites, parking areas, and similar areas associated with the acquisition, production, and delivery of borrow material and related road building materials.

Examine all intended locations of off-site facilities for archeological significance. Identify the intended location (legal description of the ¼ section) to the Resident Engineer, who will examine the site and confer with the proper authorities for this determination. Allow up to 10 working days for the archeological investigation. If the Resident Engineer and proper authority determine a site to be of potential or established archeological significance requiring further investigation, the Contractor shall either postpone the excavation until the artifacts have been removed or obtain an alternate location for the source of borrow material.

Whenever encountering archeological remains during construction operations on the project site or during the excavation of a previously approved off-site facility, immediately cease the operation and notify the Engineer, who will contact State archeological authorities to determine the disposition of the remains or artifacts.

The Contractor shall temporarily discontinue construction operations if remains of prehistoric dwelling sites or artifacts of historical or archaeological significance are encountered on the project site or on a previously approved off-site facility, and notify the Resident Engineer. The Resident Engineer will contact the State archaeological authorities to determine the disposition of the remains or artifacts. The Contractor shall

excavate the site to preserve the artifacts and remove and deliver them to the custody of the proper State authorities as directed by the Resident Engineer. For off-site facilities, if the delay for the archeological investigation is too long, the Contractor may consider an alternate source of material. In such case, with approval of the archeological authorities, it may be possible to re-bury the archeological materials and move to another location. The Contractor shall remove or rebury the archeological material in compliance with the National Historic Preservation Act and the Archaeological Resources Protection Act of 1979, the Oklahoma State Register of Historic Places Act, and the Oklahoma Violating Sepulcher and the Remains of the Dead Act (refer to Oklahoma Statute 21, Section 1168, and Section 53, Section 361, OS 21, Chapter 47 Section 1168).

The Department will pay for this removal work as extra work and adjust the Contract in accordance with Subsection 109.04, "Differing Site Conditions, Changes, and Extra Work."

If the construction operation is delayed due to archeological finds in an off-site facility, the Department will compensate a Contractor only with an extension of time commensurate with the amount of delay involving items on the critical path. Monetary compensation will not be allowed for these purposes.

When an unmarked human burial is discovered, immediately cease all activity in the surrounding area and notify the Resident Engineer. Do not resume activity until specifically authorized by the Resident Engineer.

107.10 FOREST, PARK, AND PUBLIC LAND PROTECTION

The Contractor shall perform work within or adjacent to a State or National Forest in compliance with the regulations of the Oklahoma State Fire Marshal, Oklahoma Conservation Commission, Oklahoma Department of Agriculture, Food, and Forestry - Forestry Services, United States Department of Agriculture - Forest Service, and other authorities having jurisdiction governing the protection of forests.

If performing work within or adjacent to State or National Forests, Parks, or Public Lands, the Contractor shall comply with all regulations of the Oklahoma State Fire Marshal, Oklahoma Conservation Commission, Oklahoma Department of Wildlife Conservation, Oklahoma Department of Agriculture, Food, and Forestry - Forestry Services, United States Department of Agriculture - Forest Service, or other authority having jurisdiction governing the protection of forests. The Contractor shall keep the areas in an orderly condition, dispose of all refuse, obtain permits for the construction and maintenance of all construction camps, stores, and other structures in accordance with the requirements of the duly authorized official.

The Contractor and its employees and subcontractors shall take all reasonable precautions to prevent and suppress forest fires and to notify a Forest official immediately of the location and extent of any fires.

107.11 THIRD PARTY BENEFICIARY CLAUSE

It is specifically agreed between the parties executing the Contract that it is not intended by the Contract provisions to create a third party beneficiary or to authorize anyone else to maintain a suit for personal injuries or property damage pursuant to the provisions of the Contract.

107.12 RESPONSIBILITY FOR DAMAGE CLAIMS

The Contractor agrees to indemnify, and save and hold harmless the State of Oklahoma, the Commission, the Department, and their officers, agents, and employees from all suits, actions or claims of any kind or character brought because of injuries or damages received or sustained by any person, persons, or property, regardless of fault, arising out of or as a result of any act or failure to act, whether or not negligent, in connection with the performance of the work to be performed pursuant to this Contract by the Contractor or on account of any operations of the Department or Contractor, the officers, agents, and employees of either of them performing work the project work zone, as well as, subcontractors, or any others authorized by the Contractor to perform work on the project. The Contractor agrees to defend and pay all costs of defending these claims, including attorney's fees.

The Contractor shall carry insurance of the following kinds and amounts on the Contract:

A. General

The insurance hereinbefore specified shall be acquired from State of Oklahoma licensed insurance companies to provide such coverage in the State of Oklahoma, and shall be maintained in full force and effect during all times when work is being performed under the terms of the Contract, until all work required to be performed under the Contract is deemed as completed by the Resident Engineer in accordance with Subsection 105.17, “Project Completion and Acceptance.”

The Contractor shall provide to the Department certificates of insurance showing that the Contractor is carrying insurance in at least the specified minimum amounts. Said certificates shall further provide that said insurance will not be cancelled by the insurer without the insurer first giving the Department 30 calendar days written notice of cancellation.

The Contractor shall not cause any insurance policy to be cancelled or permit it to lapse and all insurance policies shall include an endorsement to the effect that the insurance policy or certificate shall not be subject to cancellation or to a reduction in the required limits or liability or amounts of insurance until notice has been mailed to the Department, stating the date when such cancellation or reduction shall be effective, which date shall not be less than 30 calendar days after such notice. If the Contractor cancels, allows to lapse, fails to renew or in any way fails to keep the project specific liability insurance policy or any other required insurance policy in full force and effect, the Department will suspend all progress and/or final payments for the project until the required insurance is obtained. Further, the Department may deem the Contractor ineligible to bid on future projects in accordance with Subsection 102.04, “Refusal of Proposals.”

The Contractor shall provide the Department with copies of Certificates of Insurance evidencing coverage as to commercial general liability and worker’s compensation and employer's liability with the signed Contract for inclusion in the contract file. Failure to submit Certificates of Insurance with the executed Contract and bonds will result in a default under the terms of the proposal guaranty and may result in forfeiture by the Contractor of the guaranty sum.

B. Contractor’s Public Liability and Property Damage Liability Insurance

The Contractor shall obtain an insurance policy that provides commercial general liabiltiy coverage to a specific by project number, for each project awarded by the Department to the Contractor. The Contractor shall provide a Certificate of Insurance to the Department that, with respect to the work to be performed by the Contractor under the insured Contract, the Contractor carries regular Contractor’s Public Liability Insurance providing for a combined amount of not less than $1,000,000 of coverage for all damages arising out of bodily injury, death, and property damage for each occurence

with an aggregate limit of $2,000,000 for the term of the policy or as otherwise required by the proposal forms. For projects requiring railroad protective insurance policies, refer to the special provisions of the Contract for additional limits of public liability coverage that may be required. The Contractor shall have the Department named as an additional insured pursuant to 61 O.S. Section 113(B)(4) on the Contractor's Public Liability and Property Damage Liability Policy to the extent of the State's liability under the provisions of the Governmental Tort Claims Act 51 O.S. Section 151 et seq., for payment of any amounts the Department may become legally obligated to pay.

Currently, the limits provided by the Governmental Tort Claims Act are $25,000 for property damage, $175,000 for any claimant for a claim arising out of a single occurrence or accident and an aggregate amount of $1,000,000 for all claims arising out of any single occurrence or accident. The Contractor may acquire such additional insurance as the Contractor deems appropriate either through the separate policy specific to the project or through a general liability policy. In no event shall the Contractor endorse the Department on a blanket general liability policy or for coverage that exceeds the limits of the Governmental Tort Claims Act on a separate project specific policy.

C. Insurance for Subcontractor's and Contractor's Protective Public Liability and Property Damage Liability Insurance

If the Contractor subcontracts or assigns any of the work, or if the work is otherwise to be performed by anyone other than the Contractor's own employees, then such insurance shall cover all operations of any such contractor of any tier and shall be maintained until project completion.

D. Workers' Compensation Insurance and Employers' Liability Insurance

The Contractor shall provide Certificate of Insurance to the Department that, with respect to the work, the Contractor carries regular Workers' Compensation and Employers' Liability Insurance covering the Contractor's liability under the Workers' Compensation Law of the State of Oklahoma. The Contractor shall maintain the aforementioned insurance in full force and effect until project completion.

E. Railroads' Protective Liability and Property Damage Insurance

In addition to the above, the Contractor shall provide Certificate of Insurance to the Department that, with respect to the work, the Contractor has provided for and on behalf of the railroad company(ies) involved, Protective Public Liability and Property Damage Liability Insurance in an amount as may be required by the railroad company as specified in the proposal forms. Policies shall not include liability for negligence on the part of the railroad company, its agents or employees, except as set out in Coverage A, Coverage B, or Coverage C of the form of policy, or amendments thereto, referred to under Subsection 107.12.F, "Form of the Railroad Protective Liability Policy." This insurance applies to each and all railroad companies involved in the work.

F. Form of the Railroad Protective Liability Policy

For the purpose of uniformity, the AASHTO, with the assistance of the AAR, the FHWA, the National Bureau of Casualty Underwriters of New York, and the Mutual Insurance Rating Bureau of New York, has drafted the Standard Provisions for General Liability Policies, Railroad Protective Liability Form (State or Federal Highway Projects).

The Contractor shall provide the original and one copy of the Railroad Protective Liability Policy and two copies of Certificate of Insurance, indicating the amounts of coverage in effect, to the Department, for submission to the Railroad Company for approval. For Contracts that contain a Right-of-Entry Agreement provision and the Contractor submits the original policy directly to the Railroad Company, the Contractor shall provide two copies of the policy to the Department.

Any questions by the Contractor or the Surety regarding this insurance should be directed to:

Rail Programs Division
200 Northeast 21st Street
Oklahoma City, Oklahoma 73105

107.13 PERSONAL LIABILITY OF DEPARTMENT EMPLOYEES

The Department's authorized representatives are acting solely as agents and representatives of the Department when carrying out and exercising the power or authority granted to them under the Contract. While acting within the scope of their employment, Department representatives shall not be liable for actions taken on behalf of the Department, either personally or as Department employees.

107.14 NO WAIVER OF LEGAL RIGHTS

The Department shall not be precluded or estopped by any measurement, estimate, or certificate made either before or after the completion and acceptance of the work and payment therefore, from showing the true amount and character of the work performed and materials provided by the Contractor, nor from showing that any such measurement, estimate, or certificate is untrue or is incorrectly made, nor that the work or materials do not, in fact, conform to the Contract. The Department shall not be precluded or estopped, notwithstanding any such measurement, estimate, or certificate and payment in accordance therewith, from recovering from the Contractor or sureties, or both, such damage as it may sustain by reason of Contractor's failure to comply with the terms of the Contract. Neither the acceptance by the Department, or any representative of the Department, nor any payment for, or acceptance of, the whole or any part of the work, nor any extension of time, nor any possession taken by the Department, shall operate as a waiver of any portion of the Contract, or of any power herein reserved, or of any right to damages. Acceptance shall be final and conclusive except as otherwise provided in the specifications, or as regards latent defects, or frauds, or such gross mistakes as may amount to fraud, or as regards the Department's rights under any warranty or guaranty. Latent defects are nonconformities included in the completed Contract work that were not visible or apparent at the time of construction and remained hidden and dormant until discovery of the nonconformity. Upon discovery of a disputed nonconformity in the completed Contract work, which the Department has designated as a Latent Defect, the Department and Contractor agree to submit to arbitration whether or not the disputed nonconformity in the Contract work is a Latent Defect. The arbitration shall be administered in accordance with the dispute resolution procedure, as incorporated in the Contract. A waiver of any breach of the Contract shall not be held to be a waiver of any other or subsequent breach. Nothing contained in this section shall operate as a waiver or extension of any applicable statute of limitations with respect to the time within which an action may be brought for the breach of a Contract.

107.15 HAZARDOUS MATERIAL

If the Contractor encounters or exposes any abnormal condition indicating the presence of a hazardous material or toxic waste, the Contractor shall immediately suspend the work in the area and notify the Resident Engineer. The Contractor may continue the work in unaffected areas of the project, unless otherwise directed by the Resident Engineer.

Abnormal conditions include, but are not limited to, the presence of the following:

- Barrels, drums, tanks, or other chemical container;
- Noxious odors emanating from the soil or water table;
- Excessively hot earth or smoke indicating a possible chemical reaction;
- Stained or oily soil or groundwater; or
- Any other condition that indicates a hazardous material or toxic waste.

The Contractor shall treat these conditions with extreme caution and shall not attempt work without appropriately trained, qualified, and equipped personnel.

If disposing of the hazardous material or toxic waste, the Contractor shall comply with all applicable local, State, and federal rules and regulations. The disposal work may be performed by the Contractor under a supplemental agreement to the Contract or by the Department.

107.16 PROTECTION OF WETLANDS

The Contractor shall obey all laws and regulations when establishing off-site facilities, including plant sites, borrow pits, waste areas, haul roads, storage sites, parking areas, and similar areas associated with the acquisition, production, and delivery of borrow material and related road building materials.

The Contractor shall not construct or locate off-site facilities in areas designated as wetlands by the USACE before written approval of the USACE. To gain approval, the Contractor shall do the following:

- Contact the Regulatory Branch of the USACE (phone, 918-669-7400) to determine the status of wetlands;
- Request approval for proposed locations of off-site facilities;
- Present the entire plan for off-site facilities and site restoration to the USACE for approval; and
- Forward a copy of the approval to the Resident Engineer before beginning off-site activities.

If the project lies in an area designated as wetlands, the Contractor shall not disturb the area between the limits of construction and the right-of-way line without prior approval of the Resident Engineer, and shall adhere to the requirements of permits included in the Contract.

107.17 NAVIGABLE AIRSPACE

The Contractor shall comply with federal laws, rules, and regulations pertaining to constructing, erecting, or installing objects, temporary or permanent, that could potentially affect navigable airspace, including on-site and off-site facilities.

107.18 NAVIGABLE WATERWAYS

The Contractor shall perform work over, on, or adjacent to navigable waters without interfering with free navigation of the waterways or impairing the existing navigable depths, except as allowed by permit issued by the U.S. Coast Guard or the USACE, as applicable.

107.19 REGULATED FLOODWAYS

The Contractor shall perform work within regulated floodways in compliance with the requirements of permits issued by the Federal Emergency Management Agency (FEMA), USACE, or other applicable agencies.

107.20 STORM WATER MANAGEMENT

The Contractor is responsible for complying with the requirements of Sections 401 and 404 of the Clean Water Act (Title 33 U.S.C. 1251 et seq.) and the Oklahoma Department of Environmental Quality (ODEQ) General Permit for Construction Activities concerning Storm Water Management. The Contractor shall submit the Notice of Intent (NOI) to the ODEQ and/or other designated municipal authority to obtain the Authorization to Discharge storm water runoff from the project.

The Department will develop the original Storm Water Management Plan (SWMP) as part of the Plans. The original SWMP is for preliminary planning and guidance only. The Contractor is responsible for reviewing the SWMP and developing the Storm Water Pollution Prevention Plan (SWPPP) in accordance with Subsection 220.04.C, "Contractor Responsibilities for SWPPP," to conform to actual conditions encountered on the Project. The Contractor shall use good construction industry practices and ensure the waterways receiving storm water run-off from the Project are protected from siltation and other forms of Project originated pollutants. For Projects that do not include a specific SWMP, the Contractor shall use the applicable portion of the Plans, Special Provisions and the Standard Specifications for the SWPPP.

The Contractor is responsible for implementing the SWPPP for the Project and for initiating modifications to the original permit connected with the location of the Contractor's storage yard, plant sites, and borrow areas, located on or off the right-of-way. The Contractor shall protect and hold harmless the State of Oklahoma, the Department, and the officers, agents, and employees of both, from all suits, claims, or administrative actions of any kind or character, alleging damages or harm to the environment, any adjoining lands, or receiving waterways due to improper storm water management.

Upon completion of soil-disturbing activities and when permanent erosion control measures have stabilized the Project to at least 70 percent of native background cover, the Contractor shall submit to the ODEQ a Notice of Termination (NOT) in accordance with Subsection 220.04.F, "Notice of Termination (NOT)." The Contractor shall ensure compliance with the requirements of the NOT.

107.21 WILDLIFE PROTECTION

The Contractor shall comply with all applicable laws and ordinances protecting threatened and endangered species, migratory birds, and water quality, including the Endangered Species Act (Title 50 CFR Part 402), the Migratory Bird Treaty Act (Title 16 U.S.C. Chapter 7, Subchapter II), and Sections 401 and 404 of the Clean Water Act

(Title 33 U.S.C. 1251 et seq.). The Contractor shall post on site an illustrated list of all known threatened and endangered species identified in the Contractor. If evidence of any such species is encountered on the Project or at a proposed off-site facility, the Contractor shall suspend work in the area and notify the Resident Engineer, who shall contact the Department's biological authorities for an assessment. The Department shall have 10 working days to evaluate the finding. If the Department determines that the activity may affect a listed threatened or endangered species, the Contractor shall comply with any requirements and regulations of the United States Fish and Wildlife Service to avoid jeopardizing the species.

107.22 PROJECT RECORDS

The Contractor shall maintain all books, documents, papers, accounting records, and other evidence pertaining to costs incurred in the prosecution of the Work during the Contract period and for three years from the date of execution of the Final Estimate. All such records and materials shall be made available at Contractor's offices during normal business hours for inspection by the Department, the State Auditor and Inspector, and, if a federal-aid project, by representatives of the relevant federal government agency, the FHWA, and the United States Department of Transportation. The Contractor shall provide the Department with copies of all such records and materials upon request. Failure to cooperate with either State of federal authorities may result in refusal to issue proposals in accordance with Subsection 102.04, "Refusal of Proposals."

SECTION 108
PROSECUTION AND PROGRESS

108.01 SUBLETTING OF CONTRACT

The Department will not allow the Contractor to sublet, sell, assign, or otherwise dispose of the Contract, or any portion thereof, or any of the Contractor's rights, title, or interest therein without the written or electronic consent of the State Construction Engineer or an authorized representative. The Contractor shall perform at least 50 percent of the Contract amount, based on the contract unit prices, using its own organization, unless the Contract allows a greater percentage.

The Department will consider the Contractor's own organization to include only workers employed and paid directly by the Contractor, equipment owned or rented by the Contractor, and materials purchased by the Contractor for its use in performing Contract work. This does not include employees, equipment, or materials purchased by or incorporated into work of any subcontractor, assignee, or agent of the Contractor. The Department considers the use of entire work crews or major components of work crews and equipment of another contractor to be subcontracting, subject to approval by the Resident Engineer. The Department will not allow the Contractor to include another contractor's work crews, or major components of such work crews, on the Contractor's certified payroll. At any location within the project where work is in progress by either the Contractor or an approved subcontractor, the Contractor shall have a competent superintendent or supervisor who is an employee of the Contractor responsible for all construction operations, and who has full authority to direct performance of the work in accordance with Contract requirements.

All subcontracts shall incorporate the Contract, either by physical inclusion or by reference. All subcontracts shall incorporate and include all Federally imposed requirements pertaining to equal opportunity, disadvantage business opportunity, Title VI of the Civil Rights Act of 1964, the Davis-Bacon Act, prompt payment to subcontractors, service companies, service providers, or material suppliers (49 C.F.R. § 26.29) and such other requirements as may be contractually imposed. The Department reserves the right to inspect all subcontract documents. The Contractor shall make all subcontracting documentation available for inspection at his/her usual place of business during normal business hours. The Contractor shall have subcontractors, service companies, or material suppliers acknowledge the inclusion of a FHWA Form 1273 as part of their agreement with the Contractor.

The Department will approve subcontracts only for entire contract pay items required by the Contract by specified unit price and shall include all labor, equipment usage, materials, and manufactured products necessary to complete the unit. The Department will determine the value of subcontracted work using the contract bid price of the subcontracted work unit. The Contractor shall obtain approval of each subcontract before the start of the work included in the subcontract. The Department will not allow "labor and equipment only" or "labor only" subcontracts, unless otherwise required by the Contract. The Department may not pay for work performed by an unapproved subcontractor.

The Department will not recognize or approve second or third tier subcontractors. The Contractor and approved subcontractors may retain and use the services of "Specialized Service Providers" if such services are reasonably necessary for the performance of Contract work and if approved by the Resident Engineer. The Department considers "Specialized Service Providers" to be companies or individuals that perform services that may require specialized knowledge, experience, equipment, or any combination of these. Specialized services must be necessary to the completion of a portion or component of a work unit and may not be separately identified as a Contract item. The Department will not include the cost of work performed by "Specialized Service Providers" as subcontracted work for the purpose of calculating the subcontracted percentage of work. Specialized services include, but are not limited to, the following:

- Reinforcing steel placement,
- Rock blasting,
- Beam fabrication,
- Pier drilling,
- Welding,
- Concrete pumping,
- Profilographing,
- Bump grinding,
- Surveying and staking,
- Engineering and testing,
- Irrigation system or plumbing,
- Material hauling, and
- Watering.

If the Contract identifies contract pay items as “Specialty Items”, the Department will allow approved subcontractors to perform the work and will deduct the cost of "Specialty Items" performed by subcontract from the total Contract amount before calculating the amount of work the Contract requires be performed by the Contractor with its own organization. “Specialty Items” are contract pay items that are specific to the Contract and which are not normally found as a part of highway associated construction. Specialty items may require the services of skilled trades for construction of facilities which are ancillary to the highway and may include carpenters, licensed plumbing and electrical tradesmen, and other skilled craftsmen who are not normally involved in highway construction.

The Contractor shall submit requests for permission to sublet, or otherwise dispose of any portion of the Contract work, to the State Construction Engineer, by means of Department approved electronic media or in writing. The Contractor shall include in its request a statement showing that the organization (subcontractor) that will perform the work is particularly experienced and equipped for such work. The Contractor shall give assurance that the minimum wage for labor, as stated in its proposal, shall apply to labor performed on all work sublet. No subcontracts, or transfers of the Contract, shall in any case release the Contractor of its liability under the Contract and bonds.

Should the Contractor assign any of its right, title, or interest in the Contract, said assignment shall be made only with the full knowledge and written consent of the Surety. It is specifically understood that a violation of this subsection will constitute an act of default on the part of the Contractor.

108.02 NOTICE TO PROCEED AND PRECONSTRUCTION CONFERENCE

The Notice to Proceed is the written authorization for the Contractor to proceed with the Contract work. In no case shall work, other than mobilization, start before the Department issues the Notice to Proceed. The Department will begin charging Contract Time from the time work actually starts, but not later than the effective date of the Notice to Proceed. Provisions in the Contract may establish project-specific details regarding access to the work and time charges.

After the Contractor receives the Notice to Proceed and before the start of construction, the Contractor and Resident Engineer shall hold a preconstruction conference. The Contractor shall have the following people present at the preconstruction conference:

- The project superintendent,
- Other representatives or responsible officials who will be involved during the construction of the project, and
- Representatives of any subcontractors.

The Resident Engineer may invite officials of local county and municipal governments, representatives of affected utility companies and other agencies to establish a working understanding and to provide for the coordination of the work among the various parties, allowing the work to proceed with minimum delay.

The discussion of the project at the preconstruction conference may include, but not be limited to, issues regarding the following:

- The Contractor’s plans and schedules,

- Location of the work beginning,
- Utilities,
- Right of way,
- Agreements affecting the construction,
- Compliance with permits that have been issued,
- Unusual conditions,
- Compliance with Disadvantaged Business Enterprise (DBE) goals, and
- Other applicable requirements such as stormwater management, pollution controls and other pertinent items.

The parties at the preconstruction conference may discuss contract items to ensure that all parties understand the type of materials required, the method of construction, and the method of measurement and payment.

108.03 PROSECUTION AND PROGRESS

The Contractor shall provide sufficient materials, equipment, and labor to guarantee the completion of the project within the Contract Time.

The Contractor shall submit an as-planned progress schedule to the Resident Engineer for review and acceptance before starting work. The progress schedule will establish the Contractor's planned construction operations. The Resident Engineer will use the progress schedule to monitor the progress of the work. The progress schedule will provide for completion of the project within the Contract Time and will use all of the time provided by the Contract.

The Department will allow the Contractor to provide a progress schedule in the form of an activities schedule chart (ASC) and written narrative (WN) in accordance with Subsection 108.03.A, "Activities Schedule Chart and Written Narrative," or a critical path schedule in accordance with Subsection 108.03.B, "Critical Path Method (CPM) Schedule," unless the Contract specifically requires a CPM schedule.

A. Activities Schedule Chart and Written Narrative

The ASC and WN shall provide a detailed break down of the time (working days or completion date) involved in performing major construction activities for the duration of the project. The ASC shall be used for the coordination and Department monitoring of major work in the Contract, including the activities of subcontractors, vendors, and suppliers.

(1) Schedule Requirements

The Contractor shall ensure that all ASCs it submits to the Department include the following:

- A bar chart, chronologically sequenced and time scaled, with a number of activities appropriate to the project showing construction prosecution or preparation activities;
- Activity descriptions for each activity bar on the chart; and
- Activity durations by calendar days.

(2) Written Narratives

The Contractor shall ensure that all WNs it submits to the Department include the following:

- The proposed work process sequence showing major work activities required for the complete performance of all items of work under the Contract, including major shop drawing submittals, permits, fabrication, delivery activities, etc.;
- A description of readily identifiable work activities;
- A description for each bar identifying the trade or entity performing the work, the duration of the activity in work days, and the location of the work; and
- A description indicating work days per week, holidays, number of shifts per day, number of hours per shift, and major equipment to be used.

(3) Preparation of Initial Schedule

The Contractor shall develop the initial ASC and WN and submit two copies of each to the Resident Engineer at the preconstruction conference.

The Department will not allow the construction time, indicated by the ASC and WN, for the entire project or any milestone to exceed the Contract Time. Following the Resident Engineer's initial review of the ASC and WN, the Resident Engineer and Contractor shall meet for a joint review, correction, and adjustment of the schedule if required. If necessary the Resident Engineer and the Contractor will repeat this process, however, the Contractor shall complete the initial schedule within 30 calendar days after the preconstruction conference. If the Contractor fails to provide an acceptable initial schedule by that date, the Department will withhold contract payments until the Department receives an acceptable initial schedule.

(4) Progress Meetings

The Resident Engineer and Contractor shall hold progress meetings coinciding with submittal of progressive estimates to verify actual progress. In addition, the Department may require job-site progress meetings to address Change Orders, time extensions (if time extensions total at least 21 calendar days), or other circumstances as directed by the Resident Engineer. The Contractor shall submit copies of revised progress schedules to the Resident Engineer.

B. Critical Path Method (CPM) Schedule

A CPM progress schedule shall employ a network analysis system as described below. The Contractor is responsible for developing and implementing this system for the planning and scheduling of construction. As a minimum, the Contractor shall prepare the network analysis system in a form acceptable to the Department. The Department will consider scheduling methods other than CPM on an individual basis.

The system shall consist of network diagrams, computer mathematical analysis, calendar, and narrative. The network diagram shall show the order and interdependence of activities and the sequence of the work to be accomplished as planned by the Contractor in coordination with all subcontractors and other prime contractors. The basic concept of the network diagram shall be followed to show how the start of a given activity is dependent on the completion of preceding activities and its completion restricts the start of following activities.

The detailed network activities shall include, in addition to construction activities, the submittal and approval of materials and shop drawings, and the procurement, installation and testing of materials and equipment that the Resident Engineer determines significant. The system shall show early completion of certain portions of the project as required by the Contract.

The Department will not allow activity durations longer than 30 working days, unless otherwise approved by the Resident Engineer. The Department reserves the right to limit the number of activities on the schedule from 50 activities to 500 activities. Detailed networks shall show a continuous flow from left to right, drafted on paper 24 in [610 mm] wide and 36 in [914 mm] long. The drafted network diagram shall contain readable alphanumeric characters. The network diagram arrangement shall allow sufficient room between diagram paths for "red line" modification of existing activity and/or diagram arrangement. The Contractor shall ensure the diagram shows the following information for each activity:

- Identification number,
- Description, and
- Duration in calendar days.

The Contractor shall ensure that the critical path is highlighted to distinguish it from other diagram paths.

The application software program used shall be capable of compiling all completed and partially completed activities. The program shall be capable of accepting revised completion dates as modified by approved time adjustments and recalculating all tabulation dates and total float accordingly.

The software program shall be capable of listing the activities in sorts or schedules as follows:

- In order of activity numbers.
- By total float.

The Contractor shall update the mathematical analysis of the network diagram monthly, unless waived by the Resident Engineer in writing.

The cover sheet for each monthly update shall list the following:

- State job number,
- ODOT project number and description,
- Contractor name,
- Reporting period,
- Scheduled completion date, and
- Actual completion date and variation from schedule.

At the preconstruction conference, the Contractor shall submit a preliminary network analysis system defining the Contractor's planned operation for the first 60 calendar days after the date of the notice to proceed and shall indicate the Contractor's general approach for the balance of the project.

Within 30 calendar days after the date of the preconstruction conference, the Contractor shall submit to the Resident Engineer a complete network analysis system consisting of the computer mathematical analysis and diagram, unless extended in writing by the Resident Engineer. The Contractor shall submit four copies of the initial diagram, calendar, and computer analysis, and four copies of the monthly updated computer analysis.

The Resident Engineer will review the detailed network analysis system for logic and conformance to the Contract requirements, including any special notations in the plans pertaining to sequence of operations. Within 15 calendar days after the Resident

Engineer's receipt of the detailed network analysis system, the Contractor and the Resident Engineer shall meet for joint review, correction, and adjustment of the schedule, if necessary. The Department will not allow the construction time, as determined by the CPM schedule, for the entire project or any milestone, to exceed the Contract Time. The Contractor shall revise the schedule logic or activity durations if the schedule does not meet any milestone date or Contract Completion Date. After this joint meeting, but within 15 calendar days of the Resident Engineer and Contractor agreeing on schedule logic or activity duration changes, the Contractor shall submit to the Resident Engineer a revised schedule, including four copies of the diagram, an activity number order sort, and a total float sort. If necessary the Resident Engineer and the Contractor will repeat this process, however, the Contractor shall complete the initial schedule within 30 calendar days after the preconstruction conference. If the Contractor fails to provide an acceptable initial schedule by that date, the Department will withhold contract payments until the Department receives an acceptable initial schedule.

The Department and the Contractor will hold monthly job-site progress meetings to update the progress schedule. The Resident Engineer will review the progress schedule update to verify start and finish dates of completed activities, remaining duration of uncompleted activities, and proposed revisions to logic, time estimate, or both. It is the Contractor's responsibility to provide the Department with the status of activities at these progress meetings and to provide the progress schedule updates once the Resident Engineer has verified the status of activities.

The Contractor shall create new CPM activities to reflect any precise period of delays that will affect the Contract Completion Date. The Contractor and the Department will agree on the start date and the finish date of the delay activities and the logic-dependent relationship to the activities of the affected predecessor and successor activities.

The Contractor shall submit four copies of the progress schedule update illustrating the verified progress, no later than the fifth day of each month. The progress schedule update shall include an activity number sort, a total float sort, and a written narrative describing the critical path and logic revisions or modifications to the schedule, including, but not limited to, the following:

- Changes in the method or manner of the work,
- Changes to the Contract requirements,
- Extra work,
- Changes in activity durations, and
- Reasons for delay.

The Department will not allow logic revisions or modifications without prior approval by the Resident Engineer. If the Contractor fails to provide a monthly network analysis system update by the date required above, the Department will withhold contract payments until the Department receives the monthly network analysis system update.

The Contractor shall also submit two copies of revised diagrams for the following:

- Delays to the completion of critical activities;
- Actual prosecution of the work that is significantly different than that represented on the schedule, as determined by the Resident Engineer;

- Additions, deletions, or revisions of activities required by Contract modification; and
- Revisions to the schedule's logic or calendar.

The Resident Engineer will only adjust the Contract Time in accordance with Subsection 108.07, “Administration and Extension of Contract Time.”

As determined by computer analysis, only delays in activities which affect milestone dates, critical path, or Contract Completion Dates will be considered for a time extension under this subsection.

If the Contractor seeks a time extension of any milestone or the Contract Completion Date, the Contractor shall furnish documentation as required by the Department to enable the Department to determine whether a time extension is appropriate under the terms of the Contract.

Float is a commodity owned by the Contract (Contractor and Department) and may be used by the Department or Contractor on a first-come first-serve basis.

108.04 LIMITATION OF OPERATIONS

The Contractor shall perform construction operations to ensure the least interference with traffic, regarding the location of detours and the provisions for handling traffic. If the opening of a section of the project is essential to public convenience, the Resident Engineer may direct the Contractor to finish that section of the project before starting another section or sections.

108.05 CHARACTER OF WORKERS

The Contractor shall employ sufficient resources for prosecuting all classes of work in the manner and time required by the Contract.

The Contractor shall ensure all workers have sufficient skill and experience to properly perform their assigned work. If a worker, employed by the Contractor or subcontractors, does not perform the work in a proper and skillful manner or is intemperate or disorderly, the Contractor shall remove the worker from the project at the written request of the Resident Engineer, and shall not be reemployed without the approval of the Resident Engineer. If the Contractor or subcontractor fails to remove the worker, or fails to provide suitable and sufficient personnel for the proper prosecution of the work, the Resident Engineer may suspend the Work by written Shut Down Order in accordance with Subsection 104.05, “Suspension of Work Ordered by the Resident Engineer,” until the Contractor or subcontractor removes the worker or provides sufficient personnel. If the Contractor fails to provide a qualified work force or supervision to properly prosecute work, the Department may refuse to issue Proposal Forms for future contracts in accordance with Subsection 102.04, “Refusal of Proposals.”

108.06 METHODS AND EQUIPMENT

The Contractor is responsible for the following:

- Providing and using equipment of sufficient size and mechanical condition to produce work that meets the Contract requirements; and
- Ensuring the equipment used does not cause damage to the roadway, adjacent property, or other highways.

If the Contract specifically requires methods and equipment the Contractor is to use, the Contractor may not use other methods and equipment unless requested in writing and approved by the Resident Engineer. The request shall include a description of the methods and equipment proposed and the reasons for changing from those required by the Contract. If the Resident Engineer approves the change, the Contractor is responsible for producing work meeting the Contract requirements. The Resident Engineer may, if demonstrable improvement in the work or time savings occur, change the following:

- The basis of payment for the involved contract items, or
- The Contract Time.

If the Resident Engineer determines that the work produced using the substituted methods or equipment does not meet the Contract requirements, the Contractor shall discontinue use of the substitute methods or equipment and complete the remaining work using the methods and equipment required by the Contract. The Contractor shall repair or remove and replace deficient work at no additional cost to the Department.

108.07 ADMINISTRATION AND EXTENSION OF CONTRACT TIME

A. General

The Proposal Forms and Contract will state the Contract Time. The Resident Engineer will provide a monthly statement (Time and Diary Report) to the Contractor showing the number of days charged to the Contract for the preceding month and the number of days remaining for completion of the Contract as of the end of the preceding month. If the Contractor disagrees with the statement, the Contractor shall submit a written protest to the Resident Engineer within 10 calendar days of receiving the statement and shall include reasons why it believes the statement to be incorrect. If the Contractor fails to submit the protest within 10 calendar days, the Contractor will waive all rights to protest that time charge. A separate written protest of time charges submitted within the required 10 calendar day period is a requirement that must be satisfied before any corrections will be made to assessed Contract Time charges.

B. Calendar Day Contract

If the Contract Time is on a calendar day basis, it shall consist of the number of calendar days required by the Contract, counting from the effective date of the Notice to Proceed or from the date the Contractor begins work, whichever is earlier, including all Sundays, holidays, and non-work days, except as otherwise required by the Contract. The Department will exclude time charges for all calendar days elapsing between effective dates of any orders of the Resident Engineer to suspend work and to resume work after suspensions, not the fault of the Contractor.

Upon the Contractor's written request, the Resident Engineer may suspend time charges and work from December 21 to the following February 15. If the Contractor elects to work during this winter time suspension, the Resident Engineer will charge for each day the Contractor works. The Contractor shall continue to maintain the Project work site during this or any other time suspension in accordance with Subsection 105.14, "Maintenance During Construction."

The Resident Engineer may suspend time charges once the project reaches substantial completion, as defined in Subsection 105.17.A, "Substantial Completion."

This suspension is contingent upon the Contractor's diligence in completing any remaining work.

The Resident Engineer will grant time extensions or suspensions for a calendar day contract that contains incentive/disincentive provisions for the time period subject to the incentive/disincentive provision in accordance with applicable Contract provisions and Subsection 108.08, "Incentive/Disincentive for Early/Late Completion."

(1) Extensions for Adverse Weather

The Department will consider the occurrence of adverse weather conditions during the Contract Time to be a basis for extending the Contract Time if the time or work is not already suspended for other reasons.

The Resident Engineer will determine extensions of the Contract Time for adverse weather conditions on a daily basis and will only extend the Contract Time if adverse weather prevents the performance of work activities critical to milestone or Contract completion. The Contractor shall make every reasonable effort to minimize the impact of the adverse weather conditions.

The Department will consider days designated by an appropriate authority as "ozone alert days" to be adverse weather days, if that authority requires the Contractor to suspend or delay work activities that are critical to milestone or Contract completion. The Contractor shall make every reasonable effort to minimize the impact of ozone alert days.

The Resident Engineer may justify and document an extension to the Contract Time due to adverse weather by crediting an adverse weather day on the monthly Time and Diary Report with an explanation for the credit. The Contractor may file a written protest of the time charges indicated on the monthly report in accordance with Subsection 108.07.A, "Administration and Extension of Contract Time, General." If the Resident Engineer did not justify and document the extension to the Contract Time on the Time and Diary Report, the Resident Engineer will justify and document the extension with a Change Order.

(2) Extension for Non-weather Related Delays Beyond the Contractor's Control

The Department may consider the occurrence of delays to the Contractor's operations that are beyond the Contractor's control to be a basis for extending the Contract Time, if the time or work is not already suspended for other reasons.

The Contractor shall provide written notice to the Resident Engineer within 7 calendar days of the start of any delay the Contractor believes justifies an extension to the Contract Time. Within 30 calendar days of the end of the delay, the Contractor shall submit a written request to the Resident Engineer for the extension to the Contract Time that includes reasons for the extensions and supporting documentation. If the Contractor fails to provide the written notice or submit the written request within the time allowed, the Resident Engineer will not consider the request for the delay. The Contractor may only request extensions to the Contract Time for the delays that meet the following criteria:

- Beyond the Contractor's control;
- Not the fault of the Contractor or its subcontractors, suppliers, and vendors; and

- Prevent or impede the performance of work activities that are critical to milestone or Contract completion.

The Department will base the number of calendar days in the Contract Time as awarded on the original quantities in accordance with Subsection 102.05, "Interpretation of Quantities and Bid Proposal." If satisfactory completion of the Contract requires additional quantities work, greater than those stated in the Proposal Forms, the Resident Engineer may increase the Contract Time commensurate with the amount and difficulty of the additional work.

The Contractor may use scheduling methods described in Subsection 108.03(a), unless scheduling methodology prescribed in Subsection 108.03(b) is required by the Contract. The Resident Engineer will only consider time extensions for additional work or delays beyond the Contractor's control that adversely impact the Contractor's schedule and sequence of work and extend the Contract completion past the Contract Time. The Department will not consider the following Contractor arguments as grounds for an extension to the Contract Time:

- The Proposal Forms and the Contract did not state a sufficient Contract Time, or
- Previously un-protested time charges were incorrect.

Extended Contract Time approved by the Resident Engineer shall be in full force and affect the same as though it were the original Contract Time.

If the Resident Engineer determines that an extension to the Contract Time that is due to non-weather delays is justified, the Resident Engineer will justify and document the extension with a Change Order.

C. Fixed Completion Date Contract

If the Contract Time is a Fixed Completion Date, the Contractor shall satisfactorily complete all work under the Contract on or before that date in accordance with Subsection 105.17, "Project Completion and Acceptance." The Contractor may only request extensions to the Fixed Completion Date for the delays that meet the following criteria:

- Beyond the Contractor's control;
- Not the fault of the Contractor or its subcontractors, suppliers, and vendors; and
- Prevent or impede the performance of work activities that are critical to milestone or Contract completion.

The Department will not allow extension to the Fixed Completion Date caused by adverse weather, foreseeable causes, or conditions under the control of the Contractor. Subsection 108.07.B, "Calendar Day Contract," shall not apply to any Contract containing a Fixed Completion Date. If the Resident Engineer determines that an extension to the Fixed Completion Date is justified, the Resident Engineer will justify and document the extension with a Change Order.

D. Delays to Contract Time

All requests for adjustment to Contract Time shall identify delays actually encountered that prevent or impede the performance of work activities that are critical to milestone or Contract completion, in accordance with Subsection 108.07.B(2), "Extension for Non-weather Related Delays Beyond the Contractor's Control," or Subsection 108.07.C, "Fixed Completion Date Contract," at a point in time when such

work was scheduled to be in progress. The Contractor may only use a progress schedule submitted to the Department in accordance with Subsection 108.03.A, "Activities Schedule Chart and Written Narrative," or Subsection 108.03.B, "Critical Path Method (CPM) Schedule," before the start of the delayed work to support the Contractor's request for an extension to the Contract Time or delay damages.

(1)Excusable (Noncompensable Delay)

The Department will consider delays caused by the following for extensions to the Contract Time:

- Acts of God,
- Acts of the public enemy,
- Fires,
- Floods,
- Epidemics,
- Quarantine restrictions,
- Strikes,
- Freight embargoes,
- Documented national or regional material shortages which are industry wide,
- State or national emergency declarations,
- Unusually severe weather, and
- Delays not caused by the Contractor's fault or negligence.

Delays necessitated by compliance with certain federally mandated programs that occur after the Contract is let may provide a basis for an excusable delay. The Department will not allow additional compensation to the Contractor for such delays.

(2)Compensable Delay

The Resident Engineer will consider additional compensation for Department caused delays that prevent the start of work on successive activities and will adversely impact Contract completion. Float time in the scheduling of successive work elements is a shared commodity and the Department will not pay the Contractor for the use of float time. The Department will pay additional compensation by Change Order in accordance with Subsection 109.10, "Compensation for Project Delays."

(3)Notification of Delay

Within 7 calendar days of the occurrence of a delay, the Contractor shall provide written notification to the Resident Engineer of such a delay, and indicate that a request for delay consideration will be filed with the Department.

(4)Procedures Following Notification of Delay

After notifying the Resident Engineer of the request for delay consideration, the Contractor shall keep daily records of all costs for non-salaried labor, material, and equipment for all operations affected by the delay.

The Contractor shall maintain a daily record of each affected operation, including station locations. The Resident Engineer will also maintain a daily record of the affected operations. On the first work day of each week, the Contractor and Resident Engineer will meet and compare their previous week's

daily records, and the Contractor shall prepare and submit written reports to the Resident Engineer containing the following information:

- Number of days behind schedule;
- A summary of all operations that have been delayed, or will be delayed;
- In the case of a compensable delay, the Contractor shall explain how the Department's act or omission delayed each operation, and estimate the amount of time required to complete the project; and
- Contractor may request compensation for extra costs incurred as identified in Subsection 109.04, "Differing Site Conditions, Changes, and Extra Work."

The Contractor shall provide written notice to the Resident Engineer within 30 calendar days of the meeting, and shall include any disagreements between the records. If the Contractor fails to meet with the Resident Engineer to compare daily records or to report disagreements between the records, the Department will consider the Resident Engineer's records to be accurate.

The Department will not allow requests for delay costs allegedly incurred before the Contractor notified the Resident Engineer.

(5)Procedures Following Completion of Work Alleged to be Delayed

The Contractor shall submit to the Resident Engineer a report containing the following information, within 30 calendar days of project completion or completion of phase of work allegedly delayed:

- A description of the operations that were delayed and the documentation and explanation of the reason for the delay, including all reports prepared for the Contractor by consultants, if used;
- An as-built chart, or other graphical depiction of how the operations were delayed, and;
- An item by item measurement and explanation of extra costs requested for reimbursement due to the delay.

The Resident Engineer will review the Contractor's report and available inspection diaries, records, and reports. The Resident Engineer will provide a written decision to the Contractor within 60 calendar days of the receipt of the Contractor's report. The decision will contain notification of any additional time the Resident Engineer will grant.

In the case of compensable delays, if the Resident Engineer determines that the Department is responsible for delays to the Contractor's operation, the Resident Engineer's written decision will identify the nature and extent of any delay and the compensation which may be due to the Contractor in accordance with Subsection 109.10, "Compensation for Project Delays."

108.08 INCENTIVE/DISINCENTIVE FOR EARLY/LATE COMPLETION

If it is in the public's interest to complete the project at the earliest possible date, the Contract may include an incentive/disincentive provision detailing applicable dates and work stages covered by the provision.

For each calendar day the project or section of the project is opened to unrestricted continuous traffic before or after the date required by the Contract, the Department will

increase or decrease its payment to the Contractor, by the amount established by the Contract.

The Department considers "unrestricted continuous traffic" to mean no lane closures will be granted for any of the Contractor's operations necessary to complete the project, and that traffic will follow the final lane configuration as required by the plans for the finished surface for the roadway with lane striping and permanent safety features completed.

The Resident Engineer will determine when the project or section of the project is complete to open the roadway to unrestricted continuous traffic.

Subsection 108.09, "Failure to Complete on Time," relating to Liquidated Damages will remain in effect and apply to the total Contract Time. Concurrent Liquidated Damages and disincentive assessments may occur.

The Department will pay the Contractor the amount of incentive, in a progressive estimate, as funds are encumbered for such payment. Once the Contractor earns an incentive, the Resident Engineer will initiate a Change Order for presentation at the next available Commission meeting to request any additional funds necessary for payment of the incentive. The Resident Engineer will deduct the amount of disincentive from the next progressive estimate.

Should the amount of disincentive or Liquidated Damages exceed the amount due for work performed in a specific pay period, the Contractor shall reimburse the Department in the amount of the difference within 45 calendar days of notice that payment is due.

Under an incentive/disincentive provision, the Engineer may grant time extensions for the following when such occurrences adversely affect work on the critical path of the CPM schedule:

- Significant change that results in quantity overruns in accordance with Subsection 104.04, "Significant Changes in the Character of Work";
- Significant error in the plans that delays work on the critical path of the project;
- Unknown subsurface utilities; and
- Delays that are demonstrably outside the control of the Contractor caused by governmental agency or railroad company inactivity.

Under an incentive/disincentive provision, the Resident Engineer will not grant time extensions for the following:

- Labor disputes or delays in material deliveries, unless it can be shown that such disputes or delays are industry wide; and
- Adverse weather conditions.

108.09 FAILURE TO COMPLETE ON TIME

For each calendar day the work remains incomplete after the Contract Time, the Resident Engineer will deduct from the amount due the Contractor in accordance with Table 108:1, "Schedule of Liquidated Damages." Liquidated Damages are not to be considered as a penalty, but rather a recovery of costs incurred by the Department due to the added cost of engineering, inspection, testing, and other extra expenditures of public funds made necessary by the Contractor's failure to complete the work within the Contract Time. The Resident Engineer assesses Liquidated Damages as an alternative to

the more difficult and time consuming calculation of determining the actual Department costs.

Table 108:1
Schedule of Liquidated Damages

Contract Amount, *$*	Daily Assessment Rate, *$*
≤100,000	300
>100,000 – 1,000,000	500
>1,000,000 – 3,000,000	750
>3,000,000 – 7,000,000	1,000
>7,000,000	2,000

The Department does not waive its rights under the Contract by allowing the Contractor or Surety to continue and finish work after the Contract Time has elapsed.

If the Resident Engineer determines the work is substantially complete and is in a condition for safe and convenient use by the traveling public, the Resident Engineer may terminate the assessment of all or any portion of the accrued Liquidated Damages, except for Fixed Completion Date Contracts.

108.10 DEFAULT OF CONTRACT

The Engineer may declare the Contract in default and advise the Contractor and the Surety of the actions required for remedy if the Contractor does any of the following:

- Fails to start the work by the date required by the Contract;
- Fails to perform the work with sufficient resources including qualified on-site supervision, skilled personnel, and equipment necessary to assure the timely completion of the work;
- Fails to perform the work in accordance with the contract requirements;
- Neglects or refuses to remove and replace rejected materials or unacceptable work;
- Discontinues the prosecution of the work;
- Fails to resume work within a reasonable time after written notice to do so, or
- Becomes insolvent, is declared bankrupt, or commits any act of bankruptcy or insolvency;
- Allows any final judgment to remain unsatisfied for a period of 10 calendar days;
- Makes an assignment for the benefit of creditors;
- Fails to comply with contract requirements regarding minimum wage payments or EEO requirements; or
- Is convicted of any felony involving fraud, moral turpitude, or offenses against the public contracting laws of the United States or any State of the United States. (For purposes of this subsection the Department will consider entry of a plea of guilty or *nolo contendere* to be equivalent to a conviction.)

The Engineer will provide written notice to the Contractor and Surety of such delay, neglect, or default. If the Contractor or Surety does not proceed in accordance with the notice within 10 calendar days of receipt, the Department has full power and authority, without violating the Contract, to take the prosecution of the work from the Contractor. The Department may appropriate or use materials at the project site and enter into an agreement with another Contractor for the completion of the remaining work. If the Contractor has obtained materials for use on the project and has not incorporated the materials into the work, the Department may purchase acceptable materials from the Contractor at actual cost.

The Department will determine the methods used for completion of the Contract.

The Department will deduct the following from monies due the Contractor for completed work:

- All costs and charges incurred by the Department as a result of the default, including the cost of completing the work under contract, and
- Any applicable Liquidated Damages or disincentives.

If such costs exceed the sum that would have been payable under the Contract, the Contractor and Surety shall be liable and shall pay the Department the balance of such costs.

If the Department determines, after termination of the Contractor's right to proceed, that the Contractor was not in default, the rights and obligations of the parties will be the same as if the termination had been issued for the convenience of the Department in accordance with Subsection 108.11, "Termination of Contract for Convenience of the Department." The damages to which a Contractor may be entitled as a result of the improper default termination will be limited to appropriate amounts for the items listed in Subsection 108.11, "Termination of Contract for Convenience of the Department."

108.11 TERMINATION OF CONTRACT FOR CONVENIENCE OF THE DEPARTMENT

If the Engineer determines that a termination is in the Department's interest, the Department may terminate the entire Contract or any portion of the Contract. The Engineer will provide a written notice of termination to the Contractor specifying the extent of termination and the effective date.

A. Submittals and Procedures

After receipt of a notice of termination, the Contractor shall immediately proceed with the following obligations:

- Stop work as specified in the notice;
- Place no further subcontracts or orders for materials, services, or facilities, except as necessary to complete the continued portion of the Contract;
- Terminate all subcontracts to the extent they relate to the work terminated; and
- Settle all outstanding liabilities and termination settlement proposals arising from the termination of the Contract.

The Contractor shall transfer title and deliver to the Department the following items:

- Fabricated, partially fabricated, or un-fabricated parts;
- Work in progress;
- Completed work;
- Supplies;
- Other material produced or acquired for the work terminated; and
- Completed or partially completed plans, drawings, information, and other property that, if the Contract had been completed, would be required to be provided to the Department.

The Contractor is responsible for the following tasks upon notice of termination:

- Complete performance of the work not terminated;

- Inventory acceptable materials that the Contractor has obtained for use on the project and has not incorporated into the work in conjunction with the Resident Engineer at a date chosen by the Resident Engineer; and
- Take any action necessary, or that the Resident Engineer may direct, for the protection and preservation of the property related to the Contract that is in the possession of the Contractor and in which the Department has or may acquire an interest.

B. Settlement Provisions

If the Engineer orders termination of all or part of the Contract effective on a certain date, the Department will pay for completed items of work at the contract unit price as of that date. The Department will pay for contract items entirely eliminated by such termination in accordance with Subsection 109.05, "Payment for Cancelled Items." The Department will pay for partially completed work either at agreed prices or in accordance with the following:

(1) Additional Costs

Within 60 calendar days of the effective termination date, the Contractor shall submit a claim for additional damages or costs not covered in the Contract. Such claim may include the following cost items:

- Reasonable idle equipment time,
- Mobilization efforts,
- Bidding and project investigative costs,
- Overhead expenses attributable to the project terminated,
- Subcontractor costs not otherwise paid,
- Actual idle labor cost if work is stopped in advance of termination date,
- Guaranteed payments for private land usage as part of the Contract, and
- Other costs or damages documented by the Contractor.

The Department will not consider anticipated profits as part of any settlement.

The Contractor and the Department may agree upon the whole or any part of the amount due the Contractor because of the termination. The amount may include a reasonable allowance for profit on work completed. The agreed amount may not exceed the total contract price as reduced by the amount of payments previously made, and the contract price of work not terminated. The Department will amend the Contract to include this agreed amount and will pay the Contractor the agreed amount.

(2) Additional Cost Review

If the Contractor and the Department fail to agree on the whole amount due the Contractor because of the termination of work, the Department will pay the amounts determined as follows, without duplicating any amounts agreed to in accordance with Subsection 108.11.B(1), "Additional Costs":

1. For Contract work performed before the effective date of termination, the total of the following:

   1.1. The cost of work performed;
   1.2. The cost of settling and paying termination settlement proposals under terminated subcontracts (not included in the cost of work performed) that are properly chargeable to the terminated portion of the Contract; and

1.3. A sum, as profit, on the costs determined by the Department in accordance with Subsection 108.11.B(1), "Additional Costs," to be fair and reasonable. The Department will not allow profit under Subsection 108.11.B, "Settlement Provisions," if the Contractor's costs incurred on work performed exceed the bid item payments made;

2. The reasonable costs of settlement of the terminated work, including the following:

   2.1. Accounting, legal, clerical, and other expenses reasonably necessary for the preparation of termination settlement proposals and support data;
   2.2. The termination and settlement of subcontracts (excluding the amounts of such settlements); and
   2.3. Storage, transportation, and other costs incurred, reasonably necessary for the preservation, protection, or disposition of the termination inventory;

3. The fair market value of termination inventory shall not include items or material that are destroyed, lost, stolen, or damaged to the extent as to be undeliverable to the Department or a buyer unless the Department expressly accepts the risk of such loss, theft, or damage; and
4. The Department will calculate the amount due the Contractor under this clause and will deduct the following:
   4.1. All un-liquidated advance or other payments to the Contractor under the Contract;
   4.2. Any claim that the Department has against the Contractor under the Contract; and
   4.3. The agreed price for, or the proceeds from the sale of, materials, supplies, or other items acquired and sold by the Contractor not recovered by or credited to the Department.

C. Partial Termination

If the termination is partial, the Contractor may submit a proposal to the Department for, and request review of, the unit prices on the continued portion of the Contract. The Department will review unit prices for the continued portion of the Contract and will revise such prices as necessary. The Contractor shall submit the proposal and request for a review of unit prices within 90 calendar days from the effective date of termination, unless extended in writing by the Resident Engineer.

The Department may, under the terms and conditions it prescribes, make partial payments and payments against costs incurred by the Contractor for the terminated portion of the Contract, if these payments will not exceed the amount due the Contractor.

The Contractor shall maintain all project records and make them available for audit to the extent necessary to verify amount and value of each item claimed. Project records include all books and other evidence bearing on the Contractor's costs and expenses under the Contract. The Contractor shall make these records and documents available in accordance with Subsection 107.22, "Project Records."

Termination of the Contract or portion of the Contract shall not relieve the Contractor of contractual responsibilities for the work completed, nor shall it relieve the Surety of its obligation for any just claim arising out of the work performed.

108.12 LANE RENTAL

If required by the Contract, the Contractor shall pay a rental fee to the Department to restrict traffic flow on operable highway lanes. The purpose of this requirement is to encourage the Contractor to perform the work during non-peak traffic periods and to reduce traffic congestion during designated time periods. The Department will impose lane rental fees for all designated time periods for traffic lanes that are totally or partially impaired by Contractor operations.

SECTION 109
MEASUREMENTS AND PAYMENT

109.01 MEASUREMENT OF QUANTITIES

A. General

The Resident Engineer will measure all work completed under the Contract in accordance with the United States standard measure or the modernized metric International System of Units (SI).

The Department defines a “station” as 100 ft [1 km] when used as a definition or term of measurement. The Resident Engineer will, and the Contractor shall, use methods of measurement and calculation that are generally recognized as conforming to good engineering practice for the determination of quantities of material provided and of work performed under the Contract. For area calculations, unless otherwise required by the Contract, the Resident Engineer will make longitudinal measurements horizontally and will use the neat dimensions as shown on the plans, or as modified by the Resident Engineer, for transverse measurements. The Department will not deduct for individual fixtures with an area of 9 ft² [1.0 m²] or less.

If the area unit for measurement and payment is on an acre [hectare] basis, the Resident Engineer will take measurements on the slope of the ground to calculate the actual surface area, in acres [hectares], for payment.

The Resident Engineer will measure structures using the neat lines shown on the plans, or as modified by the Resident Engineer to fit field conditions.

Unless otherwise shown on the plans, the Resident Engineer will measure items measured by the linear foot [meter] (such as pipe culverts, guardrail, and under-drains) as specified in the method of measurement subsection for the pay item in the relevant section of the specifications.

The Specifications will specify, and the Resident Engineer will measure, the thickness of plates and galvanized sheet used in the manufacture of corrugated metal pipe, metal plate, pipe culvert and arches, and metal cribbing in decimal fractions in inches [millimeters]. The measurement of wire will be by Size Number in accordance with AASHTO M 32 unless otherwise specified.

The Department defines a “ton” as a short ton consisting of 2,000 lb, and a “metric ton” as a 1,000 kg. The Contractor shall ensure use of competent, qualified personnel to weigh materials measured or proportioned by weight on accurate scales at locations approved by

the Resident Engineer. If material is shipped by rail, the Resident Engineer may accept the rail car weight provided that the Department will only pay for the actual weight of material, however, the Resident Engineer will not accept car weights for material introduced into mixing plants. Each day the Contractor shall weigh empty trucks used to haul material paid by weight at such times as the Resident Engineer directs. The Contractor shall ensure that each truck bears a plainly legible identification mark.

The Contractor shall ensure that scales used to weigh truck loads of material paid by weight are adequate to weigh the entire gross load at one weighing on a single set of scales. The Contractor shall ensure the scales are inspected and certified at least every six months, or more often as the Resident Engineer may deem necessary to ensure accuracy. The Contractor shall have on hand at least ten 50 lb [22.7 kg] weights for testing scales. The Contractor may use certified commercial scales.

Instead of weighing truck loads of material on single sets of scales measuring the gross load, the Contractor may use a Department-approved automatic batch weight and printer system. The approved automatic batch weight and printer system shall be electronically controlled and capable of determining the net batch weight of material being delivered to the transporting truck. A weigh ticket containing all the required identifying information shall accompany each load as evidence of the weight. The automatic batch weight and printer system is subject to the same calibration, inspection, and certification requirements as for the truck scales.

The Contractor shall ensure material measured by volume in the hauling vehicle are hauled in vehicles approved by the USDOT and the Department, and measured at the point of delivery. Vehicles used for this purpose may be of any size or type approved by the Resident Engineer, provided that the body is of such shape that the actual volume may be readily and accurately measured. The Contractor shall load all vehicles to at least the strike-off level or capacity established by the Resident Engineer if materials are delivered to the project. The Department may require the Contractor to level the material in hauling vehicles, as deemed necessary and approved by the Resident Engineer, to verify the volume of material delivered to the project. The Resident Engineer will establish the capacity of all vehicles and the Contractor shall ensure that the capacity is plainly marked on each vehicle. The Department will not allow the capacity or marking to be changed without prior approval by the Resident Engineer.

If requested by the Contractor in writing and approved by the Resident Engineer, material specified to be measured by the cubic yard or ton [cubic meter or metric ton] may be converted to the other measurement units, as appropriate. The Resident Engineer will determine the factors for conversion from weight measurement units to volume measurement units and the Contractor shall agree to the conversion factors before the Resident Engineer uses the method of measurement for the pay quantity.

The Resident Engineer will measure bituminous material by the gallon [liter] or ton [metric ton]. The Resident Engineer will measure volume at 60 °F [15.6 °C] or correct to the volume at 60 °F [15.6 °C] using ASTM D 1250 for asphalt and ASTM D 633 for tar.

The Resident Engineer will use net certified scale weights or weights based on certified volumes, in the case of rail shipments, as a basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the work.

If the Contract requires liquid asphalt measured by the gallon [liter] and the Contractor delivers the liquid asphalt to the project with certified weight bill of lading, the Resident Engineer will convert the weight of the liquid asphalt used in the completed and accepted work to gallons [liters] using a conversion factor approved by the Department's Central Laboratory. The Resident Engineer will measure the volume or weight of the portion of any load delivered to the work and not used in the work in the vicinity of the project, and will make the necessary deduction to determine the actual volume or weight of liquid asphalt used in the work. Liquid asphalt, when measured by weight and converted to gallons [liters] shall be paid by the gallon [liter].

The Contractor shall provide all necessary means and assistance for measuring and calibrating distributors and tanks for determining the quantity of material in the distributors and tanks at any time. The Resident Engineer may require that the Contractor calibrate distributors before use on the project and at any other time the Resident Engineer deems necessary. The Contractor shall provide a calibrated gauge (strapping stick) for each distributor so the Resident Engineer can determine the volume at any content level. The Contractor shall place the distributor on a level area for these measurements.

The Resident Engineer will measure portland cement by the pound [kilogram] or ton [metric ton], as appropriate.

The Department defines "lump sum" as a pay unit that reflects complete payment for the work of the relevant pay item as required by the Contract. If the Contract requires a complete structure or structural unit (in effect, "lump sum" work) as the pay unit, the Department considers all necessary fittings and accessories to be included in the contract unit price for the relevant pay item.

If the Contract requires standard manufactured items, such as fence, wire, plates, rolled shapes, and pipe conduit, and these items are characterized by standard identifications, such as gauge, unit weight, and section dimensions, the Department will consider these standard identifications to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited specifications, the Department will accept manufacturing tolerances established by the relevant industries for the relevant work.

B. Plan Quantities

If the Contract requires payment of a contract pay item or of a portion of a contract pay item on a plan quantity basis, the quantities for payment will be those shown on the plans with deductions from, or additions to, plan quantities resulting from approved modifications to the plan quantities by change order.

If the Contractor and Resident Engineer disagree on the accuracy of the plan quantities, either party may, before any work is started that would affect the measurement, request in writing that the quantities involved be measured. The request must be accompanied with adequate information, data, and calculations to substantiate the belief that the plan quantity is incorrect. If the Contractor fails to provide information, data, and calculations sufficient to substantiate its claim of the incorrect plan quantity, the Department will only pay for the quantity required by the Contract and approved modifications to the plan quantities at the contract unit price. If the Resident Engineer finds the plan quantity to be incorrect, the Department will base

acceptance and payment on the actual quantities measured in place, or the corrected plan quantity as documented by change order.

109.02 SCOPE OF PAYMENT

The Contractor shall accept the payment from the Department, as herein provided in the Contract, as full payment for the following:

- Providing all materials, equipment, labor, tools, and incidentals necessary to complete the work;
- Performing all work required by the Contract;
- Loss or damage arising from the nature of the work, or from the action of the elements, or from any unforeseen difficulties, except as provided in Subsection 104.14, "Contractor's Responsibility for Utility Property and Services," which may be encountered during the prosecution of the work until the final acceptance by the Resident Engineer;
- All risks of every description connected with the prosecution of the work;
- All expenses incurred in consequence of the suspension or discontinuance of the work in accordance with Subsection 109.10, "Compensation For Project Delays";
- Any infringement of patent, trademark, or copyright; and
- Completing the work as required by the Contract.

The payment of any progressive estimate will not relieve the Contractor of its obligations to repair, or remove and replace, defective work or material.

109.03 PAYMENT FOR INCREASED OR DECREASED QUANTITIES

The Department will pay for actual quantities of the work that vary from the plan quantities required by the Contract at the original contract unit price or in accordance with Subsection 104.04, "Significant Changes in the Character of Work," except as provided in Subsection 109.01.B, "Plan Quantities."

Unless specifically required by the Contract, the Department will not adjust payment to the Contractor for increases or decreases in the cost of the work. Sales tax reimbursements will be available in accordance with the applicable rules and regulations of the Oklahoma Tax Commission.

109.04 DIFFERING SITE CONDITIONS, CHANGES, AND EXTRA WORK

A. General

If the Contractor has notified the Resident Engineer in accordance with Subsection 104.06, "Notification of Differing Site Conditions, Changes, and Extra Work," and the Resident Engineer and the Contractor agree that differing site conditions exist, significant changes in the character of work will be required, or extra work will be performed that was not included with the scope of the Contract, the Department will pay for such conditions, changes, and extra work using the following methods, as appropriate:

- Contract unit prices,
- Unit prices agreed upon in the order authorizing the work; or
- Lump sum amount agreed upon in the order authorizing work.

B. Submitting a Claim

If the Contractor and the Resident Engineer disagree on a method for evaluation and compensation for differing site conditions, significant changes in the character of work, or extra work, the Contractor shall submit a fully documented itemized claim in accordance with Subsection 105.18, "Claims for Adjustment," that lists the costs incurred by the Contractor in prosecuting the disputed work. In its claim the Contractor shall segregate all cost listings for disputed work and the supporting documentation from non-disputed work, and shall clearly identify the disputed work on the cost listings and supporting documentation by date, stationing, and type of work. The Contractor may only include cost items defined in Subsection 109.04.B(1), "Labor," through Subsection 109.04.B(7), "Miscellaneous," in its request for additional payment.

(1)Labor

The Contractor may request additional payment for the actual costs incurred by the Contractor for labor that is directly attributable to the disputed work. In the support of the labor costs, the Contractor shall submit certified time sheets detailing the name of each laborer or supervisor, the classification, the date of the work, the daily hours, the total hours, the wage rates, and extensions. The Contractor may include an additional amount equal to 25 percent (15 percent for overhead and 10 percent for profit) of the labor costs attributable to the disputed work.

(2)Materials

The Contractor may request additional payment for the actual costs incurred by the Contractor for materials approved by the Resident Engineer and used in performance of the disputed work, including transportation. In support of the material costs, the Contractor shall provide itemized invoices prepared by the materials supplier. The Contractor may include an additional amount equal to 20 percent (10 percent for overhead and 10 percent for profit) of the material costs attributable to this disputed work.

(3)Equipment

The Contractor may request additional payment for the actual costs incurred by the Contractor for machinery or special equipment (other than small tools) approved by the Resident Engineer and used in performance of the disputed work. The Department will determine the maximum allowable rate as listed in the most current edition of the *Rental Rate Blue Book*, published by Equipment Watch. The Department will calculate the hourly rental rate in accordance with the following equation:

$$H = \frac{(M \times R \times A) + O}{176}$$

where

H = Hourly rental rate,
M = Monthly rate,
R = Regional adjustment,
A = Age adjustment, and
O = Operating costs.

The Department will only pay for those pieces of equipment necessary for completion of the disputed work for the period of time that the disputed work was actually in progress. Additionally, if the Resident Engineer directs the Contractor to hold equipment on the job on a standby basis, the Department may pay the Contractor at a rate equal to 50 percent of the established hourly rental rate minus operating costs. The Department will limit payment for standby equipment to no more than 8 hr per day and no more than 40 hr per week. In support of the Contractor's request for compensation for equipment, the Contractor shall submit a listing of all equipment used in completion of the disputed work or held by direction of the Resident Engineer in the standby condition by type, manufacturer, date of manufacture, model, type of fuel used, horsepower rating, attachments, and any other information required to determine the proper rate. The Contractor shall also submit daily hours, total hours, and extensions. The total hourly rental rate the Department will pay for any one piece of equipment will be limited to the original purchase price listed in the *Green Guide for Construction Equipment*, published by Equipment Watch. If the total hourly rental rate for any one piece of equipment is limited by the original purchase price, the Department will reimburse the Contractor for the operating cost per hour for each hour of actual use. The Contractor may include an additional amount equal to 20 percent (10 percent for additional administrative costs and 10 percent for profit) of the cost of equipment used in disputed work or held in standby condition.

(4) Bonds, Insurance, Taxes, and Benefits

The Contractor may request additional payment for increases in the cost of premiums for property damage and liability insurance, workers' compensation insurance as well as unemployment insurance contributions, and social security taxes directly attributable to the disputed work in accordance with Subsection 109.04.B(4)(a), "Bonds," through Subsection 109.04.B(4)(f), "Employee Fringe Benefits."

(a) *Bonds*

The Contractor may request an additional amount, equal to 1 percent of the total of the labor, materials, and equipment costs, less overhead and profit, as determined in accordance with Subsection 109.04.B(1), "Labor," Subsection 109.04.B(2), "Materials," and Subsection 109.04.B(3), "Equipment," for increases to bonding costs.

(b) *Insurance*

The Contractor may request an additional amount, equal to the actual costs incurred by the Contractor for Property Damage and Liability Insurance, for the period the disputed work was in progress. The Department reserves the right to require documentation to support Property Damage and Liability Insurance rates.

(c) *Workers' Compensation*

The Contractor may request an additional amount, equal to the actual costs incurred by the Contractor for each worker performing disputed work at the rate paid by the Contractor for Workers' Compensation coverage, for the additional costs of Workers' Compensation during the period the disputed work was in

progress. The Department reserves the right to require documentation to support Workers' Compensation rates.

(d) ***Unemployment Insurance Contribution***

The Contractor may request an additional amount, equal to 3.8 percent of actual labor costs, less overhead and profit, as determined in accordance with Subsection 109.04.B(1), "Labor," for the additional costs of unemployment insurance contribution during the period the disputed work was in progress.

(e) ***Social Security Taxes***

The Contractor may request an additional amount, equal to 7.65 percent of actual labor costs, less overhead and profit, as determined in accordance with Subsection 109.04.B(1), "Labor," for the additional costs of social security taxes for labor attributable to the disputed work.

(f) ***Employee Fringe Benefits***

The Contractor may request an additional amount, equal to 20 percent of actual labor costs, less overhead and profit, as determined in accordance with Subsection 109.04.B(1), "Labor," for the additional costs of employee fringe benefits incurred by the Contractor for labor during the period the disputed work was in progress.

(5) Subcontracted Work

If the disputed work is of a nature that it is normally performed by a subcontractor in the highway industry and is subcontracted by the Contractor, the Contractor shall ensure that the subcontractor provides documentation in accordance with Subsection 109.04.B(1), "Labor," Subsection 109.04.B(2), "Materials," Subsection 109.04.B(3), "Equipment," and Subsection 109.04.B(4), "Bonds, Insurance, Taxes, and Benefits." The Contractor may request an additional amount of up to 10 percent for overhead on the subcontracted work.

(6) Work of a Non-Highway Construction Nature

If the disputed work was performed by a contractor or a subcontractor not in the highway industry and was performed by workers of a specialized trade or business, the Contractor may submit invoices for costs incurred for such services, including an additional amount of up to 10 percent for overhead.

(7) Miscellaneous

The Department will not pay for other overhead and general expense costs of any kind or the cost of any item not specifically and expressly included in Subsection 109.04.B, "Submitting a Claim."

C. Significant Change of Major Item

If a Major Item is significantly changed in accordance with Subsection 104.04, "Significant Changes to the Character of Work," either the Department or the Contractor may request a price adjustment.

(1) Significant Underrun

If a major item is significantly changed to decrease quantities, the Contractor may request a price adjustment to recover costs which would have been prorated

per unit on the larger quantity, but due to the quantity reduction are now unrecoverable. The cost which may be recovered by adjusted price are:

- Overhead costs associated with labor, materials, equipment, and subcontracted work at the rates specified in Subsection 109.04.B, "Submitting a Claim,"
- Property damage and liability insurance as allowed in Subsection 109.04.B(4), "Bonds, Insurance, Taxes, and Benefits," and
- Other miscellaneous documented costs.

(2) Significant Overrun

If a major item is significantly changed to increase quantities, the Department may request a price adjustment to reflect economies achieved by the Contractor through reduction in cost per unit for the increased quantity. The cost which may be recovered by adjusted price are:

- Material cost savings,
- Overhead cost savings,
- Cost savings resulting from increased unit production rate, and
- Other miscellaneous costs that were included in the unit price bid, such as mobilization.

109.05 PAYMENT FOR CANCELLED ITEMS

The Department will pay for canceled items in accordance with Subsection 104.04, "Significant Changes in the Character of Work," and the following:

- The Department will pay the Contractor for acceptable materials ordered by the Contractor or delivered to the project subsequent to the award of the Contract and before the date of cancellation, alteration, or suspension of the work by order of the Resident Engineer at the actual cost to the Contractor.
- Upon payment, these materials become the property of the Department.
- The Contractor shall immediately submit to the Resident Engineer certified statements covering all expenditures in preparation for work on any canceled item if such preparation has no value to the remaining contract pay items.
- The Contractor may request a proportionate amount for the preparation costs based on the portion of the contract amount over which such preparation would ordinarily be distributed when other contract items are included in that preparation.

109.06 PROGRESS PAYMENTS

The Resident Engineer will make progressive estimates for the material complete in place and for the amount of acceptable work performed in accordance with the Contract during the current period of time since the preceding estimate, with the value of this work calculated at the contract unit prices. The Resident Engineer may withhold payment of progressive estimates if the Contractor fails to timely comply with Contract requirements. These requirements include, but are not limited to, the following:

- Progress schedules,
- Certified payrolls,
- Work plans and shop drawings,
- Materials certifications, and
- Storm water management practices.

The Resident Engineer will make monthly progressive estimates, except, if the value of the work completed in half a month is equal to $25,000 or more, the Resident Engineer may make semi-monthly progressive estimates. The Resident Engineer will not make a progressive estimate, except for the Final Estimate, if the value of the work completed is less than $1,000. The estimates are approximate only and all progressive estimates and payments are subject to correction in any estimate following discovery of an error.

If the Resident Engineer or Contractor discovers any defective work or material or any overpayment based on quantity or unit price, or if the Resident Engineer reasonably doubts the integrity of any part of completed work before the final acceptance and payment, the Resident Engineer will deduct an amount, equal to the value of the defective work or overpayment, from the first estimate made after the discovery of such defect or overpayment. The Resident Engineer will not include this amount in subsequent estimates until the Contractor corrects the defect or addresses the Resident Engineer's doubt. The Resident Engineer will determine the value of the suspect or defective work and overpayment using quantities or unit prices established in the Contract.

109.07 PAYMENT FOR MATERIAL ON HAND

The Department may pay the Contractor for acceptable material stockpiled on the Project, at other approved or designated locations, or at a plant site required for Contractor's operations as approved by the Department. The Department will not pay for material on hand until after it issues the Notice to Proceed. Payment for material on hand does not constitute final acceptance. The Department will pay for this material in accordance with Department's procedure in Subsection 109.07.A, "Payment Before Incorporation," through Subsection 109.07.F, "Payment Confirmation."

A. Payment Before Incorporation

The Department may pay for material purchased by the Contractor before the material are actually incorporated into the project under the following conditions:

- The Contractor specifically purchased the material for incorporation into the work;
- The material meets the Contract requirements;
- The Contractor delivered the material to the project, other approved locations, or an approved fabricator's yard;
- The Contractor will store the material longer than 90 calendar days;
- The material is not living, perishable, or susceptible to degradation through weather or other natural phenomenon through the anticipated period of storage; and
- The Contractor can verify the purchase of the material with paid invoices.

B. Stockpiled Material Limitation

The Department will limit the quantity of each type of stockpiled material considered for payment to that amount required for the project, and the payment will not exceed each stockpiled material's pro rata share of the contract item or items required by the Contract. Payment to the Contractor for stockpiled materials does not relieve the Contractor of responsibility for replacement of those materials if the stockpiled materials are lost or damaged.

C. Blended Stockpiled Material

The Department will limit the payment for stockpiled material that is to be blended with other material to durable bulky material. The Department will pay for such material if the total value of the material exceeds $20,000, and will not pay more than 90 percent of the contract unit price of the relevant contract pay item.

D. Invoiced Items

The Department will pay only for separately invoiced items that are specifically linked to a contract pay item. The Department will limit the payment for individual items or like items that collectively have a gross value greater than $10,000 and that are specifically required for a contract pay item. The Department will not pay more than 90 percent of the contract unit price of the relevant contract pay item.

E. Raw Structural Steel

(1) General

To obtain payment for raw structural steel delivered to the fabricators, the Contractor shall submit to the Resident Engineer a Request for Payment of Materials on Hand, including the following items:

- An itemized receipt for the structural steel signed by the fabricator to acknowledge delivery of the steel at the fabricating yard, or a notarized statement by the fabricator that certifies that all items shown on the attached itemized invoice from the steel mill has been delivered to the fabricator's yard;
- An itemized invoice prepared by the steel mill listing all structural steel items for which the Contractor seeks payment that indicates the following:
  - Price for each item,
  - Total invoice price, and
  - Acknowledgement from the steel mill that the Contractor has paid the total invoice price;
- A notarized materials certificate prepared by the steel mill that attests to the quality of the structural steel and states that the steel meets the quality standards required by the Contract.

Subsection 106.05, "Plant Inspection," Subsection 106.06, "Field Office or Laboratory," and Subsection 106.07, "Foreign Materials," also will apply as appropriate, and the Department reserves the right to do inspections for material inventory, and will deduct those costs from the estimate paid to the Contractor as required by the Contract.

(2) Delivery Procedure

The Contractor shall ensure that all structural steel material are delivered to the fabricator's yard in accordance with the following delivery procedures:

- Maintain structural steel material separate from other material and inventories held in the fabricator's yard;
- Mark, by means of paint or other indelible marking, with a unique identifying number that can be readily correlated to the project number; and

- Fully account for the structural steel material throughout the fabrication process to prevent intermixing with general fabricator inventory and possible diversion of the material to another project.

(3) Payment Procedure

Upon receipt of a properly prepared Request for Payment of Materials on Hand, including all supporting documents, the Resident Engineer will initiate procedures to pay the Contractor, as a progress payment, for the un-fabricated structural steel after delivery to the fabricator's yard. The Department will not pay more than 90 percent of the contract unit price of the relevant contract pay item.

(4) Financing Statement

Prepare and submit a duly executed Financing Statement (UCC-1), in accordance with Oklahoma Statute Title 12A Section 1-9-501 et seq. The Financing Statement shall show the following:

- The project number for which the steel will be used;
- The name and address of the fabricator to whom the steel was delivered;
- The fabricator as the debtor and the Contractor as the secured party for an amount equal to the full value of the steel delivered for fabrication; and
- An itemized listing, as collateral, of all structural steel for which the Contractor is seeking payment.

The Contractor and fabricator shall execute the Financing Statement and file it with the appropriate county clerk office within five working days from the time that the fabricator receives payment. The Contractor shall ensure that, within 45 calendar days of the date of the progressive estimate containing payment for material on hand, the Resident Engineer receives three original copies of the Financing Statement along with the Payment Confirmation. The Contractor is responsible for ensuring that each delivery statement is properly stamped with a marking indicating that the forms have been placed in the county records of the county in which the fabricator's yard is located.

F. Payment Confirmation

The Contractor shall ensure that, within 45 calendar days of the date of the progressive estimate containing payment for material on hand, the Resident Engineer receives an original notarized confirmation that the supplier has been paid the total invoice amount for the material for which the Contractor was paid. If the Contractor fails to provide the required notarized confirmation within 45 calendar days, the Resident Engineer will deduct from the next progressive estimate the full amount paid for this material.

109.08 FINAL PAYMENT

When the Resident Engineer assigns a Completion Date, in accordance with Subsection 105.17, "Project Completion and Acceptance," the Resident Engineer will prepare a Final Estimate to reflect the total units incorporated into the work and the total price the Department will pay. The Final Estimate will include the following:

- Price reductions assessed for work or materials not meeting the Contract requirements;

- Liquidated Damages assessed for failure to complete the work in the Contract Time or by milestone dates;
- Incentives to be paid; and
- Disincentives to be charged.

When complete, the Resident Engineer will send a copy of the Final Estimate to the Contractor.

If the Contractor files a claim in accordance with the Contract, the Contractor shall notify the Resident Engineer of the conditions the Contractor believes warrant the claim in accordance with Subsection 104.06, "Notification of Differing Site Conditions, Changes, and Extra Work," and prepare the claim, if subsequently filed, in accordance with Subsection 105.18, "Claims for Adjustment." The Department will not allow other procedures. Upon review or final adjudication of the claim, the Resident Engineer will place any additional payment determined to be due the Contractor on a supplemental estimate and the Department will process for payment.

All progress payments will be subject to correction in the Final Estimate and payment.

Acceptance shall be final and conclusive except as otherwise provided in the Contract or as regards latent defects or frauds, or such gross mistakes as may amount to fraud, or as regards to the Department's rights under any warranty or guaranty or bond.

If the Contractor fails to sign and return the Final Estimate within 24 months of receipt, the Engineer will initiate action to administratively close the project as provided in 61 OS § 137.

109.09 (VACANT)

109.10 COMPENSATION FOR PROJECT DELAYS

The Contractor shall strictly comply with the provisions of this subsection as an essential condition precedent for the Contractor to receive compensation for delays.

A. Recoverable Costs

The Contractor may request additional costs associated with the following items as compensation for delays:

- Direct labor costs in accordance with Subsection 109.04.B(1), "Labor," and Subsection 109.04.B(4)(c), "Workers' Compensation," through Subsection 109.04.B(4)(f), "Employee Fringe Benefits";
- Costs for materials in accordance with Subsection 109.04.B(2), "Materials";
- Equipment costs for equipment approved by the Resident Engineer to be held in a standby condition during the period of the delay at a rate equal to 50 percent of the rental rate established in accordance with Subsection 109.04.B(3), "Equipment," minus operating costs.
- Costs of extended job-site overhead;
- An additional 10 percent of the value of the above items to compensate for extended home office overhead and other expenses for which no specific allowance is provided.

B. No Liability Items for the Department

The Department and Contractor agree that, in any adjustment for delay costs, the Department will have no liability for the following items of damages or expense:

- Loss of profit;
- Labor inefficiencies based on published manuals of productivity, measurement, and inefficiencies;
- Home office overhead in excess of that provided in the Contract;
- Consequential damages, including, but not limited to, loss of bonding capacity, loss of bidding opportunities, and insolvency;
- Indirect costs or expenses of any nature; and
- Attorney's fees, claims preparation expenses, or costs of litigation.

109.11 PAYMENT TO SUBCONTRACTORS

The Code of Federal Regulations requires that Contractors pay subcontractors, suppliers, and vendors promptly for work performed or materials provided, and release retainage promptly after the subcontractor, supplier, or vendor completes the work or provides materials certifications. The Department has established that, when criteria for payments are met, 30 calendar days is a reasonable time to make payment or release retainage, and requires that payment be made within that time. The 30 calendar day period for subcontracted work or materials and services provided will commence on the date the Contractor receives payment from the Department for the work. If the Contractor holds retainage for subcontracted work or materials/services provided, the 30 calendar day period shall commence on the date that the Resident Engineer determines that the subcontracted unit or portion of the Contract has been completed in accordance with Subsection 105.17, "Project Completion and Acceptance," or the project is deemed complete by the Department. Services provided to a Contractor for support of construction operations or as deemed necessary by the Contractor for upkeep of machinery or facilities used directly or indirectly for construction operations shall be paid within 30 calendar days of the last service provided. If payment is not made for work, material or services, or if retainage is not released within the required 30 calendar day period, the subcontractor will be entitled to make a formal written complaint to the Department detailing the amounts and date due, and the work performed or material provided. The Department will then institute a formal investigation and, if warranted, conduct a formal hearing. Upon a finding that the Contractor failed to perform in accordance with the terms of the Contract requirements, the Department may impose sanctions as provided in Subsection 102.04, "Refusal of Proposals," Subsection 102.14, "Rejection of Proposal," or both.

A subcontractor may initiate a request for a determination that a subcontracted unit or portion of the Contract has been completed by making a written request for such determination to the Resident Engineer, with a copy to the Contractor, as provided in Subsection 105.17, "Project Completion and Acceptance." At the time the written request is made, the subcontractor shall have submitted to the Resident Engineer required documentation including material certifications, payrolls, and other such documents as may be required to audit the completed work. If the Resident Engineer, upon inspection, finds that a unit or portion of the Contract has been satisfactorily completed, the Resident Engineer will report the fully audited final quantities to the Contractor and the subcontractor. Upon receipt from the Resident Engineer of a determination that the subcontracted work is deemed complete, the audited final quantities and payment for those quantities, the Contractor shall release any retainage held within 30 calendar days. However, if the Contractor or Subcontractor working under the direction of the Contractor damages the work, the Contractor shall repair or replace the damaged work at

no additional cost to the Department to the satisfaction of the Contract requirements and the Resident Engineer.

Failure of the Contractor to complete Contract work within the designated Contract Time or accumulation by the Contractor of deductions due to producing non-specification work may result in the assessment of negative progressive estimates representing the Department's overpayment to the Contractor for a given Contract period. The assessment of negative progressive estimates does not relieve the Contractor of the requirements for prompt payment of subcontractors and for timely release of retainage. However, if the subcontractor's work is directly responsible for the liquidated damage or non-specification work deduction, such deduction may be assessed against that subcontractor. Amounts thereafter due to the subcontractor will be the balance owed for the work less the imposed deductions.

Payment disputes between the Contractor and subcontractors relating to allocation of chargeable Contract Time and any resultant Liquidated Damages, quantity or quality of items of work subject to a subcontract or other agreement shall be referred to a neutral alternative dispute resolution forum for hearing and decision with the costs for such mediation or arbitration to be shared equally by the parties. Funding for mediation of payment disputes involving Disadvantaged Business Enterprises is available from the Department through the DBE Supportive Service Program. Such services are reimbursed by the Federal Highway Administration and are authorized by 23 CFR § 230, Subpart B. The Contractor shall include a clause in any subcontract notifying the subcontractor of their right to resolution of payment disputes through alternative dispute resolution mechanisms.

CHAPTER 200
SOILS

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SECTION 201
CLEARING AND GRUBBING

201.01 DESCRIPTION

This work consists of clearing, grubbing, removing, and disposing of vegetation and debris. This work includes protecting vegetation specified to remain. This work excludes items specified for removal in accordance with other sections of the Specifications.

201.02 MATERIALS — VACANT

201.03 EQUIPMENT — VACANT

201.04 CONSTRUCTION METHODS

Do not disturb or remove hazardous waste material, archeological or historic material, or human remains or graves without the prior approval of the Resident Engineer. Immediately notify the Resident Engineer upon encountering evidence of these items in accordance with Subsection 107.15, "Hazardous Material," and Subsection 107.09, "Protection of Archeological and Unmarked Human Burial Sites."

During clearing and grubbing operations do not scar, break, or otherwise damage trees and shrubs directed by the Resident Engineer, or shown on the Plans, to remain. If the Contractor damages these items, the Department will assess the value of the damage against the Contractor.

A. Clearing

Outside the limits of construction, remove trees only as shown on the Plans. Within the limits of construction, remove trees except those the Resident Engineer directs to remain. (The Resident Engineer's direction regarding the removal of trees within the limits of construction will comply with the “Clear Zone” requirements of the *Roadway Design Manual*.) Remove branches that overhang the roadway to at least 20 ft [6 m] above the road surface. Use experienced workers for tree trimming and pruning.

When clearing trees, logs, stumps, brush, and other debris, remove, bury, burn, or dispose of them as approved by the Resident Engineer. When burning material, obey all laws and ordinances. Supervise the fire to avoid endangering the surrounding vegetation, adjacent property, or features specified to remain in the right-of-way.

Obtain the Resident Engineer’s approval before removing from the right-of-way perishable vegetation and debris that cannot be burned. Dispose of the debris off the Project and outside the view from the Project. Make arrangements with and obtain written permission from the owner of the property intended for disposal of the debris.

B. Grubbing

Grub and dispose of stumps and roots within the right-of-way (including channels), except as specified in Subsection 201.04.C, "Preserving Areas Outside of Construction". In channel areas, leave stumps and nonperishable solid objects that extend less than 6 in [150 mm] above the original ground line or water level.

C. Preserving Areas Outside of Construction

Preserve areas outside the limits of construction (except areas needed for constructing fences or storing topsoil). Do no clear and grub outside the limits of construction except if shown on the Plans or if removing debris and dead vegetation. If an area within the median lies outside the limits of construction, equipment may cross the median only at points approved by the Resident Engineer.

The Contractor may use areas outside the limits of construction to store reserved topsoil from areas within the right-of-way. If clearing operations damage areas within the right-of-way, except for topsoil storage, restore the area and obtain the Resident Engineer's approval at no additional cost to the Department.

D. Selective Clearing

This work includes the following activities:

- Trimming selected trees and shrubs (except those directed or shown to remain);
- Removing and disposing of logs, root pods, brush, refuse dumps, and other undesirable debris; and
- Cutting, removing, and disposing of undergrowth, stumps, and standing trees.

Perform selective clearing at locations shown on the Plans and as approved by the Resident Engineer. Dispose of vegetation and debris in accordance with Subsection 201.04.A, "Clearing," and Subsection 201.04.B, "Grubbing." When selecting trees for removal, leave remaining trees from 20 ft to 30 ft [6 m to 9 m] apart.

Sever stumps, trees, and shrubs flush with, or below, the original ground line. Remove the stumps of uprooted trees and fill the holes with material approved by the Resident Engineer.

201.05 METHOD OF MEASUREMENT — VACANT

201.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) CLEARING AND GRUBBING	Lump Sum
(B) SELECTIVE CLEARING	Lump Sum

The Department will consider the cost of disposing of debris outside the right-of-way to be included in the contract unit price for *Clearing and Grubbing* or *Selective Clearing*.

If a pay item for *Clearing and Grubbing* or *Selective Clearing* does not exist, the Department will consider the cost of the work to be included in the appropriate earthwork pay item in accordance with the Plans.

SECTION 202
EARTHWORK

202.01 DESCRIPTION

This work consists of excavating material and constructing embankments, which includes hauling, stockpiling, placing, disposing, sloping, shaping, compacting, and finishing earth material. There are three categories of earthwork — excavation and borrow, embankment, and lump sum earthwork.

A. Excavation and Borrow

This work consists of removing, disposing of, or compacting earth material, except material removed under another category. The types of excavation and borrow are defined as follows:

Unclassified Excavation. Excavation of earth material within the right-of-way, with the exception of muck excavation, rock excavation, and structural excavation in accordance with Section 501, "Excavation and Backfill for Structures."

Muck Excavation. Excavation of soil mixed with organic matter or other materials not suitable for foundation material, regardless of moisture content or other characteristic.

Rock Excavation. Excavation of sound and solid masses, layers, or ledges of mineral matter classified as rock using either of the following methods:

- Cannot be effectively loosened or broken down by ripping with equipment in accordance with Subsection 202.03, "Equipment"; or
- Has a seismic velocity of at least 7,900 ft/s [2,400 m/s] (if the seismic velocities are less than 7,900 ft/s [2,400 m/s], use the ripping method to determine material classifications).

Unclassified Borrow. Material obtained outside the right-of-way or easement areas, and not classified as **Select Borrow**.

Select Borrow. Borrow material that is in accordance with Section 705, “Select Borrow,” or that is shown on the Plans (e.g., specific soil groups, group characteristics, or material obtained from a sandstone formation).

Selective Subgrade Topping. Material used to construct the top portion of the roadbed as shown on the Plans, to ensure the material consistency of the roadbed.

B. Embankment

This work consists of the following:

- Constructing roadway embankments and preparing the areas upon which they are to be placed within the right-of-way, and
- Placing and compacting approved material.

C. Lump Sum Earthwork

This work consists of excavation, borrow, or embankment necessary to complete the Project.

202.02 MATERIALS

Provide materials that are free of hazardous and industrial waste in accordance with 40 CFR Part 240 through Part 281 and State Regulations. If available, the Contractor may inspect Department-obtained information related to subsurface investigations in accordance with Subsection 102.06, “Examination of Plans, Specifications, Special Provisions, and the Work Site.”

A. Borrow

Provide borrow material free of dispersive clay, however, if dispersive clay is present in the borrow material, the Contractor must clay plate the slopes in accordance with Section 208, “Clay Plating," at no additional cost to the Department.

For Projects in Field Divisions 4, 5, 6, and 7, if subgrade treatment, in accordance with Section 307, "Subgrade Treatment," is shown on the Plans, the Department will not allow the use of borrow material with a sulfate content that exceeds the thresholds of OHD L-50 and OHD L-51, in the top 12 in [300 mm] of the grading section. Test the sulfate content of borrow material in accordance with OHD L-49.

B. Selective Subgrade Topping

Provide materials that meet the following requirements for the classes of selective subgrade topping, or as specified by classification or characteristics referenced in AASHTO M 145:

Table 202:1
Selective Subgrade Topping Classifications

Class	Requirements
I	Granular Material: A-1, A-2-4, A-2-5, or A-3 Groups
II	Section 705, "Select Borrow"
III	5 to 15 PI
IV[a]	Silt-Clay Materials: A-4, A-5, A-6, A-7-5, or A-7-6 Groups

[a] Plans may show additional PI restrictions.

Provide selective subgrade topping that passes a 1½-in [38-mm] sieve, unless specified otherwise.

202.03 EQUIPMENT

For classifying rock excavation, use a late model, well-maintained tractor-mounted hydraulic ripper equipped with one digging point of standard manufacturer’s design sized for use with, and propelled by, a crawler-type tractor with a minimum net flywheel power rating of 370 hp [276 kW] (operating in low gear).

If seismic testing is required, submit to the Resident Engineer the qualifications of the person performing and interpreting the test at least 14 days before performing the excavation work.

202.04 CONSTRUCTION METHODS

If the contract requires earthwork that affects archeological sites, wetlands, and existing environmental protection, or requires the use of explosives, perform the work in accordance with Section 107, “Legal Relations and Responsibility to Public.”

A. Excavation and Borrow

(1) Unclassified Excavation

(a) *General*

If salvaging topsoil is shown on the Plans, remove and stockpile the topsoil in accordance with Section 205, "Salvaging Topsoil," before beginning unclassified excavation.

During excavation, do not disturb areas outside the limits of construction. Use suitable excavated material to construct fills on the Project; do not waste.

Compact the top 8 in [200 mm] of the subgrade in accordance with Subsection 202.04.A(5), "Compaction of Fill." Ensure that the top of the finished subgrade meets the tolerances in accordance with Subsection 202.04.F, "Tolerances."

Obliterate old roadways with grading operations necessary to incorporate the old roadway into the new roadway and surroundings, to provide a pleasing appearance from the new roadway, as approved by the Resident Engineer.

(b) *Unsuitable Materials*

If excavation to the finished graded section results in a subgrade or slopes of unsuitable soil, the Resident Engineer may require the following:

- Removal of the unsuitable materials, and
- Backfill to the finished subgrade with an approved material.

Allow the Resident Engineer to measure the necessary cross-sections before placing the backfill. Material for backfilling must be equal to or better than the approved surrounding materials in accordance with AASHTO M 145. If required by the Contract, provide backfill material in accordance with Subsection 202.02.B “Selective Subgrade Topping.” The Resident Engineer may classify trash, metal, glass, other man-made items, and soils that cannot be compacted as unsuitable materials in accordance with Subsection 202.04.A(4), “Borrow.” Dispose of unsuitable material in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

If the material is unsuitable due to excessive moisture, the Contractor may dry and reuse it on the Project with prior approval by the Resident Engineer. Second handling is defined as an operation requiring a second movement or transporting of the material.

(2) Muck Excavation

The Plans show the approximate locations and extent of muck excavation.

Perform muck excavation operations so that the Resident Engineer can measure the volume of unsuitable material before replacing it with approved material. If muck excavation is not suitable for fills or as topsoil, remove and dispose of the material outside the right-of-way in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

If backfilling muck excavations below the water table level, use a granular material approved by the Resident Engineer, to prevent contaminated material from mixing with the backfill. Compact the backfill material in accordance with

Subsection 202.04.A(5), "Compaction of Fill." Within the roadway fill limits, cofferdams and dewatering may be necessary to perform muck excavation.

(3)Rock Excavation

The Plans show the approximate locations and extent of rock excavation. If the Contract requires excavated rock to be used as rock fill, provide rock fill in accordance with Subsection 202.04.A(5)(b)1), "Rock Fill."

Excavate rocks or other solid, unyielding material to a depth of at least 12 in [300 mm] below the subgrade elevation, and fill excavated areas to the subgrade elevation with material in accordance with Subsection 202.02.B, “Selective Subgrade Topping.” All fill material shall pass a 1½ in [38 mm] sieve. Drain depressions or pockets in the undercut or overbreak areas. In cuts, ensure compaction meets the moisture and density requirements in accordance with Subsection 202.04.A(5), "Compaction of Fill," or as shown on the Plans. Before placing fill, obtain the Resident Engineer's approval of the subgrade excavation and the fill material.

If the Plans show pre-splitting, the Resident Engineer will establish the pre-splitting line. Prior to drilling the pre-splitting holes, completely remove the overburden to expose the rock surface along the pre-splitting line. Drill bore holes along the pre-splitting line, maintaining the drill holes at the angle shown on the Plans, and ensuring that the drill holes are in the same plane. Ensure that the diameter, spacing, and loading of pre-split holes will result in a neat break. Drill the pre-split holes for the full depth of the ledge. For the initial pre-splitting of each rock cut section, use a 100 ft [30 m] test section. After drilling, loading, and shooting this test section, remove the shot material to determine if the diameter, spacing, and loading of the pre-split holes produced a neat break at the specified slope. Before continuing with pre-split drilling, completely expose the pre-split rock face in the test section for evaluation.

If the Resident Engineer rejects the results of the pre-splitting test section, adjust the diameter, spacing, and loading of the pre-split holes and perform an additional 100 ft [30 m] test section.

If the Resident Engineer approves of the results of the pre-splitting test section, continue the pre-splitting throughout the rock cut section using the same means and methods. Load the pre-splitting holes with explosives in accordance with the manufacturer’s recommendations. The Resident Engineer may direct the Contractor to discontinue pre-splitting operations if rock conditions warrant a different operation.

Thoroughly scale and clean rock slopes as directed by the Engineer. For rock excavations involving multiple lifts, scale upper lifts prior to drilling and fragmenting of lower lifts. Ensure that scaled rock slopes are stable and free from possible hazards of falling rock or rock slides that endanger public safety.

Do not trim the subgrade before completing the scaling operations.

(4)Borrow

If the Contract requires borrow from a designated off-site source, the Department will provide the right-of-way for the source. If the Plans do not designate an off-site source, the Contractor may obtain borrow from an undesignated off-site source.

Before excavating for borrow, ensure borrow is necessary and obtain the Resident Engineer's approval.

After clearing and removing topsoil from a borrow source, but before beginning borrow excavation, notify the Resident Engineer so that the Resident Engineer can take cross-section elevations and measurements of the original ground surface.

To reduce borrow excavation the Resident Engineer may direct the Contractor to widen roadway cuts and special ditches.

Obtain written approval from the Resident Engineer before excavating borrow pits closer than 500 ft [152 m] to the right-of-way.

Submit a plan detailing the excavation of a borrow source located in the upstream flood plain of a stream crossing the project. The Resident Engineer will evaluate this plan and consider its effect on the project. Do not begin the excavation of borrow until the Resident Engineer approves the plan.

When borrow excavation is complete ensure the slopes of the borrow source are uniform and the final condition of the source is in accordance with State and Federal laws. Shape the surfaces of the borrow source to accommodate the measurement of the excavation.

(5) Compaction of Fill

(a) *Preparation of Fill Foundation*

Clear and grub the trees and organic matter in accordance with Section 201, "Clearing and Grubbing," and remove the topsoil. Break up the cleared ground surface to a depth of 8 in [200 mm] by plowing or scarifying. Compact the ground surface to at least 95 percent of the standard density in accordance with Subsection 202.04.A(5)(b)2), "Earth Fill."

Remove existing pavement or reduce it to a maximum particle size of 3 in [75 mm], however, the Department will not allow existing pavement in the top 12 in [300 mm] of fill below the subgrade elevation.

1) *Fills Across Unstable Material (Incapable of Supporting Equipment)*

If unstable material is encountered, remove or bridge as directed by the Resident Engineer. The Resident Engineer may require a bridge of fill material, or a combination of fill material and geogrid fabric. Provide and place the geogrid fabric in accordance with Section 326, “Geosynthetic Reinforcement.” If bridged, limit the thickness of the fill material layer to the minimum necessary to support equipment. Dump fill material on top of the constructed fill layer and extend the bridge by pushing the fill material into place and over the unstable material until the bridge is complete.

2) *Fills on Existing Slopes 4H:1V or Steeper*

Cut horizontal benches to a width that accommodates placing and compacting operations and equipment. Begin each bench at the intersection of the original ground and the vertical cut of the previous bench.

(b) *Construction Practices*

Begin placement of material and the construction of fills at the low point and place layers in horizontal planes up to the finished grade. Slope the fill to provide constant drainage. Use spreading and disking equipment on each layer

to obtain uniform moisture and thickness before compacting. Add or remove water to obtain the specified moisture content and density of the fill.

During all stages of construction, route and distribute hauling and leveling equipment over the width and length of each layer of fill material.

Do not construct fills on frozen material, or place frozen material in fills.

Do not place rocks, broken concrete, or other solid materials at future piling locations.

If placing fill on only one side of abutments, wing walls, piers, retaining walls, or culvert headwalls, ensure the compactive effort adjacent to the structure will not cause excessive pressure to or overturn the structure. If placing fills on both sides of a concrete wall, abutment, end bent, or box type structure, place and compact fills to the same elevation on both sides of the structure.

If the fill contains rocks or boulders with diameters larger than 6 in [150 mm], do not place this fill material within 5 ft [1.5 m] of a structure.

1) *Rock Fill*

If the fill contains rock that cannot be constructed in layers of 8 in [200 mm] maximum thickness, construct the fill in layers to the thickness approved by the Resident Engineer (based on the largest rocks in the material), not to exceed 2 ft [0.6 m]. Place the larger rocks in each layer of approved thickness, furthest from the roadway centerline. Further, for rocks with diameters larger than 2 ft [0.6 m], embed in the fill, break into smaller sizes, or remove in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

If the Contract requires end dumping, dump the rock onto the edge of the fill layer being constructed and push the rock over the leading edge onto the previous layer with a crawler dozer. Use a dozer that weighs at least 70,000 lb [31,750 kg] to ensure adequate initial compaction. Use the smaller rock fill material to fill the voids created by the larger rock. Wet, compact, level, and smooth each layer. Adjust the moisture content for compaction.

For rock fill layers 12 in [0.3 m] thick or less, compact the full width with one of the following minimum procedures:

- Four passes using a 50 ton [45 metric ton] compression-type roller;
- Four passes using a vibratory roller with a dynamic force of at least 40,500 lbf [180 kN] per cycle, and a frequency of at least 16 Hz;
- Eight passes using a 22 ton [20 metric ton] compression-type roller; or
- Eight passes using a vibratory roller with a dynamic force of at least 29,250 lbf [130 kN] per cycle, and a frequency of at least 16 Hz.

For rock fill layers thicker than 12 in [300 mm], increase the number of roller-passes for each additional 6 in [150 mm] increment, by the number required for the first 12 in [300 mm], per respective roller.

Operate compressive-type rollers at speeds less than 5 mph [8 km/h] and vibratory rollers at speeds less than 3 mph [5 km/h].

Construct rock fills from 12 in [300 mm] to 2 ft [0.6 m] below the subgrade elevation with earth and rocks with diameters no greater than 8 in [200 mm]; ensure that voids are filled and the rock is chinked, creating uniform compaction. Construct the top 12 in [300 mm] of rock fills with approved material— placed in layers not exceeding 8 in [200 mm] in loose thickness— and compacted in accordance with Subsection 202.04.A(5)(b)2), "Earth Fill." Do not place rocks with a diameter larger than 3 in [75 mm] in the top 12 in [300 mm] of compacted fill.

2) *Earth Fill*

Place earth fill in loose layers of no greater than 8 in [200 mm]. Compact the earth fill material to at least 95 percent of Maximum Density (AASHTO T 99 Methods C or D), unless otherwise specified in the Contract or directed by the Resident Engineer. Determine in-place density by AASHTO T 310 (Nuclear).

Ensure the moisture content of the earth fill material, at the time of compaction, is within 2 percentage points of the optimum moisture content (AASHTO T 99) unless otherwise specified in the Specifications or approved by the Resident Engineer in writing. The Resident Engineer may adjust the moisture content range for earth fill compaction to address unusual conditions and constructability. For compaction of A-4 or A-5 soil groups, the Contractor may request, in writing, a lower moisture content range of from optimum to 4 percentage points below optimum.

Compact earth fill layers using rollers. For inaccessible areas (e.g. areas adjacent to culverts or bridge abutments), place the material in loose layers less than 4 in [100 mm] thick, and compact to the specified density using mechanical tampers.

B. Embankments

Construct embankments in accordance with Subsection 202.04.A, “Excavation and Borrow.”

C. Lump Sum Earthwork

Perform lump sum earthwork in accordance with Subsection 202.04.A, “Excavation and Borrow.”

D. Selective Subgrade Topping

If shown on the Plans, construct the top 12 in [300 mm] of the subgrade with selective subgrade topping. Before applying additives, establish the subgrade elevation every 100 ft [90 m] along each lane line. After applying additives and processing the selective subgrade topping, reestablish the subgrade elevation every 50 ft [45 m] along each lane line and break point.

The following are sources of selective subgrade topping materials:

(1) Sources Proposed by Contractor

Submit a proposal to the Resident Engineer identifying that the quantity of selective subgrade topping, as shown on the Plans, is available. During excavation, develop and reserve that quantity of selective subgrade topping in accordance with the grading plan.

(2)Mandatory Sources Designated on the Plans

If the Plans show the source of selective subgrade topping, excavate the material at the specified source, haul to the specified location, and place.

E. Sloping, Shaping, Dressing, and Finishing

Construct and dress the slopes of cuts, ditches, and fills as shown on the Plans or as directed by the Resident Engineer, except that the Department will not require rounding where rock extends to the top of a cut.

Slope, shape, and round existing surfaces as shown on the Plans or as directed by the Resident Engineer. If standard equipment cannot obtain neat, uniform surfaces, hand-trim the slopes.

For borrow pits, trim and shape slopes and tops of cuts with material approved by the Resident Engineer, and stabilize the material. Dressing includes clearing the right-of-way of stumps, brush, weeds, and other rubbish, and disposal in accordance with Subsection 201.04, “Construction Methods.”

F. Tolerances

Construct the roadbed to the profile and cross-section shown on the Plans, within the following tolerances:

- Roadbed cross-section – within 0.1 ft [30 mm].
- Roadbed profile – within 0.1 ft [30 mm] (by the algebraic difference) for any two points on the roadbed no greater than 50 ft [15 m] apart.
- Base of the selected subgrade zone – within 0.1 ft [30 mm] of the elevation shown on the Plans.

For contracts with both grading and surfacing, finish the roadbed profile and cross-section in accordance with the tolerances in Subsection 301.04, “Construction Methods.”

202.05 METHOD OF MEASUREMENT

The final in-place methods of measurement and calculation will match the original methods used to estimate quantities, unless the Resident Engineer approves otherwise. The Resident Engineer will take the original and final cross-sections on top of the topsoil. The Resident Engineer will perform the original and final earthwork surveys with topsoil in place, except for borrow sources. The Resident Engineer will not adjust earthwork quantities for topsoil volumes. The Resident Engineer will calculate excavation, borrow, and embankment in accordance with the following calculation methods:

Average End Area From Cross Sections. This method includes calculating the average of the cross sectional end areas and multiplying by the distance between them.

Original Surface vs. Final Surface (Digital Terrain Model). This method includes creating three-dimensional surfaces from the original and final surveys' data, triangulating the data points, and calculating the volume.

Three Dimensional Measurements. This method includes using acceptable measuring practices to calculate volumes for isolated and unusual locations.

A. Unclassified Excavation

The Resident Engineer will include excavation for overbreakage or slides in backslopes, not the fault of the Contractor, in the measurements for *Unclassified Excavation*. If the plane of the finished subgrade falls within rock, the Resident Engineer will include an excavation quantity for the subexcavation of rock to a theoretical maximum measurement of 12 in [300 mm], unless the Resident Engineer approves otherwise. The Resident Engineer will include the volume of unsuitable materials excavated in accordance with Subsection 202.04.A(1), "Unclassified Excavation," in the measurement of *Unclassified Excavation*.

If the Resident Engineer directs the Contractor to widen roadway cuts or special ditches to reduce borrow excavation, the Resident Engineer will measure the volume of additional excavation as *Unclassified Excavation* or relevant earthwork pay item.

B. Muck Excavation

If the Contract does not specify *Muck Excavation* as a pay item, the Resident Engineer will measure *Muck Excavation* as *Unclassified Excavation*.

C. Rock Excavation

If the Contract does not specify *Rock Excavation* as a pay item, the Resident Engineer will measure *Rock Excavation* as *Unclassified Excavation*.

D. Borrow

The Resident Engineer will not measure the volume of unapproved borrow excavation.

E. Embankments

If the Contract specifies *Embankments* as a pay item, the Resident Engineer will measure volumes based on the differences between the original ground cross sections and the final ground cross sections. The Resident Engineer will not measure material outside the limits of the typical or approved sections, or material or work required to correct settlement, shrinkage, or swell of embankments. The Resident Engineer will not deduct volumes for improvements, like culverts and manholes. The Resident Engineer will include all excavation and borrow necessary to construct the grading section in the volume for *Embankments*.

F. Pre-splitting of Rock

The Resident Engineer will measure *Pre-splitting of Rock* by the length of approved and completed pre-split rock cut. Measure pre-splitting in feet along the base of the cut section. For benched cut face, measure along the base of the total cut section.

G. Earthwork

The Resident Engineer will not measure *Earthwork*, but rely on the estimated quantities shown on the Plans.

H. Selective Subgrade Topping

If the Contract requires selective subgrade topping, the Department will consider the cost of the selective subgrade topping material to be included in the contract unit prices of the appropriate existing earthwork pay items. The Plans will show the estimated quantity of the selective subgrade topping material.

The Department considers the lump sum cost of the *Selective Subgrade Topping* pay item as payment for any additional handling or separation of the selective subgrade topping material.

202.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) UNCLASSIFIED EXCAVATION	Cubic Yard [Cubic Meter]
(B) MUCK EXCAVATION	Cubic Yard [Cubic Meter]
(C) ROCK EXCAVATION	Cubic Yard [Cubic Meter]
(D) UNCLASSIFIED BORROW	Cubic Yard [Cubic Meter]
(E) SELECT BORROW	Cubic Yard [Cubic Meter]
(F) EMBANKMENTS	Cubic Yard [Cubic Meter]
(G) PRESPLITTING OF ROCK	Linear Foot of Drilling [Meter]
(H) EARTHWORK	Lump Sum
(I) SELECTIVE SUBGRADE TOPPING	Lump Sum

The Department will pay for roadway obliteration as unclassified excavation, unless the Contract specifies *Obliterating Abandoned Road* in accordance with Section 210, “Obliterating Abandoned Road.”

The Department will not pay for a second handling of unsuitable material due to excessive moisture unless it is unavoidable, and the Resident Engineer provides prior approval. Upon the Resident Engineer’s approval, the Department will pay for the second handling as *Unclassified Excavation*.

The Department will only pay for rock excavation below the subgrade and replacement fill if the Resident Engineer approves before the fill placement. The Department will pay for the quantity of excavated rock as *Rock Excavation*, and will consider the cost for the quantity of fill material to be included in the contract unit price of the appropriate earthwork pay item.

The Department will consider the cost of drilling, loading and shooting pre-split sections to be included in the contract unit price for *Pre-Splitting of Rock*. The Department will consider the cost of the removal of pre-split material to be included in the contract unit price of *Rock Excavation.*

If the Contract does not specify a *Muck Excavation* pay item, the Department will pay for the removal, disposal, replacement of unsuitable material as the appropriate earthwork pay item. If cofferdams or dewatering is necessary to perform muck excavation, the Department will consider the cost of each to be included in the contract unit price for *Muck Excavation* or the appropriate earthwork pay item.

The Department will consider the cost of the following to be included in the contract unit price for *Borrow* or *Select Borrow*:

- Building and maintaining haul roads from off-site borrow sources to the project; and
- Clearing, grubbing, stripping, or replacing topsoil at off-site borrow sources.

If the Contractor provides borrow material consisting of dispersive clay and must clay plate the slopes, the Department will consider the cost of this clay plating to be included in the contract unit price for *Borrow* or *Select Borrow*.

The Department will pay for geogrid fabric in accordance with Section 326, "Geosynthetic Reinforcement."

If inaccessible areas of earth fill require compaction using mechanical tampers, the Department will consider the cost of the mechanical tampers to be included in the contract unit price for the appropriate earthwork pay item.

The Department will consider the cost of water used to achieve the required moisture content to be included in the contract unit price for the applicable earthwork pay items.

SECTION 203
TEST ROLLING

203.01 DESCRIPTION

This work consists of test rolling embankments and cut sections with heavy pneumatic-tired rollers.

203.02 MATERIALS — VACANT

203.03 EQUIPMENT

Before using rollers, obtain the Resident Engineer's approval of the equipment. Provide heavy pneumatic-tired rollers with at least seven tires. Ensure the pressure in each tire is at least 90 percent of the tire manufacturer’s recommended maximum pressure for rolling operations. Ensure the roller wheels and axles allow each tire to carry an equal load. Use a roller with a loading platform and ballast that can carry a load of at least 6,600 lb [2,990 kg] per tire. Provide the Resident Engineer with the certified weights of the empty roller and the ballast.

Ensure the rolling equipment can turn without damaging the area being tested.

203.04 CONSTRUCTION METHODS

Roll the full width of the grading section shown on the Plans using two complete passes. Operate the roller from 2 mph to 10 mph [3 km/h to 16 km/h], as directed by the Resident Engineer.

If the Contract requires test rolling, test roll embankments at 2 ft [0.6 m] below the subgrade elevation and at the finished subgrade elevation; test roll cut sections at the finished subgrade elevation only.

If test rolling reveals soft, yielding, or unstable areas, remove the unstable material and replace it with material approved by the Resident Engineer in accordance with Section 202, "Earthwork," at no additional cost to the Department. Perform test rolling on the corrected area.

203.05 METHOD OF MEASUREMENT — VACANT

203.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
TEST ROLLING	Lump Sum

SECTION 205
SALVAGING TOPSOIL

205.01 DESCRIPTION

This work consists of salvaging natural topsoil from areas of excavation and embankment.

205.02 MATERIALS

Topsoil. Soil consisting of vegetative matter and grass roots, or exhibiting other characteristics common to surface soils.

205.03 EQUIPMENT — VACANT

205.04 CONSTRUCTION METHODS

Clear brush, rock, shale, or other deleterious material from topsoil salvage areas shown on the Plans. Mow weeds and grasses more than 1 ft [0.3 m] tall and incorporate into the topsoil. Excavate the topsoil and stockpile at areas approved by the Resident Engineer. Topsoil depths and quantities shown on the Plans are approximate; remove all topsoil from salvage areas.

Replace contaminated or lost topsoil with an equivalent, Resident Engineer-approved material, at no additional cost to the Department.

A. Type A Salvaged Topsoil

Type A salvaged topsoil consists of the following:

- Removing existing, untreated topsoil;
- Storing the topsoil in a stockpile; and
- Placing the topsoil on prepared slopes as shown on the Plans or directed by the Resident Engineer.

Finish the roadway excavation and embankment areas as shown on the Plans or as directed by the Resident Engineer. Before placing the salvaged topsoil, apply fertilizer of the type and at the rate shown on the Plans. Spread the salvaged topsoil to a depth of 5 in [130 mm], unless otherwise directed by the Resident Engineer.

B. Type B Salvaged Topsoil

Type B salvaged topsoil consists of the following:

- Removing existing, untreated topsoil; and
- Storing the topsoil in a stockpile.

205.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Type A Salvaged Topsoil* and *Type B Salvaged Topsoil* in a stockpile in accordance with Subsection 109.01.A, "Measurement of Quantities, General." The Resident Engineer will not subtract measured quantities of *Type A Salvaged Topsoil* and *Type B Salvaged Topsoil* from excavation or embankment quantities. If the Plans show *Type A Salvaged Topsoil* as a lump sum pay item, the Resident Engineer will not measure quantities of salvaged topsoil.

The Department will consider *Type A Salvaged Topsoil* 50 percent complete when the material has been removed from its original location and stockpiled; and 100 percent complete when the material has been placed in its final location. The Department will consider *Type B Salvaged Topsoil* 100 percent complete when the material has been removed from its original location and stockpiled.

205.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) TYPE A SALVAGED TOPSOIL	Lump Sum or Cubic Yard [Cubic Meter]
(B) TYPE B SALVAGED TOPSOIL	Cubic Yard [Cubic Meter]

The Department will not pay for additional handling of *Type A* or *Type B Salvaged Topsoil*.

SECTION 208
CLAY PLATING

208.01 DESCRIPTION

This work consists of constructing a layer of clay soil, or other material approved by the Resident Engineer, on exposed slopes composed of dispersive or erosive soils.

208.02 MATERIALS

If the Contract does not specify plating material requirements, provide plating material in accordance with the following requirements:

- Plasticity Index from 8 to 18.
- Non-dispersive, using the Emerson Crumb Test, and either the Pinhole Test (ASTM D 4647) or Double Hydrometer Test (ASTM D 4221).
- Obtained in accordance with Subsection 202.04.A(4), "Borrow."
- From a Resident Engineer inspected and approved source.

208.03 EQUIPMENT — VACANT

208.04 CONSTRUCTION METHODS

Before placing the plating materials, grade, shape, and level the specified portions of the exposed slopes as required by the Contract. Immediately before delivery of the plating material, dress or bench slopes as shown on the Plans. Deliver and dump the plating material at regular intervals, and in amounts that can be uniformly spread and will create layers not greater than 8 in [200 mm] deep. Compact the layers to at least 95 percent of maximum density and test in accordance with AASHTO T 99 Methods C or D. Use AASHTO T 310 (Nuclear) to determine the in-place density. Ensure the moisture content of the plating material is from optimum to 3 percentage points above optimum moisture content in accordance with AASHTO T 99. Continue placing, spreading, and compacting until the plating material reaches the final thickness shown on the Plans. Ensure the plating surface conforms to the specified slope.

If sandy subgrade cannot support hauling and blading equipment without excessive rutting, add moisture and consolidate the subgrade or construct a temporary, plated road.

208.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the volume of the compacted in-place *Clay Plating* by multiplying the completed length of clay plating by the area of the cross section shown on the Plans.

208.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
CLAY PLATING	Cubic Yard [Cubic Meter]

The Department will consider the cost of water used in the plating process to be included in the contract unit price for *Clay Plating*.

SECTION 209
MACHINE GRADING

209.01 DESCRIPTION

This work consists of grading, using heavy machine blading and some drifting and hauling, to move earthwork material between balanced cuts and fills.

For those one-mile sections shown on the Plans where excavation does not exceed 5,000 yd^3 [3,820 m^3] and approximately balances with embankments, the Engineer will allow the use of machine grading.

209.02 MATERIAL — VACANT

209.03 EQUIPMENT — VACANT

209.04 CONSTRUCTION METHODS

Bring the roadbed to a uniform grade with elevations and typical cross-section as shown on the Plans, using the following methods:

- Drifting or hauling excavated material,
- Plowing,
- Scarifying,
- Blading,
- Removing stone and boulders from the roadway,
- Compacting, and
- Shaping.

Grade and shape side slopes and ditches in accordance with the typical cross-section. Excavate rock, hard sandstone, shale, or other solid and unyielding material in the roadbed, and backfill with specified material in accordance with Subsection 202.04.A, "Excavation and Borrow." Construct excavations and embankments in accordance with Subsection 202.04.A, "Excavation and Borrow," and Subsection 202.04.B, "Embankments." Clean inlet and outlet channels within the right-of-way.

Repair damage to adjacent structures resulting from construction operations as directed by the Resident Engineer, at no additional cost to the Department.

Blade and shape completed portions of graded work to ensure a smooth surface of uniform cross-section with lines and grades in accordance with the Plans. Maintain the roadway until final acceptance.

209.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Machine Grading* along the centerline to the nearest foot [meter].

209.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
MACHINE GRADING	Linear Foot [Meter]

The Department will consider the cost of water used to achieve the required moisture content to be included in the contract unit price for Machine Grading.

SECTION 210
OBLITERATING ABANDONED ROAD

210.01 DESCRIPTION

This work consists of obliterating specified sections of abandoned road by removing and disposing of pavement surfaces, structures, and other items.

210.02 MATERIAL — VACANT

210.03 EQUIPMENT — VACANT

210.04 CONSTRUCTION METHODS

After the abandoned road is no longer needed for traffic, break and remove pavement surfaces and base courses in accordance with Section 619, "Removal of Buildings, Structures and Obstructions, NESHAP Inspection." Remove, without damaging, items with salvage value and store the items as shown on the Plans. Items not shown on the Plans for salvage or use in the work shall become the property of the Contractor.

Remove concrete structures to at least 1 ft [0.3 m] below the ground level and cover with earth. Distribute the removed portions of broken concrete to locations directed by the Resident Engineer and cover with at least 1 ft [0.3 m] of material approved by the Resident Engineer, or remove from the project.

After removing the pavement surfaces, structures, and other items, scarify or plow the abandoned subgrade material, and round and smooth by blading. Grade, slope, and transition the toes of fills and the tops of cuts of the abandoned subgrade, except in rock. Fill ditches and grade the abandoned subgrade to drain.

210.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Obliterating Abandoned Road* along the centerline of the abandoned road to the nearest foot [meter].

210.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
OBLITERATING ABANDONED ROAD	Linear Foot [Meter]

The Department will consider the following to be included in the contract unit price for *Obliterating Abandoned Road*:

- Removing, disposing, and storing materials with salvage value;
- Disposing and obliterating other materials and debris; and
- Re-grading and shaping the roadway.

SECTION 220
MANAGEMENT OF EROSION, SEDIMENTATION, AND STORM WATER POLLUTION PREVENTION AND CONTROL

220.01 DESCRIPTION

This work consists of overseeing the construction and maintenance of erosion and sediment control measures, in accordance with these specifications, in compliance with the details shown in the Contract, and as approved by the Resident Engineer. The purpose of this work is to minimize or eliminate air pollution and pollution of rivers, streams, impoundments, and private properties from the discharge of dust and/ or storm water associated with construction activity.

Below is a listing of terms and definitions as they apply to these specifications:

Authorization to Discharge. The document issued from **ODEQ**, as a result of the **NOI** application, serving as the official notification of the site specific permit.

BMPs (Best Management Practices). A wide range of project management practices, schedules, activities, or prohibition of practices, that when used alone or in combination, prevent or reduce erosion, sedimentation, and/or pollution of adjacent properties, water bodies, and wetlands. BMPs include temporary or permanent structural and nonstructural devices and practices.

Completion Date. See Subsection 101.05, "Definitions," or Subsection 105.17, “Project Completion and Acceptance.”

Erosion. The detachment and movement of soil particles from their original location by force of water, wind, ice, and gravity.

Erosion Control. Erosion control reduces the potential of soil particles from being detached by the use of soil stabilizing practices. These practices are noted in the **SWMP** and **SWPPP**.

Final Stabilization. A point in time when all earth-disturbing activities are complete and permanent erosion and sediment controls are established and functional. The stabilized site is protected from erosive forces of raindrop impact and water flow. Typically, all unpaved areas except graveled shoulders, crushed aggregate base course, or other areas not covered by permanent structures are protected by either a uniform blanket of perennial vegetation (at least 70 percent of native background cover as found in the undisturbed

surrounding area) or equivalent stabilization measures including but not limited to riprap, geotextiles, gabions or paved ditches.

NOI (Notice of Intent). The **OPDES General Permit** application form to commence earth-disturbing activities for storm water discharges on projects which have earth disturbing activities of 1 acre or more.

NOT (Notice of Termination). The **OPDES General Permit** application form indicating the end of earth-disturbing activities and the attainment of **Final Stabilization**.

OPDES. Oklahoma Pollutant Discharge Elimination System Act.

ODEQ. Oklahoma Department of Environmental Quality.

ODEQ/OPDES General Permit. The General Permit for Storm Water Discharges from Construction Activities, issued by the **ODEQ** under the **OPDES** regulations. It requires an **SWPPP** before earth-disturbing activities for the project. ODEQ is the regulatory, enforcement and permitting authority for the Environmental Protection Agency (EPA) in the State of Oklahoma.

Sediment Control. Sediment control minimizes detached particles from leaving the site or entering a water body by the use of structural practices. These practices are noted in the **SWMP** and **SWPPP**.

Sedimentation. Sedimentation occurs when the eroded particles are deposited in a new location.

SPRP (Spill Prevention and Response Plan). The Contractor's detailed plan for prevention of pollution that stems from the use, containment, cleanup, and disposal of hazardous material, including petroleum products generated by construction activities and the use of construction equipment.

SWMP (Storm Water Management Plan). The Department's general plan for control of project-related **Erosion** and **Sedimentation**. It is developed by the Department and included in the Contract documents. It serves as a resource for bid estimation and a framework from which the Contractor develops the project **SWPPP**. The SWMP normally consists of the following:

- SWMP Information Sheet;
- Site Specific Erosion and Sediment Control Plan Sheets;
- Contract Pay Items with Plan Notes;
- Summary of Temporary and Permanent Erosion and Sediment Controls; and
- Site Specific Drainage Map.

SWPPP (Storm Water Pollution Prevention Plan). The Contractors plan for erosion and sediment control and storm water management under the **OPDES General Permit**. The SWPPP is developed by incorporating pertinent information supplied by the Department (**SWMP**) with the Contractors' information and describing site-specific controls and management of issues identified for the project based upon construction sequences and activities. See specific requirements in Subsection 220.04.C, "Contractor Responsibilities for SWPPP."

220.02 MATERIALS

Provide materials for erosion and sediment control measures that conform to details shown in the Contract and requirements of this specification. These measures are subject to updates and amendments by the Contractor during project progression. The items, estimated quantities and locations of the control measures will be shown on the Plans, however, the Resident Engineer may increase or decrease the quantity of these items as the need arises. The Resident Engineer also may allow other materials and work as the need arises and as approved in writing.

220.03 EQUIPMENT — VACANT

220.04 CONSTRUCTION METHODS

A. General

Provide an SWPPP and a NOI in accordance with the provisions of the latest version of the OPDES General Permit for Construction Activities issued by the ODEQ on construction projects with 1 acre [0.405 ha] or more of earth disturbance. Projects to be constructed within the corporate limits of a municipality may require additional permits and compliance with additional local requirements or constraints. All projects that involve earth disturbing operations require the appropriate BMPs developed for that specific site with up-to-date amendments by the Contractor.

B. Department Responsibilities for SWMP

The Department will obtain dated photographs and video documentation of pre-existing project site conditions at drainage locations and evidence of vegetation density prior to utility relocation or construction. The Department will prepare and include in the Plans the SWMP and SWMP Information. The SWMP sheets of the construction plan include:

- Nature of the activity;
- Proposed construction sequencing;
- Total site area;
- Total disturbed area;
- Runoff coefficient for pre/post construction;
- Latitude and longitude of the site;
- Basic drainage, receiving waters, and site information required for SWPPP development;
- Site Maps;
- Drainage patterns;
- Discharge locations;
- Approximate slopes;
- Limits of construction (areas of earth-disturbance and areas of no earth-disturbance or buffer zones);
- Locations of major controls;
- Temporary and permanent structural and nonstructural practices;
- Limits of right-of-way;
- Easements;
- Existing and new structures;
- Existing and proposed roadway grades;

- Wetlands and other environmental conditions;
- Notes providing special conditions for endangered and threatened species or critical habitat;
- Detours;
- Details of the description and timing of final stabilization practices; and
- Pay items and estimated pay quantities based on the above information.

The Department will provide a partially completed NOI with the award package for completion and signature by the Contractor. Require documentation from the Contractor to ensure the ODEQ Authorization to Discharge has been obtained prior to allowing earth-disturbing activities to commence.

C. Contractor Responsibilities for SWPPP

Submit for review by the Resident Engineer at the preconstruction conference as required by Subsection 108.02, "Notice to Proceed and Preconstruction Conference," SWPPPs that address:

- Intended sequence of construction with a proposed schedule of activities.
- All required erosion and sediment control measures for each construction phase.
- Compliance with the provisions of the latest version of the OPDES General Permit, which include but are not limited to the following items or activities:
- SWMP and SWPPP
- Copy of completed NOI with Contractor information and the ODEQ Authorization to Discharge.
- The proposed dates and locations of planned and actual clearing and grubbing activities, earthwork activities, and construction of temporary and permanent erosion control features.
- A description, location and schedule of temporary and permanent best management practices.
- A description, location and schedule of control practices used to divert flows from exposed soils.
- A description of construction material storage and controls used to minimize pollution from these materials.
- A prepared Spill Prevention and Response Plan.
- A description of the existing vegetation density within the project limits and adjacent land. (Include pictures and video, documented by date and location.)
- Documentation of existing conditions of streams and water courses prior to earth-disturbing activities. (Include pictures and video documented by date and location.)
- Current OPDES General Permit is available on the project site.
- How vehicle tracking will be prevented, reduced, or repaired during the project.
- Names, titles, companies, and 24 hr contact information, of people responsible for erosion and sediment control.
- A signed qualification narrative provided by the Contractor, designating the person(s) responsible for the SWPPP, identifying their familiarity with the SWPPP, and documenting their training and experience.

A Contractor Certification statement for subcontractors is recommended. This document places the responsibility of complying with and abiding by the intent and purpose of the storm water permit with the subcontractor for any and all work

performed under the authority and direction of the Contractor. A sample certification statement may be obtained on DEQ's website at *www.deq.state.ok.us.* Go to Water Quality, General Permits, Storm Water, OKR10 Storm Water Discharges from Construction Activities, Addendum D.

Develop the SWPPP using a combination of structural, nonstructural, and vegetative BMP's to adequately control erosion and sedimentation and manage storm water. Modify the SWPPP as needed to address changes in the field that develop during construction. Submit amendments to the SWPPP for approval as work progresses or as the proposed phasing/scheduling changes.

Provide a copy of ODEQ NOI and Authorization to Discharge to the Resident Engineer before commencement of earth disturbing activities. Failure to obtain the ODEQ Authorization to Discharge will not be a basis for delaying time charges.

Identify Contractor personnel responsible for on-site inspection of storm water management and documentation procedures to be used in accordance with Subsection 220.04.H(4), "Inspection and Maintenance of Measures."

D. Retention of Records

The SWPPP is a dynamic document. Retain and maintain all changes made to the SWPPP as required by the latest version of the OPDES General Permit. This will be the official record. Retain and place in the SWPPP a copy of the permit language and all inspection and maintenance reports. Perform inspection and maintenance reports from the commencement of earth disturbing activities to the completion date of the project. Make these records available to ODEQ or other regulatory agencies during normal business hours. Provide copies to ODOT of any and all ODEQ inspection reports, warning letters, technical assistance, Notice of Violation, Consent Order and/ or Administrative Compliance Orders. Submit the official SWPPP and all inspection and maintenance reports to the Resident Engineer at the completion of the project.

E. Notice of Intent (NOI)

Complete the mailing information, construction dates, and sign the Contractor's NOI provided with the Contract award package to the ODEQ prior to the preconstruction conference. Provide to the Resident Engineer copies of the submitted NOI for review at the preconstruction conference and the Authorization to Discharge certificate prior to earth disturbing activities. At the preconstruction meeting, indicate your understanding of the terms and conditions of the OPDES General Permit and that you will fully implement and maintain the SWPPP as proposed or modified during the progress of the project.

F. Notice of Termination (NOT)

The NOT must be submitted by the Contractor to the ODEQ. The Contractor will submit a copy of the NOT and ODEQ's final inspection report to the Resident Engineer. ODEQ's final inspection must not have any critical exceptions for the project to be declared complete and the Contractor relieved of any related construction site responsibilities, in accordance with Subsection 105.17 "Project Completion and Acceptance." ODEQ will require the Contractor to apply for a new permit if the project does not have 70 percent stabilization or any other discrepancies are found. ODEQ offers a one-time Inspection Request form that will aid the Contractor in determining whether a project will be accepted for termination before it submits the NOT.

G. Off-Site Pollution Prevention Plan

Prepare and submit SWPPP documentation complying with the latest version of the OPDES General Permit to ODEQ for all related work to take place outside the project right-of-way. Submit copies of required SWPPP's storm water permit documents for borrow pits, work/maintenance yards, and waste disposal yards, asphalt and concrete plants dedicated to the project to the Resident Engineer at least 48 hr before related work starts. Install, repair, and maintain BMPs outside of the project limits at no additional cost to the Department.

H. Contractor's Operations

Keep to a minimum project activity within the right-of-way in areas other than on the paved roadway to prevent damage and destruction of existing vegetation.

Keep all construction areas in an orderly condition, and promptly dispose of all refuse and discarded materials.

Repair or replace erosion and sediment control measures damaged due to negligence, improper installation, or lack of maintenance at no additional cost to the Department.

(1) Sequence of Operations

Schedule and conduct an on-site inspection with the Resident Engineer to review and designate the locations and types of erosion and sediment control protection to be placed prior to beginning any work that will disturb existing vegetation. Indicate on the SWPPP, proposed erosion and sediment control devices used to divert flows, store flows, limit runoff from exposed areas, stabilize exposed soil, and filter sediment for each phase of the scheduled work.

Coordinate the placement of the temporary and permanent erosion and sediment control measures shown in the SWMP with up-to-date documented amendments to ensure effective and continuous erosion and sediment control throughout construction.

Do not initiate earth-disturbing operations until the Resident Engineer has reviewed the SWPPP and the appropriate erosion control measures are in place.

(2) Protection of Watercourses

Locate and construct waste disposal areas, maintenance and storage yards, and haul roads within the project limits in a manner that will prevent sediment and other pollutants from entering streams and water impoundment areas or leaving the project site.

Do not operate mechanized equipment in perennial streams, unless otherwise allowed in the Contract.

Clear streambeds and watercourses, as soon as practical of false work, piling, debris, and other obstructions placed during construction which are not part of the finished work. Do not deposit concrete waste or clean haul trucks in these areas. Recover slurry from drill shaft operations and remove it from the project. Do not allow slurry to flow into streambeds.

(3) Earthwork Operations

Protect excavation or embankment slopes as construction progresses. A maximum length of 1 mi [1.6 km] may be exposed without either placement of

temporary (eg. seeding, mulching, soil retention blankets, or other approved soil stability), or permanent (eg. seeding, sprigging, or sodding) erosion control measures. Obtain approval from the Resident Engineer in the preconstruction schedule for any increase or decrease in the amount of the area exposed by construction operations. In addition to the maximum exposed surface area, no exposed area shall remain unprotected for more than 14 calendar days without being stabilized. Stabilize areas within 50 ft [15 m] of any streams within 48 hr of inactivity of construction operations. Install temporary or permanent erosion or sediment control measures on excavation or embankment slopes as work progresses in vertical increments of not more than 10 ft [3 m] unless otherwise directed by the Resident Engineer.

Maintain the top of the subgrade in all roadway sections through all construction stages so as to prevent silt from leaving the construction limits.

(4) Inspection and Maintenance of Measures

Inspect and document all measures at least once every 7 calendar days and within 24 hr of ½ in [12.5 mm] or greater rainfall event. Maintain all erosion and sediment control measures in accordance with the specifications at all times during the life of the Contract for all disturbed areas, material storage areas, discharge locations, drainage structures and vehicle entrances/exits for off-site tracking. Repair damaged measures; remove trapped sediment, and correct measures that are not working within 3 calendar days. Initiate repairs as needed or as directed by the Resident Engineer within 1 calendar day of damage occurring to erosion or sediment control measures that could result in discharge of sediment into live streams, water impoundments, or other nearby bodies of water.

Remove accumulated silt before the control measures reach 50 percent capacity. Document each inspection of erosion and sediment control measures on a *SWPPP Inspection and Maintenance Report* form approved by the Engineer, or a form proposed by the Contractor and accepted by the Engineer. Submit copies of the completed inspection forms signed by qualified personnel to the Resident Engineer within 24 hr of the inspections. Install a rain gauge at the project site and document rainfall amounts in the inspection schedule or reports.

(5) Removal of Control Measures

Remove all temporary erosion and sediment control features from the project area when no longer required, unless otherwise designated in the Contract or directed by the Resident Engineer. Restore the areas of removal as close as possible in order to meet the previous ground lines, cover, and features.

Obtain approval from the Resident Engineer to deposit sediment removed from control features within the right-of-way. If silt is disposed in stabilized areas, re-stabilize the area at no cost as directed by the Resident Engineer.

I. Storm Water Compliance Inspections

The Contractor shall perform periodic storm water compliance inspections and document each inspection in accordance with Subsection 220.04.H.4, “Inspection and Maintenance Measures.” The Resident Engineer shall perform periodic inspections for compliance with OPDES Permit or General Permit requirements and SWPPP documentation and control measures. The ODEQ may inspect for compliance with NOI requirements at any time until the NOT is submitted.

220.05 METHOD OF MEASUREMENT

SWPPP documentation and management will be measured on a lump sum basis.

Properly install and maintain erosion and sediment control applications in accordance with the specifications within the right-of-way or as approved by the Resident Engineer will be measured under other items of work.

Erosion and sediment control applications attributed to the Contractor's negligence, carelessness, lack of maintenance or are outside the right-of-way for material source or waste sites, haul roads, equipment storage and Contractor offsite facilities will not be measured for payment.

Non-Compliance Damages. The Department believes that the OPDES program is an integral part of the project, and any failure to maintain the measures in the field or lack of orderly documentation, including but not limited to continuous inspection reports and revisions of the SWPPP, may result in non-compliance citations by the ODEQ and/or other local, state and federal agencies. The Department will consider one or more of the following actions for failure to comply:

- Withhold a portion of payment for the lump sum item for SWPPP documentation and management;
- Withhold progressive payments for the project;
- Stop work on the project;
- Suspension of bidding for the Contractor;
- Apply non-compliance assessments in accordance with Subsection 220.06.B, "Non-Compliance Assessment"; or
- The Resident Engineer will proceed to maintain the project in accordance with Subsection 105.14, "Maintenance During Construction."

220.06 BASIS OF PAYMENT

Approved documentation of NOI, Authorization to Discharge, initial and updated SWPPP's, inspections, inspection reports, and acceptance of NOT by ODEQ will be paid at contract unit price as follows:

Pay Item:	**Pay Unit:**
SWPPP DOCUMENTATION AND MANAGEMENT	Lump Sum

Such payment shall be full compensation for furnishing all materials, equipment, labor, annual ODEQ permit fee and incidentals to complete the work as specified. Temporary erosion, sedimentation and storm water pollution prevention and control pay items will be measured for payment under the relevant pay items in Chapter 200, "Soils."

Payment for this item of work shall be on the following schedule:

- 10 percent for approved earth disturbing SWPPP documentation
- 15 percent when 25 percent of the Contract work is completed
- 25 percent when 50 percent of the Contract work is completed
- 25 percent when 75 percent of the Contract work is completed
- 25 percent when 70 percent stabilization has been obtained, all temporary erosion and sediment control devices have been removed and the storm water permit has been terminated.

Non-compliance assessment.

Table 220:1 Non-Compliance Assessment Schedule		
Total Disturbed Area Shown on the SWMP Sheet, *acre [ha]*		**Rates per Calendar Day**
From	To & Including	
1 [0.4]	5 [2]	$500
5 [2]	50 [20.2]	$1,000
50 [20.2]	100 [40.5]	$1,500
100 [40.5]	No Limit	$2,000

If the Resident Engineer determines it to be appropriate, non-compliance assessments will be charged in accordance with Table 220:1 for failure to comply with the procedures specified in Subsection 220.04.H, "Contractor's Operations," failure to document inspection and maintenance activities specified in Subsections 220.04.C, 220.04.D, 220.04.E, 220.04.F, and 220.04.G, or failure to document, install, or maintain field changes in erosion control measures in a timely and prescribed manner as directed in writing by the Resident Engineer. The Resident Engineer will provide written notice of non-compliance to the Contractor with a time line for accomplishment before assessments are applied. The Resident Engineer will compile a schedule of calendar days for each and every day of non-compliance by the Contractor. The compiled schedule of calendar days will form the basis for charging the non-compliance assessments.

Non-compliance assessments will continue until the Resident Engineer provides written notice of satisfactory compliance with these specifications to the Contractor.

In addition to any Non-Compliance Assessments:

Indemnify and hold harmless the Department, officers, and employees from all acts and/or failure to act by the Contractor, his/her officers, employees or agents and any other subcontractors which result in damages to the environment or to third parties or which are found to violate any rule or regulation of any regulatory agency.

Reimburse the Department for the actual cost of any reasonable legal fees, liability, damage judgment or finding, fine, penalty, or expenses as a result of Contractor's negligent acts or violations of the above noted laws in its performance of the Contract.

Reimburse the Department within 10 calendar days of the amount of assessment, damage judgment or finding, fine, penalty, or expense or the Department may withhold this amount from the Contractor's next pay estimate or claim against the Contractor's bond if estimates are inadequate and deliver that sum to the permitting agencies issuing the assessment, damage judgment or finding, fine, or penalty.

These assessments are not to be construed as a penalty but are actual damages to recover the costs assessed against the Department due to the Contractor's failure to comply with the above requirements.

SECTION 221
TEMPORARY SEDIMENT CONTROL

221.01 DESCRIPTION

This work consists of constructing, maintaining, and removing the following items at locations shown on the Storm Water Pollution Prevention Plan (SWPPP):

- Temporary slope drains to avoid sheet flow on slopes;
- Temporary bale barriers to trap sediment at the toes of slopes, or across ditches and defined waterways;
- Temporary silt fences to prevent sediment from moving off the right-of-way;
- Temporary sediment filters to trap sediment and debris;
- Temporary sediment basins to collect sediment-laden runoff from disturbed areas;
- Temporary silt dikes to trap sediment at the toes of slopes, or across ditches and defined waterways;
- Temporary rock filter dams to dissipate the energy of flowing water and collect sediment near the toes of slopes, at upstream and downstream drainage structures, and in roadway ditches or defined waterways.

221.02 MATERIALS

A. Temporary Slope Drain

For temporary slope drains, use flexible tubing, plastic sheeting, plastic screen, burlap, asphalt, pipe, or other materials. For inlets, use wood, pipe end sections, or other solid material. Construct outlets of loose rock, brush, straw, waste concrete, or pipe end sections.

B. Temporary Bale Barrier

For temporary bale barriers, use standard-sized rectangular bales of straw or hay measuring 18 in × 20 in × 36 in [450 mm × 500 mm × 900 mm]. Bind bales with wire or plastic twine. Anchor bales with stakes (approximately 3 ft [0.9 m] long) that are capable of being driven firmly into the ground.

C. Temporary Silt Fence

Provide material for temporary silt fence in accordance with Subsection 712.06, “Filter Fabric for Silt Fence.”

For temporary silt fence, use woven, polypropylene, polyester, or polyamide material that is resistant to ultraviolet degradation, mildew, and rot. Seal or selvage the edges of woven fabrics to prevent unraveling. Use fabric at least 3 ft [0.9 m] wide. Use posts with length of at least 4 ft [1.1 m], and the ability to resist damage during installation and to support applied loads.

D. Temporary Sediment Filter

Provide bales of straw or hay and stakes for Type I-A and I-B sediment filter in accordance with Subsection 221.02.B, “Temporary Bale Barrier.” Provide material for Type I-C sediment filter in accordance with Subsection 221.02.C, “Temporary Silt Fence.” Provide any type of available non-erodible material for Type II sediment filters, such as loose rock, broken concrete, or other salvageable materials.

E. Temporary Sediment Basin

For both the inlet and outlet flows of the sediment basins, use the following:

- Loose rock capable of withstanding anticipated water velocity displacement, or
- Other non-erodible materials approved by the Resident Engineer.

For Type I sediment basins, provide an outflow pipe with a diameter of at least 12 in [300 mm].

F. Temporary Silt Dike

Provide materials for temporary silt dikes in accordance with Subsection 735.07, "Temporary Silt Dike Materials."

Provide No. 11 gauge wire staples, at least 6 in [150 mm] long.

G. Temporary Rock Filter Dam

Provide materials in accordance with the following subsections:

Material:	Subsection:
Stone Fill for Gabions	713.03
Wire Mesh	732.09
Filter Fabric	712.02

Provide ¾ in [19 mm], No. 6 Deformed Reinforcing Steel Bars for Rock Filter Dam Type 4.

221.03 EQUIPMENT — VACANT

221.04 CONSTRUCTION METHODS

Construct temporary sediment control devices so that water is prevented from entering the driving lanes.

A. Temporary Slope Drain

At the end of each day, construct diversion dikes in fill sections, and construct or extend slope drains at points along the diversion dikes. Construct slope drains from the toe of the slope so that they may be extended as additional fill is completed. Provide inlets with each slope drain. Existing conditions and available materials will determine the type of outlet control.

Place slope drains on back slopes as the excavation of the cut area progresses, until the final grade is obtained and permanent controls are in place.

Maintain slope drains and diversion dikes to ensure they are free of debris and open to the flow of water. Remove slope drains when permanent controls are complete.

B. Temporary Bale Barrier

Embed bale barriers 6 in [150 mm] into the soil. Keep bale barriers in good condition by immediately replacing broken or damaged bales. Remove accumulated sediment in accordance with Subsection 221.04.H, "Removal of Sediment."

Remove or leave bale barriers at the Resident Engineer's direction.

(1) Type I

As ditch checks, place the bales in staggered positions across the defined waterways and stake in place. Place the bales up the slopes of the waterway on

each side of the flow line. To concentrate the flow of water into the center of the waterway, ensure the top of the center bale is lower than the top of the adjacent bales.

(2) Type II

As slope barriers, place the bales end-to-end, parallel to the slope, and no further than 4 ft [1.2 m] from the toe of the slope. Stake to secure in place. At specified locations, replace bales with loose rock or other acceptable filtering material—two-thirds the height of a bale —to act as a spillway.

C. Temporary Silt Fence

Construct temporary silt fence to handle stress from hydraulic and sediment loading. Bury the bottom 6 in [150 mm] of the filter fabric in a trench to prevent undercutting. Backfill the trench and compact the soil over the fabric. Splice fabric ends together with hog rings, locking plastic ties, or other methods approved by the Resident Engineer.

Space the posts no more than 5 ft [1.5 m] apart, and embed at least 1 ft [0.3 m]. Use hog rings, locking plastic ties, or other methods approved by the Resident Engineer to securely fasten the geotextiles to the upstream face of the posts to withstand pressure during storms.

Maintain the integrity of the silt fences during construction to contain sediment runoff. Inspect temporary silt fences immediately after each rainfall, and at least daily during prolonged rainfall. Correct silt fence deficiencies immediately. Make a daily review of the location of temporary silt fences in areas where construction activities have changed the natural contour and drainage runoff, to ensure that they are properly located for effectiveness.

Remove accumulated sediment in accordance with Subsection 221.04.H, “Removal of Sediment,” and before it exceeds a depth of 6 in [150 mm].

Remove the fences when the Resident Engineer approves. After removing the fences, grade and dress the affected area to the Resident Engineer’s satisfaction.

D. Temporary Sediment Filter

Construct sediment filters as soon as the inlets are completed to receive runoff water.

Place bales for Types I-A and I-B—staked tightly together—so that the water flow is slowed and goes over the bales, before entering the inlet.

Place a temporary silt fence for Type I-C so that the water flow slows and goes through the fence before it enters the inlet.

Place non-erodible filter material for Type II sediment filters so that the water will slow and flow over and through the material before entering the inlet.

Immediately repair damage to the filters. Remove accumulated sediment in accordance with Subsection 221.04.H, “Removal of Sediment.”

Sediment filters may be removed as directed by the Resident Engineer.

E. Temporary Sediment Basin

Shape inlets to confine the water to the defined channel as it enters the basin. Construct outlets to slow the velocity of water so the sediment basin will retain

sediment. Either stockpile excavated material from construction of sediment basins or use it on the sediment basin dikes.

Maintain sediment basins until permanent erosion control is complete. Remove accumulated sediment in accordance with Subsection 221.04.H, “Removal of Sediment.”

F. Temporary Silt Dike

Place silt dikes on the contour and in a row, with ends tightly abutting the adjacent silt dike. Overlap the ends of the filter material 6 in [150 mm] at adjacent silt dike sections and secure with wire staples.

Ensure the sewn seam and front side of the silt dike section follow the approach apron. The exiting apron will lie underneath the silt dike section and extend out beyond the discharge side as shown on the Plans.

If installing silt dikes across surface drainage ditches, ensure the highest point of the silt dike in the center of the ditch is lower than the lowest point of the dike at either end. This will direct the water over the center of the silt dike and not around the ends.

Place silt dikes along the contour, or at a 1 to 2 percent gradient, to a specified discharge point if installing them as diversion dikes.

Inspect silt dikes after each rainfall and each 7-day period. Repair deficiencies or damages at no additional cost to the Department. Remove sediment in accordance with Subsection 221.04.H, “Removal of Sediment.”

G. Temporary Rock Filter Dam

Place rock filter dams where erosion is expected, such as near the toe of slope, upstream and downstream of drainage structures, and in roadway channels or ditches. Construct rock filter dams with 4H:1V, or flatter, side slopes within clear zones, and 2H:1V side slopes outside clear zones.

The Plans show the dimensions of rock filter dams. Secure rock filter dams Type 1 and 2 with wire mesh. Place rocks on the mesh to the specified heights. Fold the upstream side of the mesh over the rock, and secure to the downstream side using wire ties or hog rings. In streams, secure or stake the mesh to the streambed before placing rocks.

Maintain at least 12 in [300 mm] between the top of the rock filter dam weir and the top of the embankment for filter dams at sediment traps. Embed rock filter dams at least 4 in [100 mm] into the existing ground. For rock filter dams Type 4, stake sack gabions with bars in accordance with Subsection 221.02.G, “Temporary Rock Filter Dam.”

Inspect rock filter dams after each rainfall. Repair deficiencies or damages at no additional cost to the Department. Remove sediment in accordance with Subsection 221.04.H, “Removal of Sediment.” When approved by the Engineer, rock filter dams can be left in place.

H. Removal of Sediment

Remove sediment from control measures in accordance with Subsection 220.04.H(4), “Inspection and Maintenance of Measures.” After completing sediment removal, leave control measures in a functioning condition. If control measures are damaged or inadvertently moved during the sediment removal

process, immediately reinstall or replace at no additional cost to the Department. Before disposing of removed sediment in the right-of-way, obtain the Resident Engineer's approval in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

221.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the replacement of temporary sediment control measures due to natural causes or as approved by the Resident Engineer.

The Resident Engineer will measure installed temporary slope drains on each section of cut or fill slope.

The Resident Engineer will measure temporary bale barriers along the length of each bale, including the length of spillways.

The Resident Engineer will measure the length of temporary silt fence in place.

The Resident Engineer will measure rock filter dams by the volume of rock in place.

221.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) TEMPORARY SLOPE DRAINS	Linear Foot [Meter]
(B) TEMPORARY BALE BARRIER	Linear Foot [Meter]
(C) TEMPORARY SILT FENCE	Linear Foot [Meter]
(D) TEMPORARY SEDIMENT FILTER	Each
(E) TEMPORARY SEDIMENT BASIN	Each
(F) TEMPORARY SILT DIKE	Linear Foot [Meter]
(G) TEMPORARY ROCK FILTER DAM	Cubic Yard [Cubic Meter]

The Department will consider the cost of construction, maintenance, and removal of temporary sediment control measures to be included in the contract unit price for the appropriate temporary sediment control pay item.

The Department will consider the cost of the following to be included in the contract unit price for *Temporary Slope Drains*:

- Inlets,
- Outlets, and
- Diversion dikes.

The Department will consider the cost of spillways to be included in the contract unit price for *Temporary Bale Barrier*. The Department will consider the cost of the following to be included in the contract unit price for *Temporary Sediment Basin*:

- Inlets, and
- Outlets.

The Department will consider the cost of other materials required to construct or stake rock filter dams to be included in the contract unit price for *Temporary Rock Filter Dam*.

The Department will consider the cost of removing sediment trapped by the various temporary sediment control measures to be included in the contract unit price for the appropriate temporary sediment control pay item.

SECTION 228
NYLON EROSION CONTROL MAT

228.01 DESCRIPTION

This work consists of providing and installing nylon erosion control mat for lining ditches and protecting slopes.

228.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Nylon Erosion Control Mat	735.04.G
Seed	735.03
Mat Fasteners	735.05.B

228.03 EQUIPMENT – VACANT

228.04 CONSTRUCTION METHODS

A. Placing Mat

(1) Ditch and Slope Preparation

Before installing nylon erosion control mat, grade, shape, and finish ditch and slope surfaces so that they are stable, firm, and free of rocks or obstructions that would puncture the mat or prevent it from directly contacting the ditch and slope surface.

(2) Ditches

Observe the planting seasons shown on the Plans. Apply the sod, sprig, or seed shown on the Plans to the ditch surfaces before installing the mat. Uniformly distribute common Bermuda grass seed at a rate of 6 lb per acre [6.7 kg per ha] on the exposed soil before installing the mat. Distribute the seed in accordance with Subsection 232.04.B(1), "Seeding Method A – Hydraulic Seeder Method," or Subsection 232.04.B(4), "Hand Broadcasting Method."

Use three rows of mat for the standard ditch placement. Place the first row in the centerline of the ditch, then place the two side rows adjacent to the first on the ditch slopes, using lap joints of at least 3 in [75 mm].

At the terminal ends of the ditch, dig an anchor slot transverse to the ditch centerline at least 12 in [300 mm] vertically into the soil, secure the mat in the anchor slot with fasteners, backfill the anchor slot with soil, and compact the backfilled soil to the density of the surrounding soil.

On ditches with grades exceeding 6 percent, install a 6 in [150 mm] deep check slot transverse to the ditch centerline every 25 ft [7.5 m], and secure the mat in the check slots with fasteners.

(3) Slopes

Observe the planting seasons shown on the Plans. Apply the sod, sprig, or seed shown on the Plans to the slopes before installing the permanent mat.

Dig an upper anchor slot at least 12 in [300 mm] vertically into the soil at the top end and a lower anchor slot at least 6 in [150 mm] at the bottom end, each transverse to the mat row. Secure the mat in the anchor slots with fasteners, backfill the anchor slots with soil, and compact the backfilled soil to the density of the surrounding soil.

If a concrete lined ditch intersects the slope, install the nylon erosion control mat as directed by the Resident Engineer. Overlap the mat on the concrete lined ditch at least 6 in [150 mm] and fasten adjacent to the concrete edge

Install the mat so that the longitudinal edge will overlap the previously installed mat edge at least 3 in [75 mm].

For slopes over 50 ft [15 m] long, dig a transverse check slot at least 6 in [150 mm] deep for every 35 ft [11 m] of installed mat, and secure the mat in the check slots with fasteners.

(4) End of Roll

Overlap the ends of the mat roll 3 ft [0.9 m], with the up-slope end on top.

B. Fastening the Mat

To hold the mat in place, press fasteners firmly against the mat and drive them securely into the underlying soil. Install fasteners every 3 ft [0.9 m] along each longitudinal edge lap joint and down the center of each mat width. Offset the center fasteners 18 in [450 mm] longitudinally from the edge fasteners. Install fasteners across the width of mat at anchor slots, check slots, and end overlaps on 18 in [450 mm] centers.

C. Maintenance

Maintain the seeded and matted areas until project completion, including reseeding, replacing mat, and refilling eroded areas.

228.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the area covered by the nylon erosion control mat installed in place, not including overlaps between adjacent pieces of mat.

228.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
NYLON EROSION CONTROL MAT	Square Yard [Square Meter]

The Department will consider the cost of mat fasteners and seeding to be included in the contract unit price for *Nylon Erosion Control Mat*.

SECTION 229
DITCH LINER PROTECTION

229.01 DESCRIPTION

This work consists of providing and installing excelsior mat or solid slab sod to protect ditch liners.

229.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Excelsior Mat	735.04.C
Solid Slab Sod	735.01
Mat Fasteners	735.05.B

229.03 EQUIPMENT — VACANT

229.04 CONSTRUCTION METHODS

A. Placing Excelsior Mat

Place the excelsior mat so that the fibers are in contact with the soil and the netting is on top of the mat. Place one strip of mat adjacent and parallel to each side of the ditch liner.

Hold the mat in place with fasteners as shown on the Plans. Press them firmly against the mat and drive them into the underlying soil to secure the mat.

B. Placing Solid Slab Sod

Place the type of sod as shown on the Plans in accordance with Subsection 230.04.A, "Solid Slab Sodding Operations." Apply 185 gal [700 L] of water and 5 lb [2.25 kg] of 10-20-10 fertilizer per 100 ft [30 m] of ditch liner.

C. Repairs

Replace damaged ditch liner protection. Restore eroded soil beneath or surrounding the ditch liner and re-grade before replacing ditch liner protection.

229.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Ditch Liner Protection* along the centerline of the ditch. (The linear measurement includes the ditch liner protection for both sides of the ditch to the width shown on the Plans.)

229.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
DITCH LINER PROTECTION	Linear Foot [Meter]

The Department will consider the cost of the following to be included in the contract unit price for *Ditch Liner Protection*:

- Mat fasteners,
- Water, and
- Fertilizer.

SECTION 230
SODDING AND SPRIGGING

230.01 DESCRIPTION

This work consists of providing and planting Bermuda grass sod or sprigs.

230.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Bermuda Grass Solid Slab Sod	735.01
Bermuda Grass Mulch Sod	735.01
Bermuda Grass Row Sprigging	735.01
Bermuda Grass Broadcast Sprigging	735.01
Water	735.08

230.03 EQUIPMENT

A. Rolling Equipment

Provide rolling equipment of a size and weight capable of firmly compacting the sod into the soil and removing air voids.

B. Watering Equipment

Provide watering equipment capable of applying water as shown on the Plans from locations off the slopes, and measuring the water with a calibrated meter.

C. Row Sprigging Equipment

Provide equipment that performs the following in one continuous operation:

- Opens the furrows;
- Places the sprigs in the furrow; and
- Covers the sprigs and furrow with soil.

230.04 CONSTRUCTION METHODS

A. Solid Slab Sodding Operations

Prepare areas for solid slab sodding operations by performing the following:

- Grubbing existing vegetation;
- Filling and reshaping eroded areas;
- Cleaning ditches; and
- Refinishing slopes and medians to the typical grading section.

Ensure the soil is moist in accordance with Subsection 230.04.F, “Soil Moisture and Watering Requirements.”

Clear the area of litter and debris.

The Plans will show the location, placement, and seasonal requirements of solid slab sod.

Place the slabs of sod in rows soil side down. On slopes, ensure the rows run parallel to the roadway. Place each slab tightly against the edge of adjoining slabs. Ensure the transverse joints do not run continuous across adjoining rows. Fill voids with additional sod. Compact the area using rollers or other equipment approved by the Resident Engineer.

Immediately after placement, thoroughly water the sodded area. When the area stabilizes, fill voids with soil approved by the Resident Engineer and water again. Continue watering in accordance with Subsection 230.04.F, "Soil Moisture and Watering Requirements."

Apply fertilizer in accordance with Subsection 230.04.G, “Fertilizer Operations.”

B. Mulch Sodding Operations

Prepare areas for mulch sodding operations by performing the following:

- Filling and reshaping eroded areas;
- Cleaning ditches; and
- Refinishing slopes and medians to the typical grading section.

Ensure the soil is moist in accordance with Subsection 230.04.F, "Soil Moisture and Watering Requirements."

Before placing the mulch sod, scarify the cut and fill slopes.

Place the mulch sod on the prepared areas and spread it uniformly to a compacted thickness of 3 in [75 mm]. Roll slopes along the contour lines unless the Resident Engineer directs otherwise.

Immediately after placement, thoroughly water the sodded area. When the area stabilizes, fill voids with soil approved by the Resident Engineer and water again. Continue watering in accordance with Subsection 230.04.F, "Soil Moisture and Watering Requirements."

Apply fertilizer in accordance with Subsection 230.04.G, “Fertilizer Operations.”

C. Row Sprigging Operations

Prepare areas for row sprigging operations by tilling to a depth of at least 4 in [100 mm] with an offset or tandem disk plow. Ensure the soil is moist in accordance with Subsection 230.04.F, "Soil Moisture and Watering Requirements."

Apply fertilizer in accordance with Subsection 230.04.G, “Fertilizer Operations.”

Plant the sprigs with an automatic sprig planter in accordance with Subsection 230.03.C, “Row Sprigging Equipment.” Hand-plant in areas where the sprig planter cannot operate. Plant the sprigs in furrows parallel to the contour lines of the slopes. The distance between furrows shall not exceed 20 in [500 mm] on centers. Place the sprigs 3 in [75 mm] deep at the rate of 60 bushels/acre [14 m^3/ha] with the ends of sprigs meeting or overlapping.

Do not operate the sprig planter faster than 4 mph [6.4 km/h].

On the same day the sprigs are planted, use rollers or other approved equipment to compact the entire sprigged area. Roll slopes along the contour lines.

Immediately after placement, thoroughly water the sprigged area. When the area stabilizes, fill voids with soil approved by the Resident Engineer and water again. Continue watering in accordance with Subsection 230.04.F, "Soil Moisture and Watering Requirements."

D. Broadcast Sprigging Operations

(1) Broadcast Sprigging Method A

Prepare areas for Broadcast Sprigging Method A by tilling to a depth of at least 4 in [100 mm] with an offset or tandem disk plow. If rain or other conditions pack the soil before planting is complete, repeat the tillage. Plant at least 80 bushels/acre [8.70 m^3/ha] of sprigs, unless the Contract requires otherwise. Broadcast the sprigs uniformly on the soil surface. Within 2 hr of planting the sprigs, disk the areas to a depth of 3 in [75 mm] with an offset or tandem disk plow.

(2) Broadcast Sprigging Method B

Incorporate at least 12 bushels [0.42 m^3] of sprigs into 100 yd^3 [76 m^3] of topsoil salvaged in accordance with Subsection 205.04.B, “Type B Salvaged Topsoil.” Use a method approved by the Resident Engineer to meter and distribute the sprigs into the stockpiled topsoil. Keep both the soil and sprigs moist during the mixing operation. Before placing the soil-sprig mixture, prepare areas for Broadcast Sprigging Method B by scarifying parallel to the contours with equipment approved by the Resident Engineer. Spread the soil-sprig mixture within 4 hr of mixing to a thickness of 5 in [125 mm].

(3) Fertilizing, Rolling, and Watering

Use the following procedures for Broadcast Sprigging Methods A and B:

- Apply fertilizer in accordance with Subsection 230.04.G, “Fertilizer Options.”
- Compact the area using rollers or other approved equipment. Roll slopes along the contour lines.
- Water the sprigged areas within 24 hr of placement and continue watering in accordance with Subsection 230.04.F, “Soil Moisture and Watering Requirements.”

E. Planting Seasons and Weather Restrictions

Perform sodding and sprigging, as permanent erosion control, during the planting seasons shown on the Plans. The Contractor may perform permanent sodding and sprigging operations during a “non-planting season” if the Contractor submits and the Resident Engineer approves a written letter guaranteeing growth at the beginning of the next “planting season.” As cut and fill sections are completed, place and finish the salvaged topsoil, and sod or sprig in accordance with seasonal limitations. Regardless of the dates specified, the Resident Engineer may suspend the work during excessively wet or dry weather conditions.

Promptly begin sodding or sprigging and proceed until completed, or until the end of the “planting season.” If a “non-planting season” interrupts permanent sodding and sprigging operations, resume work at the beginning of the next planting season.

If a “non-planting season” interrupts permanent sodding or sprigging, apply temporary sodding or sprigging on cuts, fills, and disturbed areas susceptible to erosion. Begin this work immediately after placing the topsoil, or as the Resident Engineer directs.

F. Soil Moisture and Watering Requirements

During sodding or sprigging operations, ensure the soil is moist, from 1 in [25 mm] below to at least 5 in [125 mm] below the surface. Estimate the required moisture content of the soil using the hand-squeeze test. The soil should form a tight cast when squeezed. The cast should break into two pieces without crumbling or leaving excess water on the hand.

Water sodded or sprigged areas daily for the first 7 days after planting. Continue watering these areas as necessary for 30 days after planting, unless the Contract requires or the Resident Engineer directs otherwise. Water short sections of sodded or sprigged areas until the top 1 in [25 mm] of the soil is moist.

Adjust the application rate and fineness of the spray to provide uniform infiltration and prevent erosion or runoff.

G. Fertilizer Operations

Apply fertilizer at the specified rates in accordance with Section 234, “Fertilizing and Agricultural Liming.” Do not place fertilizer on hard or glazed surfaces.

The Contractor may disk to prepare soil, remove weeds, and incorporate fertilizer in one operation, if approved by the Resident Engineer.

If the Plans show fertilizer that contains phosphorous, apply the fertilizer and mix into the soil before applying the sod or sprigs using an offset or tandem disk plow.

If the specified fertilizer contains only nitrogen, apply the fertilizer after the sodding or sprigging operations are complete.

H. Repair and Maintenance

Repair and maintain sodded or sprigged areas until the Resident Engineer approves all of the project or that part of the project including the sodded or sprigged areas.

(1) Repair

Recover, replace, and compact soil removed by erosion. Fill and reshape eroded areas, clean ditches, and refinish slopes and medians to the typical grading section. Reapply sod or sprigs, re-fertilize, and water the damaged areas during the "planting seasons" shown on the Plans.

(2) Maintenance

Control weeds by mowing, hand cutting, applying herbicides, or other methods approved by the Resident Engineer. Remove weed growth on sodded areas as directed by the Resident Engineer. If using herbicides, apply them in accordance with label instructions and with the approval of the Resident Engineer. Mow in accordance with Section 241, “Mowing.”

230.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Solid Slab Sodding*, *Mulch Sodding*, *Row Sprigging*, *Broadcast Sprigging (Method A)*, and *Broadcast Sprigging (Method B)* by the area sodded or sprigged.

The Resident Engineer will measure *Watering* using a Contractor-provided calibrated meter.

230.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) SOLID SLAB SODDING	Square Yard [Square Meter]
(B) MULCH SODDING	Square Yard [Square Meter]
(C) ROW SPRIGGING	Square Yard [Square Meter]
(D) BROADCAST SPRIGGING (METHOD A)	Square Yard [Square Meter]
(E) BROADCAST SPRIGGING (METHOD B)	Square Yard [Square Meter]
(F) WATERING	K-Gallon [Kiloliter]

The Department will pay for fertilizer in accordance with Section 234, “Fertilizer and Agricultural Liming.”

If the Resident Engineer directs mowing operations, the Department will pay for mowing in accordance with Section 241, “Mowing.”

SECTION 231
PLANTING

231.01 DESCRIPTION

This work consists of providing, handling, planting, and establishing plant materials.

231.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Plant Materials	735.02.A
Organic Mulch	735.02.C
Water	735.08

231.03 EQUIPMENT

If machine-planting trees, the equipment must be capable of digging, lifting, carrying, and placing a plant into a hole (dug by the same or an identical machine) without damaging the ball of soil or the plant. Obtain the Resident Engineer's approval of the equipment before use.

231.04 CONSTRUCTION METHODS

A. General

Perform this work under the supervision of an experienced nurseryperson. Provide credentials to the Resident Engineer before starting work.

Maintain and protect new plants and existing trees, shrubs, and turf from damage or injury before, during, and after planting, establishment, and maintenance operations.

For the purpose of Section 231, "Planting," BR refers to bare-rooted and B&B refers to balled and burlapped.

B. Product Delivery, Storage, and Handling

Delivery plant material from the growing site to the planting site with special care and prevent excess drying of the roots and balls and wind damage to the foliage. The Department recommends tarps or covered vehicles.

Pick up trees by the container or rootball, not by the trunk.

If unable to plant BR plants within 2 hr of delivery and B&B or container plants within 24 hr, heel-in using moist soil or mulch or store in a protected area. Maintain heeled-in plants and water as necessary until planted. Remove container grown plants from containers at planting time only. The Department will not accept plants that remain heeled-in during the summer.

Replace plants that the Department determines unfit for planting, at no additional cost to the Department.

C. Planting Procedures

(1) Planting Seasons and Weather Restrictions

Plant deciduous B&B and BR plants from November 25 to March 31, evergreen plants from October 1 to May 15, and container plants from September 15 to April 30.

Regardless of the specified planting dates, suspend work when the temperature is below 25 °F [-3.8 °C], the wind velocity is over 25 mph [40 km/h], the natural ground or topsoil is frozen or wet, or the continuation of prevailing weather will damage plant materials.

Complete planting operations as early in the specified season as possible.

Remove plants that are not in accordance with the specifications after planting, and replant immediately. If the current planting season is over, replant during the next planting season.

(2) Plant Locations

The Resident Engineer may adjust plant locations shown on the Plans to suit actual field conditions.

Kill existing vegetation with an herbicide approved by the Resident Engineer before planting. Remove debris before planting.

(3) Planting Hole

Make plant holes vertical and cylindrical unless using an approved tree-digging machine. When excavating in rocky subsoil (or in impervious material that would

hamper proper drainage, normal root development, and growth), loosen the soil with the Resident Engineer's approval.

Dig a large planting hole as deep as the rootball and two to three times as wide as the diameter of the top of the rootball. Ensure that the planting hole is at least three times the diameter of the container, and at least 8 inches remains between the fully spread roots of a BR plant and the sides of the planting hole. For holes in material impervious to drainage (rocky or heavy clay), loosen the bottom and sides of the hole.

If planting grouped plants (shrubs) in a bed, loosen or till the soil to a depth between 8 inches to 10 inches. Remove thick turf before tilling.

Ensure the plant hole diameter is large enough to allow at least 8 in [200 mm] of backfill between the fully spread roots and the sides and bottom of the hole.

Make plant-holes for containerized plants 3-times the diameter of the container and 6 in [150 mm] deeper than the height of the container, unless otherwise required by the Contract.

If the Plans show grouped plants in a plant bed, loosen the plant bed to a depth of at least 6 in [150 mm] and break up clods before excavating the plant holes.

Uniformly spread excess material from plant-hole excavations over the surrounding area. If the excess material is not appropriate for spreading, dispose of it as approved by the Resident Engineer.

(4) Planting Procedures for B&B, Container, and BR Plants

(a) Prune

Prune sparingly. Examine the tree for injury to roots or branches. Cut crushed roots at a point just in front of the break. Prune only broken branches, making sure to leave the branch collar intact.

(b) Fertilizer

Never apply a high-nitrogen fertilizer at planting time. The Department will specify the requirement for additional fertilizing in the plans.

(c) Soil

Use existing, native soil to backfill the hole.

(d) Tree Placement

Never carry trees by the trunk. Add a sufficient amount of soil to the hole to bring the tree or shrub to its original level. For B&B trees and shrubs, The Department will allow the burlap tie to be higher than the original soil line. In heavy, clay soils, the Department will allow the root ball to be slightly higher than the surrounding ground level, but soil must be added to slope from the top of the root ball to the ground level.

(e) Filling Plant Hole

If planting B&B, cut the twine and remove the burlap from the top of the root ball after placing the tree in the planting hole. Cut and remove a minimum of one-third of the burlap from all sides of the root ball to prevent the burlap from exposure to direct air contact. Remove a minimum of one-third of any wire

baskets from the root ball after placing the tree in the hole. Completely remove all containers, peat pots, and root control bags.

(f) BR Planting

Spread-out the roots when placing BR plants in the planting holes. Backfill the hole with thin layers of friable native soil. Carefully tamp the soil around the roots to prevent damage or bruising. Use the same process of watering and adding soil as needed.

(g) Tree Well

Make a shallow saucer-like depression from the trunk to 18 in [450 mm] outside the plant hole and construct a 6 in [150 mm] high, 3 in [75 mm] thick ridge of compacted soil in a circle 18 in [450 mm] outside of the plant hole (at the edge of the depression) around the tree.

(h) Excess Soil

Uniformly spread excess soil from plant-hole excavations over the surrounding area. If too much excess soil exists, dispose of it as approved by the Resident Engineer.

(5) Machine Planting of Trees

(a) Digging

Ensure each excavated tree has a ball of soil encompassing the root system. Provide a ball size in accordance with the requirements of ANSI Z 60.1.

(b) Transporting

Transport the tree from the digging location or nursery to the new locations using the same machine that excavated the tree.

(c) Planting

Place the tree in a hole dug by the same size spade used to excavate the tree. The holes must be at least 3 in [75 mm] larger in diameter than the root ball. Scarify or loosen the sides and bottom of the hole to allow water to drain before placing the tree. Place the top of the ball at a slightly higher elevation than the surrounding ground. Remove the machine, backfill the hole with existing native soil or a 50/50 mix of native soil and planting mix, water, mulch, and stake the tree.

D. Staking

Stake container trees with calipers 1 in [25 mm] or larger, and B&B and machine planted trees with calipers 1½ in [12.5 mm] or larger.

Use nylon staking ties (webbing or strapping) to attach the stake to the trunk. Place the staking ties loosely around the trunk just above the lowest set of branches and attached to stakes placed outside the perimeter of the tree well. Leave at least 3.5 ft [1 m] of the stake above ground.

Leave the stakes for at least 1 year but not more than 2 years.

E. Organic/Mulch

Establish and maintain a 6 in to 8 in [150 mm to 200 mm] thick layer of approved, organic mulch in a 6 ft [1.8 m] diameter around the newly planted tree including

filling the tree well. Do not use landscape fabric or plastic. Pull the mulch away from the tree trunk to provide aeration. Do not make mulch volcanoes.

F. Watering

Water plant material regularly until start of establishment period. Provide at least 1 in [25 mm] of water per week; water slowly and thoroughly. If 1 in [25 mm] or more of rainfall occurs during one week, the Department will not require supplemental irrigation for that week. The Department will not allow turf irrigation.

G. Plant Establishment Period and Contractor's Warranty.

Take responsibility for the proper maintenance, survival and condition of all plants for the establishment period specified in the Contractor's landscaping warranty bond or on the plans after final acceptance in accordance with Subsection 105.17(c). Notify the Engineer upon completion of installation of all plants.

Mowing as part of the Planting work will be identified in the Contract. Continue any mowing of the Planting areas specified in the Contract throughout the establishment period. The cost of mowing during the establishment period will be included in the cost of other bid items.

Provide a Landscaping Warranty Bond to the Department in the amount of the total sums bid for all landscape items as evidence of warranty during the plant establishment period. The cost of the bond will not be paid separately, but will be included in the costs of other bid items.

The Department will conduct interim inspections of all landscape items during the plant establishment period, as well as at the end of the plant establishment period. As part of the warranty to the Department, and at no cost to the Department, replace dead, dying, or unhealthy plants with plants of the same size and variety during the appropriate planting season. Healthy plants should have at least 85 percent of the canopy alive with leaves the appropriate size and color for the species.

At the end of the establishment period, the Department will release the Contractor from further warranty work and responsibility provided all plants are established and all previous warranty and remedial work, if any, has been completed to the satisfaction of the Department.

H. Carry-Over Work

Stop planting operations at the end of the initial planting season, even if the planting activities are incomplete. The Department will not extend the initial planting season for failure to complete the work. Continue and complete the work during the next planting season.

The Department will charge time from the beginning of the next planting season until remaining planting is complete. The Department will not charge time from October 1 to November 25 for deciduous plants or for replanting operations.

231.05 METHOD OF MEASUREMENT

The Resident Engineer will measure healthy plants by each category.

231.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) TREES (KIND)	Each
(B) SHRUBS (KIND)	Each
(C) VINES OR GROUND COVERS (KIND)	Each
(D) TREES MACHINE PLANTED (KIND)	Each

The Department will consider the cost of water for watering plants, mulch, and fertilizer to be included in the unit price of the relevant trees shrubs, or ground covers pay item.

SECTION 232
SEEDING

232.01 DESCRIPTION

This work consists of preparing seedbeds, providing and planting seeds, and seeding for temporary and permanent erosion control.

232.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Seed	735.03
Water	735.08

232.03 EQUIPMENT

A. Hydraulic Seeder

Use a factory-designed hydraulic seeder. Ensure the tank holds at least 1,000 gal [3.8 kL], and include a mechanical agitation system with an operating capacity that can suspend and homogeneously mix the seed and water. The distribution hoses must be large enough to prevent clogging and include spray nozzles that provide uniform distribution.

Mount the equipment on a traveling unit capable of distributing the seed without operating on the area requiring seed.

B. Grass Seed Drill

Use an approved native grass seed drill equipped with two planter boxes and two planting mechanisms that will simultaneously plant large chaffy seed and fine clean seed. Ensure the drill has the following characteristics:

- A mechanism for accurately adjusting the rate of seed flow;
- Double-disk openers for opening furrows on maximum 8 in [200 mm] centers;
- Disk, each with a depth-regulating band 1 in [25 mm] from the disk edge; and

- Furrow openers, each with heavy press wheels to compact the soil behind the opener and leave the seed covered to a depth of from ½ in to ¾ in [12 mm to 19 mm].

C. Corrugated Roller Seeder

Use a corrugated roller seeder equipped with two planter boxes and two planting mechanisms that will simultaneously plant large chaffy seed and fine clean seed. Ensure the roller wheels are corrugated, mounted on tandem axles, spaced on 2 in [50 mm] centers, and capable of placing the seed from ¼ in to ½ in [6 mm to 12 mm] deep. The seeder shall also include a mechanism for adjusting the rate of seed flow, and weigh from 125 lb to 250 lb per foot [186 kg to 372 kg per meter] of rolling width.

232.04 CONSTRUCTION METHODS

A. Seedbed Preparation

Prepare the area by performing the following:

- Mowing existing vegetation in accordance with Section 241, “Mowing”;
- Filling and reshaping eroded areas;
- Cleaning ditches; and
- Refinishing slopes and medians to the typical grading section.

Till the top 4 in [100 mm] of soil along the soil contours. Disk the soil to incorporate thick layers of previously applied mulch or existing vegetation. Harrow and roll the soil to crush and pack dirt clods larger than 1 in [25 mm]. Apply water where necessary.

When the Plans specify hydraulic seeding, leave or make the seedbed surface rough before seeding.

B. Seed Planting Methods

Plant the seed uniformly at the specified rate. When several species of seed cannot be combined due to different characteristics—size, weight, hulled, or unhulled—plant the seed separately.

(1) Seeding Method A - Hydraulic Seeder

Distribute the seed with a hydraulic seeder in accordance with Subsection 232.03.A, “Hydraulic Seeder.” Load no more than enough seed for 2 acre [0.80 ha] of coverage into the 1,000 gal [3.8 kL] spray tank of a hydraulic seeder, and mix with water. If using less than 1,000 gal [3.8 kL] of water, reduce the following in proportion to the water:

- The amount of seed,
- Other specified materials (inoculants, fertilizer, etc.), and
- The seeding area per load.

If required by the Contract, place inoculants in the spray tank with the seed.

Power-spray to uniformly distribute the seed.

If distributing seed and fertilizer as a water slurry, apply the mixture to the area to be seeded within 30 min of mixing the components.

(2) Seeding Method B - Grass Seed Drill

Plant the seed with a grass seed drill in accordance with Subsection 232.03.B, "Grass Seed Drill." Perform grass seed drilling on the approximate soil contours.

(3) Seeding Method C - Corrugated Roller Seeder

Distribute the seed with a corrugated roller seeder in accordance with Subsection 232.03.C, "Corrugated Roller Seeder." On slopes, plant along the soil contours.

(4) Hand Broadcasting Method

Use hand-broadcasting in areas that are small or inaccessible to equipment.

C. Planting Season and Weather Restrictions

Perform seeding as erosion control in accordance with Subsection 230.04.E, "Planting Seasons and Weather Restrictions."

D. Soil Moisture and Watering Requirements

During seed application, ensure the soil is moist, from 1 in [25 mm] to at least 5 in [125 mm] below the surface. Estimate the required moisture content of the soil using the hand-squeeze test. The soil should form a tight cast when squeezed. The cast should break into two pieces without crumbling or leaving excess water on the hand.

E. Fertilizer Application

Apply fertilizer in accordance with Section 234, "Fertilizing and Agricultural Liming."

F. Repairs and Maintenance

Repair and maintain seeded areas, at no additional cost to the Department, until the Resident Engineer approves all of the project or that part of the project including the seeded areas.

(1) Repair

Recover, replace, and compact soil removed by erosion. Fill and reshape eroded areas, clean ditches, and refinish slopes and medians to the typical grading section. Reseed, re-fertilize, and water the damaged areas during the "planting seasons" shown on the Plans.

(2) Maintenance

Control weeds by mowing, hand-cutting, applying herbicides, or other methods approved by the Resident Engineer. Remove weed growth on seeded areas as directed by the Resident Engineer. If herbicides are necessary, use them in accordance with label instructions, and with the approval of the Resident Engineer. Mow in accordance with Section 241, "Mowing."

232.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Seeding Method A*, *Seeding Method B*, and *Seeding Method C* by the area seeded.

232.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) SEEDING METHOD A	Acre [Hectare]
(B) SEEDING METHOD B	Acre [Hectare]
(C) SEEDING METHOD C	Acre [Hectare]

The Department will pay for water used to water seeded areas in accordance with Section 230, "Sodding and Sprigging." The Department considers the cost of water used as a carrier in hydraulic seeding operations to be included in the contract unit price for *Seeding Method A.*

The Department will consider the cost of hand broadcasting seed to be included in the contract unit price for the appropriate seeding pay items.

The Department will pay for fertilizer in accordance with Section 234, "Fertilizing and Agricultural Liming," and mowing in accordance with Section 241, "Mowing."

SECTION 233
MULCHING

233.01 DESCRIPTION

This work consists of providing, applying, and fastening mulching materials to the soil surface.

233.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Vegetative Mulch	735.04
Asphalt Mulch	735.04
Excelsior Mat	735.04
Excelsior Mulch	735.04
Wood Cellulose Fiber	735.04
Mulch Fasteners	735.05

233.03 EQUIPMENT

Provide equipment in accordance with the following:

A. Equipment for Vegetative and Excelsior Mulch

Use the following equipment methods to distribute vegetative and excelsior mulch:

(1) Adhesive Spray Method

Apply and fasten vegetative and excelsior mulch using a machine that includes a blower to distribute the vegetative material and a pump to distribute the liquid adhesive. Arrange the discharge pipe of the blower and the discharge nozzles of the liquid adhesive hoses so that the liquid adhesive is evenly distributed into the mulch as it emerges from the blower discharge spout. Ensure the hoses can

distribute the liquid adhesive at the specified rate. Ensure the machine can operate the liquid adhesive pump and the mulch blower, and distribute the liquid adhesive-bound mulch at the specified rate over the areas shown on the Plans with one pass of the machine. Do not allow the beater mechanism to shorten the stem lengths of the vegetative material.

(2) Mulching Tiller Method

Ensure the machine for applying vegetative or excelsior mulch meets the specifications for "Adhesive Spray Method," except that the Department will not require a liquid adhesive pump or accessories. Use a mulching tiller that is a heavy disk-type roller with flat disks about ¼ in [6 mm] thick and spaced no more than 12 in [300 mm] apart.

B. Equipment for Wood Cellulose Fiber Mulch

To apply wood cellulose fiber mulch, use factory-designed hydraulic equipment with enough pump capacity to apply the specified quantities. Use a slurry tank that holds at least 1,000 gal [3.8 kL] and includes a mechanical agitation system that can suspend and homogeneously mix the mulch and water. Ensure the slurry distribution hoses are large enough to prevent clogging and include spray nozzles that will evenly distribute the slurry.

Mount the equipment on a traveling unit. Ensure the traveling unit can apply wood cellulose fiber mulch without tracking into the mulching area.

C. Equipment for Asphalt Mulch

Ensure the distributor equipment includes the following:

- Pressure gauge,
- Volume-measuring device or calibrated tank,
- Power unit for the pump,
- Full-circulation, adjustable, spray bar, and
- Hand-operated, spray bar.

Check the distribution rate and uniformity of application as directed by the Resident Engineer.

233.04 CONSTRUCTION METHODS

A. Mulching Operation

Before applying the mulch material as temporary erosion control, repair eroded areas and clear debris that might hinder a uniform mulch application.

If using mulch over seeding or sodding, apply the mulch material within 24 hr after seeding or sodding. If mulched areas become damaged, reshape the area, seed or sod, and mulch again as originally specified.

Do not perform mulching operations during conditions that will result in a non-uniform application or wasted material.

B. Type of Application

The following are accepted methods of application:

(1) Adhesive Spray Method for Excelsior and Vegetative Mulch

Broadcast the vegetative or excelsior mulch into a continuous cover of uniform thickness. Apply the mulch at the rate of 2 ton/acre [4.5 metric ton/ha]. During the spreading operation, inject the adhesive material into the mulch at the mulch blower discharge spout to uniformly distribute it throughout the mulching material. Unless otherwise required by the Contract, use emulsified asphalt, SS-1, at the rate of 2,000 gal/acre [18,708 L/ha]. If the Department requires the use of other fastener types, the Plans will show the type and quantity. To prevent wind from displacing mulch, place a bank of soil or a complete coverage of asphalt along the edge of the mulched area. Promptly remove clumps of excess material.

(2) Mulching Tiller Method for Excelsior and Vegetative Mulch

Spread the mulching materials uniformly in accordance with Subsection 233.04.B(1), "Adhesive Spray Method for Excelsior and Vegetative Mulch." Apply at a rate of 2.5 ton/acre [5.6 metric ton/ha] for vegetative mulch, or 2 ton/acre [4.48 metric ton/ha] for excelsior mulch. Immediately after the mulch-spreading operation, till the mulched area to press the material 3 in [75 mm] into the soil. Use a disk plow to till impermeable soil before spreading and tilling the mulch. If mulching loose, sandy soil, do not exceed the mulch application rate. If mulching slopes, operate the tiller along the contour of the slope.

(3) Asphalt Mulching

Dilute the mulching asphalt with three parts water to one part emulsified asphalt. Apply at the rate of 1.25 gal/yd² [5.66 L/m²]. If impermeable soil may cause appreciable mixture runoff, reduce the amount of water to eliminate runoff and ensure the emulsified asphalt is applied at the rate of 0.3125 gal/yd² [1.415 L/m²]. If applying asphalt mulch over sodded areas, water the sod immediately before application.

(4) Wood Cellulose Fiber Mulch

Complete seed, fertilizer, lime, and other erosion control items before applying cellulose material.

Apply wood cellulose fiber mulch at a rate of at least 1,200 lb/acre [1,345 kg/ha] of air-dry material. Disperse, suspend, and apply the material using water at the rate of 3.3 gal to 1 lb [27.5 L to 1 kg] of material. Apply the cellulose fiber to form a uniform layer over the area shown on the Plans.

(5) Excelsior Mat

Place the mat so that the fibers are in contact with the soil and the netting is on the top. Place each strip of mat parallel to the direction of the flow of water.

233.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Asphalt Mulching* by the volume of undiluted emulsified asphalt.

233.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) VEGETATIVE MULCHING	Acre [Hectare]
(B) EXCELSIOR MULCHING	Acre [Hectare]
(C) ASPHALT MULCHING	Gallon [Liter]
(D) WOOD CELLULOSE FIBER	Acre [Hectare]
(E) EXCELSIOR MAT	Square Yard [Square Meter]

SECTION 234
FERTILIZING AND AGRICULTURAL LIMING

234.01 DESCRIPTION

This work consists of providing and applying fertilizer or agricultural liming materials.

234.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Fertilizer	735.06.A
Agricultural Limestone	735.06.B
Hydrated Lime	735.06.B

234.03 EQUIPMENT

Provide fertilizer and lime spreaders in accordance with the following:

A. Vertical Drop and Broadcast Type

Use an agricultural-type spreader to apply dry fertilizer or lime. Ensure the machine uniformly distributes materials at the specified rates without damaging the fertilizer granules or lime.

B. Power Spray

Provide equipment for distributing fertilizer or lime with water in accordance with Subsection 232.03.A “Hydraulic Seeder.”

234.04 CONSTRUCTION METHODS

A. General

Apply fertilizer and lime with vertical drop or broadcast spreader, unless otherwise shown on the Plans. Do not apply during weather that could result in waste or poor distribution. Apply the fertilizer or lime before or during the ground preparation for permanent seeding or sodding depending on the type of fertilizer required by the Contract. If directed by the Resident Engineer, re-fertilize repair work, at no additional cost to the Department.

B. Methods of Applying Fertilizer or Lime

(1) Vertical Drop or Broadcast Method

Apply the fertilizer or lime uniformly at the specified rate with a spreader in accordance with Subsection 234.03, "Equipment." Ensure the equipment does not rut or damage the prepared surface.

(2) Power Spray Method

Apply the fertilizer or lime in water at the specified rate. Ensure the maximum quantity of fertilizer placed in the spray tank with 1,000 gal [3.8 kL] of water does not exceed the quantity specified for 2 acre [0.8 ha] of seeding or sodding. Also ensure that the maximum amount of lime placed in the spray tank with 1,000 gal [3.8 kL] of water does not exceed the quantity specified for 1 acre [0.4 ha] of seeding or sodding. If less than 1,000 gal [3.8 kL] of water is loaded into the spray tank, reduce the quantity of fertilizer or lime loaded and the area treated per load in proportion to the water.

(3) Hand Broadcast Method

Apply the lime or fertilizer with hand-operated equipment on areas inaccessible to large spreaders or power sprayers.

234.05 METHOD OF MEASUREMENT

The Resident Engineer will measure materials for *Fertilizing*, *Agricultural Limestone*, and *Agricultural Hydrated Lime* with approved scales or use the manufacturer's guaranteed weights. If the Contractor provides a substitute grade of fertilizer, the Resident Engineer will calculate the equivalent weight of each fertilizer element provided by the substitute grade per the area as would have been applied with the specified grade.

234.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) FERTILIZING	Ton [Metric Ton]
(B) AGRICULTURAL LIMESTONE	Ton [Metric Ton]
(C) AGRICULTURAL HYDRATED LIME	Ton [Metric Ton]

SECTION 241
MOWING

241.01 DESCRIPTION

This work consists of mowing or hand-cutting vegetation at locations directed by the Resident Engineer.

241.02 MATERIALS — VACANT

241.03 EQUIPMENT

If possible, use mechanical equipment for mowing operations.

241.04 CONSTRUCTION METHODS

To prevent rutting, mow when the ground can support mowing equipment. Repair damage to the surface at no additional cost to the Department.

Mow directed locations to a height of 3 in to 5 in [75 mm to 125 mm]. Remove litter, debris, and grass clippings to prevent smothering the grass or retarding growth.

In locations inaccessible to mechanical mowers, use hand-cutting methods to provide a uniform appearance.

241.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the area of locations directed by the Resident Engineer and actually mowed.

241.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
MOWING	Acre [Hectare]

CHAPTER 300
BASES

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SECTION 301
GENERAL REQUIREMENTS FOR BASES

301.01 DESCRIPTION

This section consists of the general requirements for the construction of bases.

301.02 MATERIALS

Make necessary preliminary investigations to locate the proposed source of acceptable material. If available, the Contractor may inspect Department-obtained information related to subsurface investigations in accordance with Subsection 102.06, “Examination of Plans, Specifications, Special Provisions, and the Work Site.”

Unless otherwise required by the Contract, provide soils and aggregates with maximum and in-place densities in accordance with Subsection 202.04.A(5), “Compaction of Fill.”

301.03 EQUIPMENT

A. Mixing Equipment

(1) Traveling Plants

Provide single or multiple-pass traveling plants approved by the Resident Engineer. Ensure the traveling plants are capable of pulverizing and mixing the material (identified in the job-mix formula) in accordance with Chapter 300, "Bases," and Chapter 700, "Materials." Mount the plant on wheels or on treads that will not damage the subgrade.

If a single-pass machine is used, ensure it is designed to pick up material from a windrow or blanket and is capable of picking up and mixing the material (separated from the mixing table) during at least half of the mixing cycle.

Ensure the plant has equipment for metering and inserting liquids into the mixture in accordance with the specified mixture or mix design. Repair equipment leaks immediately.

(2) Stationary Plants

Provide stationary plants of the following types:

- Batch mixing, that uses a revolving blade or rotary drum mixer, or
- Continuous mixing.

Proportion all the ingredients in the job-mix formula by weight or volume and provide access to the Resident Engineer to verify the proportions in each batch of a batch mixer, or the rate of flow of a continuous mixer. Set the charge and mixing time in a batch mixer, or the rate of feed to a continuous mixer, to completely mix the materials. Ensure both plant types deliver a uniform mixture.

B. Compactors

Unless otherwise specified, use the following equipment to achieve uniform density across the base or subbase in accordance with Subsection 202.04.A(5), “Compaction of Fill”:

- Non-vibratory steel-wheeled roller,
- Vibratory compactor,
- Pneumatic tired roller,
- Tamping type roller, or
- Any combination of the above equipment.

C. Sprinklers

Ensure sprinklers discharge water uniformly and continuously.

D. Distributors and Supply Tanks

Ensure distributors and supply tanks meet the requirements of Subsection 401.3.A, "Distributors and Supply Tanks."

301.04 CONSTRUCTION METHODS

A. Tolerances

Provide the required subgrade, subbase, and base in accordance with the following:

(1) Surface Elevation and Smoothness

Finish the subgrade, subbase, and base to elevations within ½ in [13 mm] of the elevations shown on the Plans. Ensure the surface smoothness is within ½ in [13 mm] in 10 ft [3 m]. Test for surface smoothness by placing a 10 ft [3 m] straightedge between any two contacts on the finished surface and measuring the distance from the surface to the straightedge.

(2) Width and Thickness

Finish subbases and bases to the minimum width shown on the Plans or directed by the Resident Engineer. Ensure an average job thickness within ¼ in [6 mm] of the thickness shown on the Plans. The Resident Engineer will determine the average job thickness by measuring the completed thickness at intervals of no more than 1,000 ft [300 m] in each driving lane. For individual measurements that exceed the plan thickness by more than ½ in [13 mm], the Resident Engineer will use the Plan thickness plus ½ in [13 mm]. For individual measurements of thickness that measure less than the Plan thickness by more than ½ in [13 mm], the Resident Engineer will require the Contractor to correct the thickness and rework the material.

B. Corrections

Correct material dimensions that exceed the specified tolerance by methods approved by the Resident Engineer, at no additional cost to the Department.

301.05 METHOD OF MEASUREMENT — VACANT

301.06 BASIS OF PAYMENT

The Department will consider the cost of water to be included in the contract unit price for the appropriate existing Base pay item.

SECTION 303
AGGREGATE BASE

303.01 DESCRIPTION

This work consists of providing and placing one or more layers of aggregates, and specified additives, on a prepared subgrade or subbase.

303.02 MATERIALS

Provide aggregate material for the gradation type shown on the Plans (Type A, Type B or Type C) in accordance with Subsection 703.01, "Aggregate for Aggregate Base."

During aggregate production, do not change the approved gradation type or source, unless the Resident Engineer approves another gradation type or source in writing.

303.03 EQUIPMENT — VACANT

303.04 CONSTRUCTION METHODS

A. Preparation of Subgrade

Prepare the subgrade in accordance with Subsection 310.04.B, "Subgrade Method B for All Other Subbases, Bases, Pavement, or Surface," or as required by the Contract.

B. Preparation of Existing Base Course

Prepare existing aggregate base course in accordance with Section 311, “Processing Existing Base and Surface,” or as required by the Contract.

C. Mixing Aggregate Base

Mix or blend materials for aggregate base using a stationary or traveling plant at outside locations approved by the Resident Engineer.

(1) Stationary Plant

Mix the aggregate and water uniformly in an approved central mixing plant (pugmill, rotary drum, or continuous mixer). Add water during the mixing operation to achieve the proper moisture content for compaction in accordance with Subsection 303.04.E, "Shaping and Compaction."

(2) Traveling Plant

Perform the following steps to produce aggregate base using a traveling plant:

- Clean the specified area of vegetation and deleterious materials.
- Overlay the specified area with at least 3 in [75 mm] of base material and compact to achieve a work table for mixing operations.
- Before combining the aggregates required to produce a specified mixture, deliver and place the weighed and properly proportioned materials in measured windrows.
- If the mixing machine requires a blanket of material, spread the windrow to a uniform depth and width consistent with the machine’s capability.

- Add water during the mixing operation to achieve the proper moisture content for compaction in accordance with Subsection 303.04.E, "Shaping and Compaction." Avoid using excess water during mixing and compaction to prevent undue softening of the subgrade.
- Ensure the device used to pick up the material does not contaminate the mixture by cutting into the work table.
- Continue mixing until the aggregate and water are evenly distributed and a uniform mixture is produced, meeting specification requirements.
- During the mixing process, adjust the mixing equipment to prevent material from moving in a longitudinal direction.

D. Spreading

Transport the mixed aggregate base materials to the roadbed and place using an asphalt lay-down machine, unless otherwise approved by the Resident Engineer.

Place aggregate base material in layers of from 4 in to 8 in [100 mm to 200 mm] compacted thickness.

Spread and compact the aggregate base material over the full width of the roadbed before placing a succeeding layer. Finish compacted layers to the grades, elevations, and thicknesses shown on the Plans. Correct segregated areas at no additional cost to the Department. Stagger longitudinal and transverse joints at least 1 ft [0.3 m] in each succeeding layer.

When constructing successive layers of aggregate base, minimize disturbance to the surface of the previously placed layer. Adjust placement procedures or equipment to ensure compliance with the Contract requirements.

E. Shaping and Compaction

Compact each layer to the proper density: no less than 98 percent of maximum density for Type A Aggregate Base and 95 percent for Types B, C, and D Aggregate Base, in accordance with AASHTO T-180, Method D.

Apply water uniformly over the base materials during compaction to ensure a uniform texture, firmly keyed aggregates, and proper consolidation of layers. Prevent damage to aggregate particles during compaction.

Cure the aggregate base material before applying the prime coat. If the density required by the Contract is achieved, the Department will not consider moisture content as an acceptance criterion.

F. Tolerances

Finish the aggregate base in accordance with Subsection 301.04.A, "Tolerances."

303.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the volume of the compacted in-place *Aggregate Base Type A*, *Type B*, and *Type C* by multiplying the completed length of aggregate base by the area of the typical section shown on the Plans.

303.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) AGGREGATE BASE TYPE A	Cubic Yard [Cubic Meter]
(B) AGGREGATE BASE TYPE B	Cubic Yard [Cubic Meter]
(C) AGGREGATE BASE TYPE C	Cubic Yard [Cubic Meter]

SECTION 305
CALICHE BASE

305.01 DESCRIPTION

This work consists of constructing a base of approved deposits of calcareous and siliceous material constructed on the prepared subgrade.

305.02 MATERIALS

Provide materials in accordance with Subsection 703.09, “Caliche Base.”

305.03 EQUIPMENT — VACANT

305.04 CONSTRUCTION METHODS

A. Preparation of Subgrade

Before placing the new subbase and base course material on the roadbed, prepare the subgrade in accordance with Subsection 310.04.B, “Subgrade Method B for All Other Subbases, Bases, Pavement, or Surface,” or as shown on the Plans.

Pulverize the existing surface and base materials and place the materials to establish the new subgrade in accordance with Section 311, “Processing Existing Base and Surface,” or as shown on the Plans.

B. Mixing and Placing

If material is to be combined and blended on the roadbed, deliver weighed material and place it in measured windrows, each in the proper proportions before blending. Do not exceed the amount that can be uniformly mixed by the equipment on the project during one day's operation.

Before mixing is complete, uniformly moisten the mixture for the length of the section being treated to ensure workability and prevent excess wet and dry spots in the finished blend. Avoid using excess water during mixing and placing to prevent undue softening of the subgrade.

C. Spreading

After the Resident Engineer tests and approves the blended windrow, spread the caliche base material uniformly over the length and width of the section. Prevent segregation of the mixture. Ensure that the thickness of each layer of caliche base material does not exceed the compaction equipment’s capability to obtain the specified density.

D. Compaction-Density

Uniformly moisten each layer during compaction and continue rolling to produce a density of at least 100 percent of maximum density, determined in accordance with AASHTO T 99.

E. Tolerances

Finish the caliche base in accordance with Subsection 301.04.A, "Tolerances."

305.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the volume of the compacted in-place *Caliche Base* by multiplying the completed length of caliche base by the area of the typical section shown on the Plans.

305.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
CALICHE BASE	Cubic Yard [Cubic Meter]

SECTION 307
SUBGRADE TREATMENT

307.01 DESCRIPTION

This work consists of providing, placing, and compacting one or more layers of a mixture of soil, chemical additives, and water to achieve a stable subgrade. Chemical additives used to stabilize or modify are defined as cementitious additives (portland cement, fly ash, or cement kiln dust) or lime additives.

On projects where sulfate soils may be present, especially for projects in Field Divisions 4, 5, 6, and 7, determine soluble sulfate content of the soil in accordance with the Department's Materials Division test method OHD L-49. Determine the applicability of subgrade treatment in accordance with OHD L-50 and OHD L-51. Do not perform subgrade treatment if sulfate content exceeds the threshold value specified in OHD L-49, OHD L-50, and OHD L-51.

A. Subgrade Stabilization

Incorporate chemical additives into the subgrade to increase the strength of the subgrade soils and to provide structural value for the pavement structure.

B. Subgrade Modification

Incorporate chemical additives into the subgrade to change the PI of the subgrade soils and improve its workability as a platform to support construction equipment.

307.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Portland Cement	701.02
Water	701.04
Fly Ash	702.01
Cement Kiln Dust	702.03
Hydrated Lime	706.01
Quick Lime	706.02

Store all additives in a building or compartment that will protect them from dampness and allow easy access for inspection and identification of each shipment. Do not mix additives from different sources in storage. Do not mix lime from different sources in storage. Do not use additives that have been contaminated or exposed to moisture.

307.03 EQUIPMENT

Provide subgrade stabilization equipment in accordance with Subsection 301.03, "Equipment."

307.04 CONSTRUCTION METHODS

A. General

Regulate the sequence of subgrade treatment, use the prescribed amount of additive, and maintain the work or rework. Complete a layer of treated material containing a uniform mixture of soil, additive, and water that has the following characteristics:

- No loose or segregated material,
- Uniform density and moisture content,
- Full depth compaction, and
- A smooth surface suitable for placing subsequent courses.

B. Weather Limitations

Apply additives for subgrade stabilization when the air temperature is at least 40 °F [4 °C] and rising. Apply additives for subgrade modification when the air temperature is at least 33 °F [1 °C] and rising. Measure the air temperature at a location 4 ft [1.2 m] above the ground, in the shade, and away from artificial heat.

Do not apply additives if the ground is frozen. Protect the quality of the additive and treated subgrade from the weather.

C. Preparation of Existing Roadbed

Before beginning any subgrade treatment, shape and compact the roadbed to the dimensions and elevations shown on the Plans or directed by the Resident Engineer. Roll the subgrade and correct soft areas revealed by this rolling, as approved by the Resident Engineer.

D. Scarifying and Loosening

If directed by the Resident Engineer, scarify and loosen the subgrade material before applying the additive. Scarify and loosen a length of roadway on which the

additive application and mixing can be completed in one day. Avoid loosening the subgrade material below the depth of specified additive treatment.

The Resident Engineer may waive portions of the work if excessive rock is encountered. Excessive rock is defined as subgrade material consisting of at least 25 percent particles with a dimension greater than 2½ in [63 mm]. Perform exploratory scarifying directed by the Resident Engineer to make an excessive rock determination.

E. Application

Base the additive type and final application rates on classification tests of the subgrade soil. The Department will perform the classification tests. If approved by the Resident Engineer, the Contractor may have tests performed by a Department-approved laboratory at no additional cost to the Department. Apply the additive at a rate prescribed by the Department's Materials Division procedures for stabilization (OHD L-50) or modification (OHD L-51). If available, a copy of a soils report may be obtained from the Department's Office Engineer Division before the Bid Opening. The soils report consists of soil classification data and is for estimating purposes only. Refer to the Department's Materials Division Website for the most current OHD procedures.

To propose the substitution of a cementitious additive not shown on the Plans, submit a proposal to the Resident Engineer for approval. In the proposal, include the following:

- The test results performed by a Department-approved laboratory;
- The recommended application rates; and
- The cost comparison of the planned and proposed additives.

Do not substitute additives before the Resident Engineer approves the requested substitution.

Provide equipment to control the additive application rate. If the classification of subgrade soil changes, establish a new application rate in accordance with the Department’s Division procedures for soil stabilization (OHD L-50) or modification (OHD L-51) before applying the additive.

(1)Application of Cementitious Additive

Use dry methods of application for placing the cementitious additive on the subgrade. Use approved types of spreading equipment that can distribute the cementitious additive uniformly.

Do not apply cementitious additive using the slurry method. Do not allow the additive to become wet before mixing, and do not place on a wet subgrade.

Do not apply cementitious additives if wind blows the additive off the subgrade work area. Replace lost additive at no additional cost to the Department. Complete on the same day mixing, compacting, and finishing subgrade areas where additives are placed. Remove additive exposed to moisture and replace before completion of the first mixing operation, at no additional cost to the Department.

For subgrades requiring soil modification, before applying the cementitious additive, pretreat with lime at the rate prescribed in the Materials Division policy for soil modification in accordance with Subsection 307.04.E.2, “Application of Lime.”

(2) Application of Lime Additive

Do not apply lime if wind blows the lime additive off the subgrade work area. Use approved types of spreading equipment that can distribute the lime additive uniformly.

Place the lime on an area of subgrade where the first mixing operations can be completed on the same day. Do not expose the lime additive to open air for more than six hours.

(a) Dry Method

1) Quick Lime

For quick lime, use Department-approved equipment that uniformly distributes controlled amounts.

2) Hydrated Lime

Use bagged hydrated lime for dry-method application as approved by the Resident Engineer only under unusual circumstances or when it would be impossible or impractical to use other methods. Meet all applicable Federal, State, and local laws. Ensure that the bagged lime indicates the manufacturer's certified weight.

(b) Slurry Method

Do not use compressed air in any of the slurry mixing methods. Mix lime with water into a slurry using one of the following methods that will maintain the lime and water slurry in a uniform mixture until spread:

1) Central Plant

Meet mixing requirements using integral paddles, recirculating pumps, or other devices. Equip the slurry distributor truck with a recirculating pump or agitator that can keep the lime and water in a uniform mixture until spread.

2) Transit Mix

Using a Department-approved method, weigh or meter the lime from the storage bin into the tank transit mix truck. Equip the tank transit mix truck with a recirculating pump or agitator that can maintain a uniform mixing of lime and water while in transit.

Equip the distributor truck with a pump. Apply the slurry through spray bars under pressure to assure a uniform flow and distribution. Ensure that the slurry mixture meets the following:

- At least 1 ton [0.9 tonne] of lime to 500 gal [1,893 L] of water, and
- A maximum of 40 percent lime.

F. Mixing

Spread the additive, and mix with the subgrade continuously. Unless otherwise approved by the Resident Engineer, complete the mixing operation during the same day that the additive is applied. Before field mixing determine the optimum moisture content for maximum density of the compacted soil-additive mixture in accordance with AASHTO T-99. To account for moisture loss during the mixing process, increase the moisture content by from 2 percentage points to 5 percentage points above the optimum moisture content for the mixture.

Use a pulver mixer equipped with a spray bar in the mixing chamber and capable of producing a soil-additive mixture with a moisture content within the specified range. Use a Department-approved mixing procedure that using traveling mixing equipment that uniformly disperses the additive and water through the soil.

(1)Mixing for Cementitious Additive Treatment

Reduce the size of the soil-additive mixture to meet the following gradation requirements:

Table 307:1
Soil-Additive Mixture Gradation

Sieve Size	Percent Passing
1½ in [37.5 mm]	100
¾ in [19.0 mm]	≥50

In a single mixing, achieve the gradation and moisture content requirements to the depths specified on the Plans. The Department will not pay for the second use of a pulver mixer if the Resident Engineer determines that the gradation or moisture content do not meet requirements. Modify the work process to meet the above requirements in a single mixing if directed by the Resident Engineer.

The Contractor shall provide, but the Department will not pay for, additional cementitious additive and re-pulverization to the correct moisture content of any portion of the work area that the additive has hydrated before compaction, unless waived by the Resident Engineer.

(2)Mixing for Lime Treatment

(a)First Mixing

Mix the soil, lime, and water to achieve a uniform mixture of material with a maximum diameter of 1½ in [37.5 mm]. Add water in the first mixing process to ensure proper chemical reaction between the lime and soil. Allow the mixture to cure. When using hydrated lime, allow a curing time of 72 h at temperatures above 40 °F [4 °C]. When using quick lime, allow a curing time of 48 h at temperatures above 40 °F [4 °C].

The Resident Engineer may extend the cure time if the temperature falls below 40 °F [4 °C] during the curing period. The Department does not require cure time extensions for modification or lime pretreatment.

Maintain the materials in a moist condition during the curing period. Seal the surface of the treated area by lightly rolling the surface to repel water and contain moisture. If directed by the Resident Engineer, rescarify portions of the treatment area and provide additional sprinkling to ensure proper moisture.

(b)Quick Lime Mixing

Minimize harmful exposure of workers to the heat of hydration. Use Department-approved means to turn under a significant portion of the quick lime within 2 h after spreading and before adding water. To initiate hydration, add sufficient water within 6 h after spreading.

CAUTION: Uncovered quick lime in the presence of moisture may be hazardous to worker.

(c) Final Mixing

After the specified curing time, use Department-approved methods to mix the material uniformly. Ensure the soil-lime mixture meets the following requirements (tested in a dry condition):

Table 307:1
Soil-Additive Mixture Gradation

Sieve Size	Percent Passing
1½ in [37.5 mm]	100
No. 4 [4.75 mm]	60 minimum

(3) Mixing for Lime Pretreatment

Provide the first lime mixing in accordance with Subsection 307.04.F.(2)(a), "First Mixing."

(4) Mixing for Depths of At Least 8 in [200 mm] Compacted Thickness

No treated layer shall exceed 8 in [200 mm] in depth. For cut sections deeper than 8 in [200 mm], remove material above the bottom 8 in [200 mm] to treat the bottom layer.

During normal fill construction, add and mix the specified amount of treatment additive to each 8 in [200 mm] layer. Complete the fill construction as shown on the Plans.

The Resident Engineer may approve the use of special equipment or methods to vary the mixing depths.

(5) Mixing for Excessive Rock Areas

In two separate stages, pulverize and mix excessive rock areas as directed by the Resident Engineer. The Resident Engineer may waive the particle size requirement.

G. Compaction

(1) General

Compact the soil-additive mixture immediately after final mixing. Complete compaction on the same day as the mixing.

Sprinkle and roll the soil-additive mixture. Scarify, reshape, sprinkle, and re-compact with rolling to immediately correct all irregularities, depressions, or weak spots.

(2) Moisture-Density Requirements

Compact before an appreciable loss of mixing moisture occurs. Ensure compaction within 2 percentage points of optimum moisture content for the mixture. The Resident Engineer may authorize changes or adjustments in the moisture requirements.

Before beginning compaction, conduct moisture-density tests on roadway samples to verify the target density for the soil-additive mixture. Use the AASHTO T99 test method modified to provide one compacted specimen of the mixture.

Uniformly compact the depth of the soil-additive mixture to at least 95 percent of target density. Determine field density in accordance with AASHTO T 310 or Subsection 202.04.A(5), "Compaction of Fill."

(3) Excessive Rock

The Resident Engineer may adjust the requirements for soil-additive mixture uniformity, target density, and optimum moisture in excessive rock areas. Provide substantial compliance to the specification requirements in these areas, as approved by the Resident Engineer. The Resident Engineer may waive the density and moisture content requirements and approve compaction by visual observation.

H. Finishing and Curing

Compact the final layer of the treated subgrade to the lines, grades, and typical sections shown on the Plans. Finish the completed section with a light roller to prevent hairline cracks. Sprinkle the treated subgrade to maintain the moisture content until placing a prime coat seal or succeeding layer.

Avoid placing construction loads or operating equipment until the treated subgrade has cured and can withstand the loads without damaging the subgrade. If the subgrade deforms under the construction loads and cannot return back to its original condition, or if it deflects more than 1 in [25 mm], allow the subgrade additional curing time before operating equipment on the subgrade.

The Department will not pay for the replacement and refinishing the treated subgrade if the material loses the required stability, density, or finish before the next course is placed.

I. Tolerance

Finish the treated subgrade in accordance with Subsection 301.04.A, "Tolerances."

After completing the final grade, use a color-sensitive indicator solution, such as phenolphthalein or thymol blue, to measure the thickness and uniformity of the compacted soil and chemical mixture in accordance with Subsection 301.04.A(2), "Width and Thickness." Apply the indicator solution along the side of a small hole excavated to the required depth of chemical treatment and note the depth and uniformity of the color change.

307.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the area of completed in-place Cementitious Stabilized Subgrade, Cementitious Modified Subgrade, Lime Pretreatment, Lime Stabilized Subgrade, Lime Modified Subgrade, Modified Subgrade, and Stabilized Subgrade.

307.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) FLY ASH	Ton [Metric Ton]
(B) CEMENT KILN DUST	Ton [Metric Ton]
(C) PORTLAND CEMENT	Ton [Metric Ton]
(D) LIME	Ton [Metric Ton]

Pay Item:	**Pay Unit:**
(E) CEMENTITIOUS STABILIZED SUBGRADE	Square Yard [Square Meter]
(F) CEMENTITIOUS MODIFIED SUBGRADE	Square Yard [Square Meter]
(G) LIME PRETREATMENT	Square Yard [Square Meter]
(H) LIME STABILIZED SUBGRADE	Square Yard [Square Meter]
(I) LIME MODIFIED SUBGRADE	Square Yard [Square Meter]
(J) MODIFIED SUBGRADE	Square Yard [Square Meter]
(K) STABILIZED SUBGRADE	Square Yard [Square Meter]

The Department will not pay for lime exposed to open air for more than six hours, or for lime lost due to excessive washing or blowing.

If *Selective Subgrade Topping* is a separate pay item, the Department will consider the cost of cementitious or lime additives to be included in the contract unit price for the relevant subgrade modification or stabilization pay item.

The Department will pay for quick lime based on a 90 percent available lime index (using the rapid sugar method in accordance with ASTM C-25) and will calculate payments as a percent of CaO by weight.

The Department will pay for hydrated lime based on a 90 percent available lime index (using the rapid sugar method in accordance with ASTM C-25) and will calculate payments as percent $Ca(OH)^2$ by weight.

If the available lime index for quick lime or hydrated lime falls below 90 percent, the Department will reduce the payment by 1 percent of the lime contract unit price for each 1 percent from 90 percent to 80 percent.

If the available lime index falls below 80 percent, the Department will not pay for the additional lime necessary to bring the available lime index to 90 percent.

The Department will consider the cost of excavating layers deeper that 8 in to be included in the contract unit price for the relevant subgrade modification or stabilization pay item.

The Department will consider the cost of water and rolling to be included in the contract unit price for the relevant subgrade treatment pay item.

The Department will pay for *Prime Coat* in accordance with Section 408, "Prime Coat."

The Department will consider the cost of chemical additives, at the specified rate for the appropriate soil classification in accordance with OHD L-51, to be included in the contract unit price for *Modified Subgrade*.

The Department will consider the cost of chemical additives, at the rate specified for the appropriate soil classification in accordance with OHD L-50, to be included in the contract unit price for *Stabilized Subgrade*.

If a separate pay item for *Selective Subgrade Topping* exists, the Department will consider the cost of cementitious and lime additives to be included in the contract unit price for *Cementitious Stabilized Subgrade, Cementitious Modified Subgrade, Lime Stabilized Subgrade,* or *Lime Modified Subgrade.*

SECTION 310
SUBGRADE

310.01 DESCRIPTION

This work consists of preparing the existing materials for the immediate construction of subbase, base, pavement, or surface.

310.02 MATERIALS — VACANT

310.03 EQUIPMENT — VACANT

310.04 CONSTRUCTION METHODS

A. Subgrade Method A for Traffic-Bound Surface Course

Shape and crown the width of the existing roadbed with a blade grader to the grade shown on the Plans. Complete the cross section to at least a 2 percent crown or as directed by the Resident Engineer.

Remove unstable soil and exposed rocks larger than 3 in [75 mm], and replace with acceptable material. Finish each subgrade layer to a smooth, uniform surface and maintain this condition until placement of the succeeding layer.

B. Subgrade Method B for All Other Subbases, Bases, Pavement, or Surface

Scarify or process the subgrade to create uniform moisture to a depth of 8 in [200 mm].

In rock cuts that cannot be scarified or otherwise processed, shape the subgrade with material in accordance with Subsection 202.02.B, “Selective Subgrade Topping”, or as directed by the Resident Engineer.

Pulverize the loosened soil and compact the top 8 in [200 mm] uniformly to a maximum density of at least 95 percent in accordance with Subsection 202.04.A(5), “Compaction of Fill.”

Unless approved by the Resident Engineer, provide subgrade material with moisture content within 2 percentage points of optimum, in accordance with AASHTO T 99. Use mechanical tampers to compact sections of the subgrade inaccessible to rolling equipment.

Finish the subgrade in accordance with Subsection 301.04.A, "Tolerances." Test the subgrade to ensure it meets the Contract requirements and correct deficiencies before placing the succeeding course.

Excavate unstable material below the top 12 in [300 mm] of the subgrade and backfill with acceptable material to the subgrade elevation in accordance with Subsection 202.04, “Construction Methods,” and as approved by the Resident Engineer.

Remove and replace unstable material in fill areas at no additional cost to the Department.

Correct or remove and aerate unstable material due to excess moisture in the top 12 in [300 mm] of the subgrade at no additional cost to the Department.

310.05 METHOD OF MEASUREMENT — VACANT

310.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) SUBGRADE METHOD A	Square Yard [Square Meter]
(B) SUBGRADE METHOD B	Square Yard [Square Meter]

The Department will pay for this pay item once for work performed on the subgrade as defined in Subsection 101.02, "Definitions," regardless of the work necessary to stabilize the subgrade as all subbases or base courses are placed on the subgrade.

If excavation (beyond machine drifting) is necessary to complete the subgrade to the elevations shown on the Plans, the Department will pay for this work as the appropriate earthwork pay items in accordance with Section 202, "Earthwork." The Department will pay for additional material needed to finish the subgrade to the elevations shown on the Plans as the appropriate earthwork pay items in accordance with Section 202, "Earthwork."

SECTION 311
PROCESSING EXISTING BASE AND SURFACE

311.01 DESCRIPTION

This work consists of removing, processing, reusing, or disposing of existing aggregate surface course, base course, or asphalt surface.

311.02 MATERIALS — VACANT

311.03 EQUIPMENT — VACANT

311.04 CONSTRUCTION METHODS

Loosen or scarify the aggregate or other material to its full depth and width. Break aggregate or asphalt into pieces that will pass a 3 in [75 mm] sieve. Place the materials in windrows on the subgrade or shoulder. Avoid contamination of base or surface material due to excess soil or other foreign material. The Department will not pay for the costs of reworking damaged or contaminated material.

Compact processed material used for base courses, shoulders, and drives in Method B, Method C, and Method D to at least 95 percent of maximum density in accordance with AASHTO T 99.

A. Method A—For Salvage and Stockpiling

Prepare storage area by removing grass, weeds, and other waste before stockpiling material. Avoid the addition of excess amounts of soil or other foreign material which would render it unusable. Load and haul the processed material to storage locations shown on the Plans.

B. Method B—For Use in Subgrade

Place processed material in windrows on the shoulder during shaping and conditioning the subgrade. After completing the subgrade, spread the processed material uniformly over the width of the section and compact with the subgrade.

C. Method C—For Use as Subbase

Spread the processed material evenly on the previously shaped, conditioned, and compacted subgrade and compact.

D. Method D—For Use in New Base Courses, Shoulders, or Drives

Place the processed material on the completed subgrade as a base course, shoulder, or drive, or blend uniformly with new material for any course. Obtain approval by the Resident Engineer before using processed material.

311.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Processing Existing Base and Surface, Method A, Method B, Method C,* and *Method D* along the centerline to the nearest foot [meter].

311.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) PROCESSING EXISTING BASE AND SURFACE, METHOD A	Linear Foot [Meter]
(B) PROCESSING EXISTING BASE AND SURFACE, METHOD B	Linear Foot [Meter]
(C) PROCESSING EXISTING BASE AND SURFACE, METHOD C	Linear Foot [Meter]
(D) PROCESSING EXISTING BASE AND SURFACE, METHOD D	Linear Foot [Meter]

SECTION 317
CEMENT TREATED BASE

317.01 DESCRIPTION

This work consists of constructing a cement-treated base (CTB) using a soil, aggregate, and cement mixture.

317.02 MATERIALS

Provide material in accordance with the following subsections:

Material:	Subsection:
Portland Cement	701.02
Water	701.04
Fly Ash	702.01
Curing Agents	701.07.D
Aggregates	703.02

Provide a separator fabric in accordance with Section 712.05, "Geotextiles for Bases" except ensure the fabric meets the requirements of AASHTO M288, Class 1 and weighs at least 15 oz/yd² [500 g/m²].

317.03 EQUIPMENT

Use equipment for producing and placing the CTB in accordance with Subsection 301.03, "Equipment," except, only use stationary plants and equipment that combines placement and initial compaction.

317.04 CONSTRUCTION METHODS

A. Mix Design and Proportioning

Submit the mix design, in accordance with OHD L-53, to the Materials Engineer for approval before placing the CTB.

Submit to the Resident Engineer a single-point gradation for the combined aggregates with a plus and minus tolerance for each sieve.

Ensure cementitious materials consist of at least 75 percent portland cement, and no more than 25 percent fly ash.

Test the compressive strength in accordance with OHD L-53.

B. Placement

Before spreading the CTB, moisten the surface of the compacted subgrade unless the subgrade has been primed. Finish and compact the CTB to produce a smooth, dense surface that is free of surface compaction planes, cracks, ridges, or loose material.

Compact the CTB within 2 hr of adding water to the aggregate and cement. Follow the recommendations of the mix design. Compact the CTB to at least 95 percent of the maximum density and test in accordance with OHD L-53. Place the CTB in a single layer. Ensure the compacted thickness is from 4 in to 6 in [100 mm to 150 mm]. After strike off and consolidation, finish the CTB to meet the required elevation, cross section, and smooth surface finish. Use equipment that automatically controls both grade and line to trim the surface of the CTB.

Keep the CTB surface moist during finishing operations and until the application of the curing agent. Apply a curing agent on the finished CTB surface at the rate of at least 1 gal per 150 ft^2 [4 L per 14 m^2].

Use butt or sawed longitudinal construction joints; those between driving lanes shall match the longitudinal joint of overlying pavement. Place other longitudinal joints within 3 ft [1 m] of the longitudinal joint of the overlying pavement and construct transverse joints as butt joints. Before placing the overlying pavement, sweep the CTB surface. Place and secure the separator fabric onto the surface of the CTB in such a manner that the fabric remains free of wrinkles and cracks. Overlap the fabric 8 in [20 cm].

Limit construction traffic on the CTB to that necessary to apply asphalt cement, fabric, and overlying pavement. Do not use the CTB layer as a haul road. Allow only concrete delivery trucks necessary to deposit fresh concrete directly in front of the paver. Place overlying pavement on the base after compressive strengths reach at least 600 psi [4,150 kPa] in accordance with OHD L-53. Repair damage to the CTB at no additional cost to the Department.

C. Weather Limitations

If the aggregate or subgrade is frozen or the ambient air temperature in the shade is 40 °F [5 °C] and rising, do not mix CTB. Protect CTB from freezing for 7 days after placement.

D. Tolerances

Finish the CTB in accordance with Subsection 301.04.A, “Tolerances.”

317.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the surface area of the completed *Cement Treated Base* placed at the thickness shown on the Plans.

317.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
CEMENT TREATED BASE	Square Yard [Square Meter]

The Department will consider the cost of paving fabric and asphalt cement to be included in the contract unit price for *Cement Treated Base*.

SECTION 318
ECONOCRETE BASE

318.01 DESCRIPTION

This work consists of the construction of an econocrete base.

318.02 MATERIALS

Provide material in accordance with the following subsections:

Material:	Subsection:
Aggregate	703.02
Portland Cement	701.02
Water	701.04
Air Entraining Agent	701.03
Fly Ash	702.01
Chemical Admixtures	701.03
Curing Agents	701.07

318.03 EQUIPMENT

Use equipment for producing and placing the econocrete base in accordance with Subsection 414.03, “Equipment.”

318.04 CONSTRUCTION METHODS

Use the absolute volume method for a cubic yard [cubic meter] to design the econocrete base mix proportions. Identify the following in the design:

- The source of each material,
- The proportion of each material,
- The properties of the mixture, and
- The compressive strength of the mix at 28 days.

Submit the mix design to the Resident Engineer for approval at least 40 days before placing the econocrete base. Ensure the mix design meets the following criteria:

- The mix requires a cement content of at least 200 lb/yd³ [118 kg/m³]. The Contractor may substitute up to 25 percent of the cement content with fly ash at a ratio of 1 lb [1.0 kg] of fly ash per 1 lb [1.0 kg] of cement. Do not use fly ash from November 1 through April 1.

- The mix produces a maximum slump of 3 in [75 mm].
- The mix produces an air content of from 4 to 12 percent.
- The mix produces a compressive strength at 28 days of at least 1,200 psi [8,300 kPa]; determine the compressive strength by testing six cylinders in accordance with Subsection 701.01.D, "Tests and Samples."

Construct the econocrete base in accordance with Subsection 414.04, “Construction Methods,” with the following exceptions:

- After strike off and consolidation, finish to the elevation and cross section shown on the Plans, and to create a smooth surface finish.
- Do not place longitudinal or transverse joints in the econocrete base except for butt joints used for construction joints.

Apply a curing agent at a rate of at least 1 gal per 150 ft² [1 L per 3.75 m²] of econocrete base and allow it to cure for 7 days. A curing day is a period of 24 hr during which the ambient air temperature remains at least 40 °F [4 °C]. Begin the curing time count when the econocrete base construction is complete for the day and after the curing agent is applied.

The Department will not allow construction traffic or the placement of overlying pavements on the econocrete base until the unconfined compressive strengths of test cylinders made during the base placement reach at least 500 psi [3,500 kPa]. Limit construction traffic on the base; do not use as a haul road. Repair damage to the base at no additional cost to the Department.

From 12 hr to 48 hr before placing reinforcing steel for the overlying pavement, sweep the econocrete base and make a second application of curing agent at a rate of at least 1 gal per 100 ft² [1 L per 2.5 m²]. Do not allow traffic on the econocrete base after the second application of curing agent.

Finish the econocrete base in accordance with Subsection 301.04.A, “Tolerances.”

318.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the surface area of completed *Econocrete Base* placed at the thickness shown on the Plans.

318.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
ECONOCRETE BASE	Square Yard [Square Meter]

SECTION 319
OPEN-GRADED BASES

319.01 DESCRIPTION

This work consists of constructing a permeable base course, which includes the following:

- Mixing aggregate and bituminous material or aggregate, portland cement concrete, and water in a central plant, and
- Spreading and compacting the mixture on a prepared surface.

319.02 MATERIALS

Provide materials in accordance with Section 708, “Plant Mix Bituminous Bases and Surfaces,” and the following subsections:

Material:	Subsection:
Aggregate	703.03
Water	701.04
Fly Ash	702.01
Portland Cement	701.02

319.03 EQUIPMENT

Use equipment for producing, heating, mixing, hauling, spreading, compacting, and finishing the Open-Graded Bituminous Base (OGBB) in accordance with Subsection 411.03, “Equipment.”

Use equipment for producing, mixing, hauling, spreading, compacting, and finishing the Open-Graded Portland Cement Concrete Base (OGPCCB) in accordance with Subsection 301.03, “Equipment,” and Subsection 414.03, “Equipment.”

319.04 CONSTRUCTION METHODS

A. General

(1) Prime Coat

If required by the Contract, apply a prime coat in accordance with Section 408, "Prime Coat."

(2) Tolerances

Finish open-graded bases in accordance with Subsection 301.04.A, “Tolerances.”

(3) Hydraulic Efficiency

Construct and maintain a hydraulically efficient open-graded base. Perform a hydraulic efficiency test 24 hr before placing the overlying pavement. Do not place overlying pavement until achieving acceptable hydraulic efficiency, defined as 1 qt [1 L] of water absorbed into the base surface with no remaining standing water 15 sec after pouring. Remove and replace open-graded base that fails to achieve acceptable hydraulic efficiency as directed by the Resident Engineer, at no additional cost to the Department.

Ensure that soil, mud, or other materials are not tracked, spilled, or washed onto the open-graded base. Repair damage to the open-graded base as approved by the Resident Engineer, at no additional cost to the Department.

B. Open-Graded Bituminous Base (OGBB)

Construct OGBB in accordance with Subsection 406.04, “Construction Methods,” with the following exceptions:

(1) Weather Limitations

Construct OGBB in accordance with Subsection 411.04.H, "Temperature and Weather Limitations."

(2) Construction Traffic

Do not allow construction traffic on the OGBB until the OGBB has cooled overnight and do not place overlying pavement on the OGBB until the curing period is complete. Limit construction traffic on the OGBB; do not use OGBB as a haul road. Repair damage as approved by the Resident Engineer, at no additional cost to the Department.

C. Open-Graded Portland Cement Concrete Base (OGPCCB)

Ensure the following construction requirements are met:

- The mix has a cement content of at least 240 lb/yd³ [142 kg/m³].
- Limit fly ash substitution to no more than 28 percent of the required cement, maintaining a substitution ratio of 1 lb [1 kg] of fly ash per 1 lb [1 kg] of cement.
- The water to cement ratio is no greater than 0.45, calculated using the following equation:

$$W/C = W/(C+F)$$

where

W/C = Water to cement ratio,
W = Weight of water (measure the amount of water mixed into the batch, plus the free water on wet aggregate, minus the water absorbed by dry aggregate),
C = Weight of cement, and
F = Weight of fly ash.

The Resident Engineer will review and approve the water to cement ratio calculation.

(1) Mixing and Placing

Mix and place OGPCCB in accordance with Subsection 414.04.C, "Mixing Concrete," Subsection 414.04.E, "Setting Forms," and Subsection 414.04.F, "Placing Concrete."

(2) Weather Limitations and Maintenance Quality

Do not mix OGPCCB if the aggregate or subgrade is frozen. Mix and place OGPCCB when the ambient air temperature is at least 40 °F [5 °C] and rising.

Protect and maintain the quality of the base after its placement and approval by the Resident Engineer. Ensure repairs yield a uniform and durable surface; replace

low areas and other flaws for the full depth of the base. Maintain and repair the OGPCCB at no additional cost to the Department.

(3) Base

Ensure the subgrade is uniformly moist at the time of the OGPCCB placement.

(4) Consolidation of Mixture

Consolidate the mixture using vibratory equipment during lay-down operations to achieve at least 95 percent of maximum density as determined in accordance with AASHTO T 121. Measure the consolidation of the finished OGPCCB from 15 min to 30 min after placement and consolidation using a nuclear density gauge in accordance with AASHTO T 310.

(5) Water Curing

Cure the completed OGPCCB by directing a fine spray of water onto the surface every 2 hr, for a period of 16 hr. Begin curing immediately after its initial set, when water no longer removes cement paste.

(6) Construction Joint

Prepare construction joints in the OGPCCB by cutting back the edge of the base to create a vertical face. Replace material removed to create the construction joint, at no additional cost to the Department.

(7) Traffic Restrictions and Curing Period

Do not allow construction traffic on the OGPCCB, except the paver.

Ensure the 3-day curing period is complete before placing pavement layers on top of the OGPCCB. Place material for succeeding layers using the side discharge method.

319.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the area of in-place *Open-Graded Bituminous Base* and *Open-Graded Portland Cement Concrete Base* completed to the thicknesses shown on the Plans.

319.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) OPEN-GRADED BITUMINOUS BASE	Square Yard [Square Meter]
(B) OPEN-GRADED PORTLAND CEMENT CONCRETE BASE	Square Yard [Square Meter]

The Department will pay for *Prime Coat* in accordance with Section 408, "Prime Coat."

SECTION 325
SEPARATOR FABRIC FOR BASES

325.01 DESCRIPTION

This work consists of installing a separator fabric for bases.

325.02 MATERIALS

Provide separator fabric in accordance with Subsection 712.05, "Geotextiles for Bases."

325.03 EQUIPMENT — VACANT

325.04 CONSTRUCTION METHODS

A. Shipping and Storage

Provide separator fabric in wrapper that will protect the fabric from ultraviolet radiation and abrasion from shipping and handling. Label each roll to identify each product for inventory and quality control. In the field, store and protect the fabric rolls from the elements.

B. Installation

Before placing fabric, ensure the subgrade is smooth and free of obstructions that may damage the fabric.

Place the fabric smooth, straight, and free of wrinkles at the locations shown on the Plans. Overlap each transverse joint of fabric (between rolls) with the end of the preceding role placed above the beginning of the succeeding role at least 17 in [430 mm]. Place and cover the fabric with base material on the same day. Apply at least 4 in [100 mm] of base material by end dumping. Fill and compact ruts in the base material.

Repair damaged fabric in sections that meet the specified overlap requirements, at no additional cost to the Department.

C. Weather Limitations

If wind disturbs the fabric, secure it with large nails and washers, or with base material.

325.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the area covered by *Separator Fabric* after placement, not including overlaps.

325.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
SEPARATOR FABRIC	Square Yard [Square Meter]

SECTION 326
GEOSYNTHETIC REINFORCEMENT

326.01 DESCRIPTION

This work consists of installing geosynthetic reinforcement material beneath the aggregate base layer in the pavement structure, or beneath the roadway embankment. This includes the use of geogrids and geotextiles. Geotextile is made of synthetic fibers manufactured in a woven or loose nonwoven manner to form a blanket-like product used to reinforce soil and rock. Geogrid is a continuous sheet of net-shaped synthetic material formed by tensile elements that reinforce soil and rock by interlocking.

326.02 MATERIALS

Use geosynthetic reinforcement that is an integrally-formed single layer structure.

Provide geogrids in accordance with Subsection 712.07, "Geogrid Subgrade Reinforcement of Pavement Structures."

Provide geotextiles in accordance with AASHTO M 288 for Class 1 geotextiles.

326.03 EQUIPMENT — VACANT

326.04 CONSTRUCTION METHODS

A. General

Label each roll with product identification for inventory and quality control. In the field, protect geosynthetic rolls from the following:

- Site construction damage,
- Ultraviolet radiation (including sunlight for more than 24 hr),
- Strong acids,
- Strong bases,
- Flames,
- Sparks,
- Temperatures above 160 °F [70 °C], and
- Other environmental conditions harmful to the geosynthetic.

If storing the geosynthetics outdoors, elevate the rolls above the ground surface and protect them with an opaque, waterproof cover.

On the first full day of geosynthetic installation, ensure the geosynthetic manufacturer or a representative is present to observe and advise.

Before placing the geosynthetic, clear the site of topsoil, trees, stumps, rocks, and large debris in accordance with Section 201, "Clearing and Grubbing." Place the geosynthetic in the direction of the fill operation. Tension the geosynthetic by hand and secure to the ground as directed by the Resident Engineer. Anchor the geosynthetic to the ground so that wrinkles formed during fill or aggregate placement unfold freely as additional fill is placed. Ensure the overlapping sections of the geosynthetic do not separate during the placement of fill.

Cut the geosynthetic and overlap diagonally to accommodate curves in the alignment and to prevent excessive wrinkling. Secure overlap areas with small piles

of aggregate fill, pins with washers, or large, heavy-gauge staples driven securely into the subgrade.

Do not operate tracked construction equipment directly on the geosynthetic. Place a layer of fill with a thickness of at least 8 in [200 mm] over the geosynthetic before operating tracked vehicles on the geosynthetic.

Operate rubber-tired equipment over the geosynthetic at speeds no greater than 5 mph [8 km/h] if the underlying subgrade can support the loads without rutting, and the tires do not damage or wrinkle the geosynthetic. Avoid sudden braking or sharp turning when operating equipment on the geosynthetic.

(1) Placement in the Pavement Section

After clearing the site, grade and smooth with a non-vibratory, steel-wheeled roller to achieve a firm, level working surface.

Place the geosynthetic at the elevation and alignment shown on the Plans and parallel to the centerline of the roadway. Unroll the geosynthetic in the direction of the fill operation. Do not place geosynthetic more than 500 ft [152 m] ahead of the aggregate base placement.

End-dump the aggregate base material directly onto the geosynthetic or on the previously placed aggregate base. Blade the aggregate base material onto the geosynthetic so that the aggregate base rolls onto the material ahead (e.g. by gradually raising a dozer blade while moving forward).

Fill ruts in the aggregate base with additional aggregate base material; do not blade adjacent material to fill ruts.

Place at least 8 in [200 mm] of aggregate base material over the geosynthetic.

(2) Placement under Roadway Embankment

After clearing the site, end dump fill material onto the geosynthetic or on the previously placed fill. Blade the fill material onto the geosynthetic so that the fill rolls onto the material ahead (e.g. by gradually raising a dozer blade while moving forward).

Place at least 8 in [200 mm] fill material over the geosynthetic.

B. Geotextile

Place geotextile in accordance with Subsection 325.04, “Construction Methods.” If placing geotextile rolls side-by-side or end-to-end, overlap, sew, or join the edges in accordance with AASHTO M 288, Appendix A3, and Table 8. Ensure sewn seams are in accordance with AASHTO M 288, Appendix A1.

C. Geogrid

Place the geogrid at the locations shown on the Plans or as directed by the Resident Engineer. Keep the geogrid smooth and taut while placing the cover material and ensure that stakes or anchors do not restrict the movement of the geogrid. Ensure the geogrid sections do not separate at overlaps during placement of cover material. If placed at curves, cut the geogrid and overlap diagonally to prevent buckling.

(1) Overlap

Overlap geogrid rolls by placing the end of the roll to be covered first over the end of the succeeding roll. Overlap adjacent rolls of geogrid 3 ft [0.3 m] in each

direction tie adjacent rolls with hog rings or cable ties at intervals of 5 ft [1.5 m]. Secure the geogrid corners with fill material.

(2) Placement of Fill

Do not operate equipment directly on geogrid placed on soft ground.

For normal soil conditions, dump fill directly onto the geogrid. For softer soil conditions, dump fill on previously placed fill that will bear the weight of the fill material and push the fill over the geogrid. When placing fill on the subgrade, work from areas of stronger soil conditions to areas of weaker soil conditions. For very soft soil conditions, use a lightweight, low ground-pressure dozer to place fill as directed by the Resident Engineer.

For most soil conditions, compact with a light roller and add moisture. For very soft soil conditions, use static rather than vibratory compaction. If rutting or severe pumping occurs under equipment, add fill to strengthen the section.

326.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the area of completed *Geotextile Reinforcement* and *Geogrid Reinforcement*, not including overlaps.

326.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) GEOTEXTILE REINFORCEMENT	Square Yard [Square Meter]
(B) GEOGRID REINFORCEMENT	Square Yard [Square Meter]

The Department will consider the cost of preparing, grading, and rolling the site to be included in the contract unit price for *Geotextile Reinforcement* and *Geogrid Reinforcement*.

The Department will pay for aggregate as *Aggregate Base Type A*, *Type B*, and *Type C* in accordance with Section 303, “Aggregate Base.”

CHAPTER 400
GENERAL REQUIREMENTS FOR SURFACES

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SECTION 401
GENERAL REQUIREMENTS FOR SURFACES

401.01 DESCRIPTION

This work consists of all types of surface construction.

401.02 MATERIALS

Provide materials for surface construction in accordance with the relevant section or sections of Chapter 700, "Materials."

401.03 EQUIPMENT

A. Distributors and Supply Tanks

Provide distributors and supply tanks capable of uniformly applying bituminous material in accordance with the following:

- At the temperatures specified in the relevant specification sections;
- On variable widths of surface not to exceed 26 ft [7.8 m];
- At rates from 0.01 gal/yd² to 1.0 gal/yd² [0.045 L/m² to 4.5 L/m²]; and
- With constant pressure and uniform temperature.

Ensure the distributor can apply material to vertical faces of asphalt pavement at the joints between paving operations.

Prevent variation that exceeds the specified application rate by more than 0.01 gal/yd² [0.05 L/m²].

Provide a distributor equipped with the following:

- A tachometer,
- Pressure gauges,
- Volume-metering devices or a calibrated tank,
- A thermometer for measuring temperatures of tank contents,
- A power unit for the pump,
- Full circulation spray bars adjustable vertically and laterally,
- A positive shut-off valve, and
- Fittings that prevent bituminous material from dripping.

Frequently check and adjust the angle of the spray nozzles and the height of the spray bar to ensure uniform distribution of the bituminous material. The Department will not allow drilling, clogging, or streaking the bituminous material. If any of these conditions occur, stop the operation and correct the problems creating these conditions before resuming distribution.

If the Resident Engineer directs, check the rate and uniformity of distribution.

Provide supply tanks in accordance with AASHTO M 156, Section 3.

B. Compactors

Provide rollers of the following types:

- Vibratory steel-wheel,

- Non-vibratory steel-wheel,
- Pneumatic tire, or
- A combination of the three types.

Provide rollers in good condition, capable of reversing without backlash, and operating at speeds that do not displace the bituminous mixture.

Equip vibratory rollers with working amplitude controls or frequency controls designed specifically for the compaction of the specified bituminous material.

Use rollers of a type, number, and weight to complete the compaction of the bituminous material before its temperature drops below the specified minimum.

The Department will not allow equipment that crushes the aggregate in the bituminous material.

401.04 CONSTRUCTION METHODS

A. Tolerances

Provide the required surface construction in accordance with the following:

(1) Surface Elevation and Smoothness

Finish the surface elevations for new pavement construction and overlays within ½ in [13 mm] of the elevations shown on the Plans. If the Plans do not show the elevations for overlays, provide a finished surface in accordance with the surface smoothness tolerances. Ensure the surface smoothness is within ⅛ in in 10 ft [3 mm in 3 m]. Test for surface smoothness by placing a straightedge between two contacts on the finished surface and measuring the distance from the surface to the straightedge.

(2) Width

Finish surfaces to the minimum width shown on the Plans.

B. Corrections

Correct material dimensions that exceed the specified surface tolerance using methods approved by the Resident Engineer only, at no additional cost to the Department.

C. Surface Protection

Before starting paving operations, submit to the Resident Engineer a plan to protect the pavement from damage by the paving operations. If paving operations spall, crack, chip, rut, or deface the pavement, repair the pavement at no additional cost to the Department.

401.05 METHOD OF MEASUREMENT — VACANT

401.06 BASIS OF PAYMENT — VACANT

SECTION 402
TRAFFIC-BOUND SURFACE COURSE

402.01 DESCRIPTION

This work consists of constructing a surface course of hard and durable particles of sand, gravel, crushed stone, or disintegrated granite and placing the surface course material on a prepared subgrade.

402.02 MATERIALS

Provide aggregate materials in accordance with Subsection 703.05, “Aggregates for Traffic Bound Surface Course.”

402.03 EQUIPMENT — VACANT

402.04 CONSTRUCTION METHODS

A. Preparation of Subgrade

Before placing surface course material on the subgrade, complete the subgrade in accordance with Subsection 310.04.A, “Subgrade Method A for Traffic-Bound Surface Course” or Section 202, “Earthwork” as applicable.

B. Shaping and Maintenance

If placing material adjacent to the roadway, shape and compact as directed by the Resident Engineer.

Correct irregularities, such as holes, ruts , waves, and undulations, with material from the working windrow on the subgrade. Continue shaping the surface material until it is compacted and free of irregularities. Place the surface course material to the elevations shown on the Plans.

Remove excess material and stockpile at a location approved by the Resident Engineer.

C. Traffic Control

Unless otherwise specified, avoid closing the road to traffic. Minimize interference with traffic. Maintain warning signs and lights to safeguard against traffic accidents. Place windrows or piles of surface course material on the shoulders and off the traveled roadway at the end of the workday.

402.05 METHOD OF MEASUREMENT

For each material quantity of the relevant traffic-bound surface course pay item, the Resident Engineer will deduct the weight of moisture that is in excess of 5 percent of the oven-dry weight.

402.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) TRAFFIC BOUND SURFACE COURSE TYPE A	Ton [Metric Ton]
(B) TRAFFIC BOUND SURFACE COURSE TYPE B	Ton [Metric Ton]
(C) TRAFFIC BOUND SURFACE COURSE TYPE C	Ton [Metric Ton]
(D) TRAFFIC BOUND SURFACE COURSE TYPE D	Ton [Metric Ton]
(E) TRAFFIC BOUND SURFACE COURSE TYPE E	Ton [Metric Ton]
(F) TRAFFIC BOUND SURFACE COURSE TYPE F	Ton [Metric Ton]

SECTION 403
CHIP SEAL

403.01 DESCRIPTION

This work consists of constructing a single or double surface treatment of aggregates and bituminous materials.

403.02 MATERIALS

Provide materials in accordance with the following sections:

Material:	Section:
Cover Aggregates	703.04
Bituminous Prime	708
Bituminous Binder	708.03

Unless otherwise specified, use the following aggregates for surface treatments.

For single bituminous surface treatments, use:

- Cover Aggregate No. 2,
- Cover Aggregate No. 3,
- Cover Aggregate No. 3C,
- Precoated Aggregates, or
- Light Weight Cover Aggregates (LWCA).

For double bituminous surface treatments, use:

- Cover Aggregate No. 1, and
- Cover Aggregate No. 2.

403.03 EQUIPMENT

Provide distributors, supply tanks, and compactors in accordance with Subsection 401.03, “Equipment.”

Provide self-propelled mechanical spreaders mounted on pneumatic tired traction wheels capable of the following:

- Operating independently of supply trucks;

- Receiving the aggregate from the supply truck directly into the hopper and then into the spreader box;
- Controlling the spreading of aggregate to a rate of 10 lb/yd² to 45 lb/yd² [5 kg/m² to 25 kg/m²];
- Spreading the aggregate from 3 ft to 12 ft [0.9 m to 3.6 m] wide; and
- Spreading the aggregate up to 24 ft [7.2 m] wide, if required by the Contract.

403.04 CONSTRUCTION METHODS

A. Weather and Seasonal Limitations

Limit the construction of bituminous surface treatment to the following weather and seasonal limitations:

(1) General

Comply with weather and seasonal conditions for constructing bituminous surface treatment in accordance with Subsection 105.15, “Opening Sections of Project to Traffic,” and Subsection 105.17, “Project Completion and Acceptance,” for acceptance of the work.

(2) Seasonal Limitations

Apply bituminous surface treatment during the construction periods provided in Table 403:1, "Construction Seasonal Limitations," or on dates requested in writing and approved by the Resident Engineer.

Table 403:1
Construction Seasonal Limitations

Asphalt Type	Construction Period
Cutback Asphalt	April 1 through Nov. 15
Asphalt Cement	May 1 through Sept. 30
Emulsified Asphalt	May 15 through Sept. 15

(3) Temperature and Weather Limitations

Apply bituminous surface treatment in accordance with the temperature and weather limitations provided in Table 403:2, "Temperature and Weather Limitations."

Measure the ambient temperatures in the shade, 4 ft [1.2 m] above the ground, and away from artificial heat.

Ensure the temperature and weather conditions allow completion of the work. Before starting bituminous surface treatment, verify that the minimum temperatures specified in Table 403:2 also occurred on the previous calendar day. Suspend work if the ambient temperature is forecast to fall below the specified minimum temperature within 72 hr. Suspend work during adverse weather conditions, such as wind chill, rain, fog, or abnormally high relative humidity, as determined by the Resident Engineer.

Table 403:2 Temperature and Weather Limitations				
Asphalt Type	**Minimum Temperature, °F [°C]**			**Base or Pavement Surface Condition Due to Weather**
	Ambient	**Surface**	**Aggregate**	
Cutback Asphalt	50 [10]	60 [15]	40 [4]	Dry
Emulsified Asphalt	60 [15]	70 [20]	50 [10]	No visible free moisture present
Asphalt Cement	60 [15]	70 [20]	50 [10]	Dry

(4) Detours and Shoo-Flys

The Resident Engineer may waive the minimum temperature requirements for construction of temporary bituminous surface treatment for detours, shoo-flys, or other incidental construction.

B. Traffic

Provide traffic control that ensures the following:

- No vehicles travel on the surface treatment before the application and stabilization of cover material;
- Construction operations pose no risk to the health, safety, or property of the traveling public; and
- No unnecessary delay to the traveling public.

C. Preparation of Base

Prepare the base as required by the Contract before applying bituminous surface treatment.

Clean the base of foreign material before placing the prime coat. If reconstructing a base previously sealed or patched with bituminous materials, remove areas with excess bituminous materials from the base course surface before applying the bituminous binder.

D. Protection of Structures

Protect surfaces of structures from discoloration while applying bituminous surface treatments.

E. Heating Bituminous Material

Heat bituminous material uniformly and consistently, using an effective and positive control method. Heat bituminous material in accordance with Subsection 708.03, “Asphalt Materials.” Ensure the fluidity of the heated bituminous material and prevent damage due to overheating.

Do not heat bituminous material with steam. Protect the bituminous material or its container from coming into contact with flames. The Department will reject overheated or damaged bituminous material.

F. Application of Prime Coat

If required by the Contract, apply a prime coat in accordance with Section 408, “Prime Coat.”

G. Application of Tack Coat

If required by the Contract, apply a tack coat in accordance with Section 407, “Fog Seal and Tack Coat.”

H. Application of Bituminous Binder and Cover Aggregate

Before placing the first application of bituminous binder, allow the prime coat to penetrate and harden. Clean the primed base of dirt and loose material.

Ensure the aggregate is immediately available for spreading before starting the application of bituminous binder.

(1) Bituminous Binder

Uniformly apply the bituminous binder. Delineate one edge of the bituminous surfacing before the first application of bituminous binder. At transverse joints, to prevent double or no bituminous binder application created by operation starts and stops, spread building paper over the treated surface before the joint to ensure the specified distribution of bituminous binder at the nozzles when they reach the untreated surface. Remove and dispose of the paper after starting or restarting the bituminous material application.

If the roadway is closed to traffic and the surface width does not exceed 24 ft [7.3 m], bituminous material may be applied to the full width in one pass for each application.

If the roadway is not closed to traffic and traffic is maintained on one-half of the width, apply prime and bituminous material on the closed half of the roadway width. During the bituminous material application on the second half of the roadway, ensure that the distributor nozzle nearest the center of the roadway overlaps the previous bituminous application from half to the full width of the nozzle spray.

(2) Cover Aggregate

Immediately after applying the bituminous binder, apply cover aggregates in accordance with Table 403:3, "Approximate Single Treatment Application Rates," and Table 403:4, “Approximate Double Treatment Application Rates.” Uniformly spread the cover material at the specified rates. The Department will allow hand-spreading in areas inaccessible to mechanical spreaders.

(3) General Application Requirements

Prevent overlaps, streaks, or gaps in the application of bituminous binder and cover aggregate. Correct overlaps, streaks, and gaps, as approved by the Resident Engineer, at no additional cost to the Department. Ensure the finished surface is free of the following:

- Bleeding,
- Loose chips, and
- Loss of imbedded aggregates.

Apply the bituminous material and cover aggregate at the distribution and coverage rate shown on the Plans.

Use Table 403:3, "Approximate Single Treatment Application Rates," and Table 403:4, “Approximate Double Treatment Application Rates,” to estimate

quantities of aggregate and bituminous binder. Rates are based on midpoint requirements of bituminous binder and aggregate.

Table 403:3
Approximate Single Treatment Application Rates

Material	Aggregate Type			
	LWCA	No. 2	No. 3	No. 3C
Aggregate	100 yd^2/yd^3 [110 m^2/m^3]	25 lb/yd^2 [14 kg/m^2]	28 lb/yd^2 [15 kg/m^2]	35 lb/yd^2 [19 kg/m^2]
Bituminous Binder (residual asphalt)	0.3 gal/yd^2 [1.4 L/m^2]	0.3 gal/yd^2 [1.4 L/m^2]	0.3 gal/yd^2 [1.4 L/m^2]	0.3 gal/yd^2 [1.4 L/m^2]

Table 403:4
Approximate Double Treatment Application Rates

Material	Aggregate Type and Increment		
	No. 1	No. 2	
		First	Second
Aggregate	40 lb/yd^2 [22 kg/m^2]	20 lb/yd^2 [11 kg/m^2]	15 lb/yd^2 [8 kg/m^2]
Bituminous Binder (residual asphalt)	0.4 gal/yd^2 [1.8 L/m^2]	0.2 gal/yd^2 [0.9 L/m^2]	0.15 gal/yd^2 [0.7 L/m^2]

Apply bituminous binder at temperatures in accordance with Section 708, "Plant Mix Bituminous Bases and Surfaces."

Apply bituminous binder and cover aggregate in the following sequences:

(a)*Single Treatment*

Apply bituminous binder, and spread No. 2, No. 3, No. 3C, Precoated Aggregates or LWCA cover aggregate at the rates shown on the Plans.

(b)*Double Treatment*

For the first application, apply bituminous binder and spread No. 1 cover aggregate over the surface at the rates shown on the Plans.

For the second application, apply bituminous binder on the surface of the No. 1 cover material, and spread the first application of No. 2 cover aggregate (first increment) over the surface at the rates shown on the Plans.

For the third application, apply bituminous binder on the surface of the No. 2 cover material (first increment), and spread the second application of No. 2 cover aggregate (second increment) over the surface at the rates shown on the Plans.

I. Rolling

Roll the entire surface after each application of cover aggregate and ensure it is firmly imbedded into the bituminous binder.

To prevent tracking bituminous binder during rolling, hand spread additional aggregate to fill irregularities and cover bare spots.

Perform final rolling of the surface with at least four passes over the entire surface with a pneumatic-type roller in accordance with Subsection 401.03.B, "Compactors." Operate the roller at a speed of 7 mph [10 km/h] or less.

J. Maintenance

Remove unsatisfactory material. Make repairs with bituminous binder and aggregate, to establish a uniformly dense treatment with maximum retention of the cover aggregate. Maintain until project completion is accomplished in accordance with Subsection 105.17, "Project Completion and Acceptance."

Correct irregularities with additional bituminous binder and aggregate at no additional cost to the Department.

For excessive bleeding, apply blotting material free of clay, silt, loam, or other foreign matter as directed by the Resident Engineer.

403.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the finished surface area of the *Chip Seal (Single Treatment)* or *Chip Seal (Double Treatment)* complete-in-place. The Resident Engineer will measure the *Preparation of Base* to the nearest foot [meter] along the centerline when specified on the Plans.

403.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) CHIP SEAL (SINGLE TREATMENT)	Square Yard [Square Meter]
(B) CHIP SEAL (DOUBLE TREATMENT)	Square Yard [Square Meter]
(C) PREPARATION OF BASE	Linear Foot [Meter]

The Department will consider the cost of bituminous binder, cover aggregate, and sand or other approved aggregate (for blotting) to be included in the contract unit price for the appropriate chip seal pay item.

The Department will consider the cost of applying every layer of a double treatment, as required by the Contract, to be included in the contract unit price for *Chip Seal (Double Treatment)*.

The Department will pay for tack coat in accordance with Section 407, "Fog Seal and Tack Coat," and prime coat in accordance with Section 408, "Prime Coat."

SECTION 404
THIN SURFACE COURSES

404.01 DESCRIPTION

This work consists of applying micro-surfacing or Ultra-Thin Bonded Wearing Course to an existing pavement surface in layers not greater than 1 in [25 mm] thick.

Micro-Surfacing. A mixture of well-graded aggregate, polymerized asphalt emulsion, fillers, additives, and water that is mixed on the Project.

Ultra-Thin Bonded Wearing Course (UTBWC). A mixture of well-graded aggregate, polymerized Performance Grade binder, and mineral fillers that is mixed at an asphalt plant and delivered to the Project.

404.02 MATERIALS

Provide materials in accordance with Section 707, "Thin Surface Courses."

If storing or stockpiling the mineral aggregates, prevent segregation, mixing of the materials or sizes, and contamination. Supply a uniform gradation of aggregates to the mixing plant. Screen and weigh the mineral aggregate at the stockpile site before delivery to the jobsite. Use screens and scales approved by the Resident Engineer.

404.03 EQUIPMENT

A. General

Use equipment capable of maintaining the quantities of material in the stockpiles and preventing segregation of aggregates. Keep equipment used to store and handle the bituminous material clean.

B. Equipment for Micro-Surfacing

Provide a self-propelled, compartmented, continuous-flow machine capable of the following:

- Mixing, discharging, and placing the micro-surfacing material;
- Delivering and proportioning the aggregate, emulsified asphalt, mineral filler, and water to a revolving multi-blade mixer;
- Storing enough materials to supply the proportioning devices; and
- Simultaneously loading materials and laying micro-surfacing.

Provide individual volume or weight controls to proportion materials added to the mix. Calibrate and mark the material control devices.

Equip the mixing machine with the following:

- A feeder that provides a uniform, positive, metered, predetermined amount of the specified mineral filler to the aggregate feed;
- Devices on the aggregate feeder and the emulsion pump that measure the aggregate and emulsion used by the mixer; and
- A water pressure system and nozzle-type spray bar to spray water immediately ahead and outside of the spreader box.

C. Equipment for Ultra-Thin Bonded Wearing Course

Use a Material Transfer Vehicle to transfer the UTBWC material to the paver in accordance with Subsection 411.03.F, "Material Transfer Vehicle (MTV)."

Provide a paver approved by the Resident Engineer. Ensure the paver has the following:

- A receiving hopper for hot mix asphalt;
- A feed conveyor;
- An asphalt emulsion storage tank;
- A system for measuring the Polymer Modified Asphalt Emulsion Membrane volume;
- A spray bar; and
- A heated, variable width, vibratory or combination vibratory-tamping bar screed.

Ensure the paver is capable of the following:

- Spraying the Polymer Modified Asphalt Emulsion Membrane;
- Applying the hot mix asphalt overlay;
- Leveling the surface of the mat in one pass;
- Placing the hot mix asphalt within 5 seconds after the application of the Polymer Modified Asphalt Emulsion Membrane; and
- Paving at a controlled speed from 30 ft/min to 90 ft/min [9 m/min to 27 m/min].

Prevent wheels and other parts of the paving machine from contacting the Polymer Modified Emulsion Membrane before applying the hot mix asphalt. Provide a machine with a screed that is capable of crowning the pavement at the center and adjusting the extensions vertically to accommodate the pavement profile.

404.04 CONSTRUCTION METHODS

If constructing under traffic, place equipment, loading vehicles, and supply trucks in the lane being paved. Operate equipment for micro-surfacing to allow traffic to move safely and quickly around the work area.

A. Weather Limitations

Place material when the roadway surface temperature is at least 55 °F [13 °C] with no fog or rain. The Resident Engineer may allow paving on a damp pavement surface with aggregate voids free of standing water and a good weather forecast.

B. Surface Preparation

Clear vegetation, loose aggregate, and soil from the roadway surface. If required for micro-surfacing, dampen the surface (prevent free-standing water) ahead of the spreader box.

C. Micro-Surfacing

(1) Test Panel

Before applying the mixture, place a test panel to demonstrate the following, at a location directed by the Resident Engineer:

- The modified emulsion and the mineral aggregate are compatible under field conditions;

- The mix is uniform;
- The mix meets the requirements for proportioning the asphalt, mineral filler, and mineral aggregate;
- The mix meets the performance requirements for set, cure, and stability; and
- The thickness of the micro-surfacing conforms to the typical section.

The Resident Engineer will determine the acceptability of the mix based on the test panel results.

(2) Leveling Course

If required by the Contract or directed by the Resident Engineer, apply leveling courses not exceeding 1 in [25 mm] thick to correct surface irregularities. Before placing the final surface course, cure the leveling course as approved by the Resident Engineer.

If directed by the Resident Engineer, fill ruts, utility cuts, and depressions with micro-surfacing material before placing the final surface course. If directed by the Resident Engineer, fill ruts individually using a spreader box from 5 ft to 6 ft [1.5 m to 1.8 m] wide, or fill multiple ruts with a full-width scratch coat pass using the spreader box.

(3) Spreading

Spread the micro-surfacing mixture uniformly using a mechanical spreader box with augers for internal mixing. Ensure the flexible seals maintain contact with the roadway surface to prevent the loss of mixture. Provide an adjustable rear flexible seal to act as a strike-off. Prevent loss of mixture during spreading operations on super-elevated curves. Spread the mixture to fill cracks and minor surface irregularities. Leave a uniform application of fine aggregate and asphalt on the roadway surface.

Make micro-surfacing joints neat and uniform. If the Resident Engineer determines that a rough joint may affect the steering of an automobile, remove the joint and apply a new micro-surfacing patch at no additional cost to the Department. Apply patches full width using a spreader box.

(4) Curing and Maintaining Traffic

Protect the micro-surfacing from traffic damage until the mixture cures and does not adhere to tires. Repair damage from traffic at no additional cost to the Department.

Complete micro-surfacing application early enough each day to allow the micro-surfacing to cure and traffic to safely travel over the completed work before dark.

D. Ultra-Thin Bonded Wearing Course

(1) Application

Using a metered mechanical pressure spray bar, uniformly spray the Polymer Modified Emulsion Membrane at a temperature from 120 °F to 180 °F [49 °C to 82 °C], or as recommended by the material supplier. Ensure the sprayer accurately and continuously monitors the spray rate and applies the membrane uniformly across the width of the overlay. The Resident Engineer may adjust the spray rate based on the pavement surface conditions and the recommendations of the material supplier.

Apply the UTBWC at a temperature from 290 °F to 330 °F [143 °C to 166 °C] over the full width of Polymer Modified Emulsion Membrane immediately after applying the Polymer Modified Emulsion Membrane. Place the UTBWC with a heated vibratory or combination vibratory-tamping bar screed. Pave continuously to reduce surface imperfections.

Apply UTBWC at the target rate shown on the Plans, or as determined by the Resident Engineer, to minimize fractures in the top size aggregate in the finished pavement surface and at the paving edges for tapering.

(2) Compaction

Immediately after placing the UTBWC, compact in two to three passes with approved steel, double-drum asphalt rollers (in non-vibratory mode) of at least 10 ton [9 metric ton]. Use enough roller units to finish compacting before the material temperature falls below 195 °F [91 °C]. Do not stop the rollers on the freshly placed UTBWC. Equip rollers with a water system and scrapers to prevent the fresh mix from adhering to the roller drums. If a water system is not sufficient, add a release agent approved by the Resident Engineer. To prevent aggregate degradation, avoid excessively rolling UTBWC in the driving lanes. The Resident Engineer will determine the acceptable extent of fracturing at the edge of the pavement due to rolling operations. Do not allow traffic on the new pavement until the rolling operation is complete and the material temperature is below 160 °F [71 °C].

Ensure the compacted thickness of the finished UTBWC is at least ½ in [13 mm] for Type A, ⅝ in [16 mm] for Type B, and ¾ in [19 mm] for Type C.

(3) Acceptance

A lot consists of one day's run, or a maximum of 500 ton [500 metric ton].

The Resident Engineer will perform the following tasks:

- Take the first sample after the hot mix plant start-up from the third, fourth, or fifth production truck loads;
- Sample the mixture at the hot mix plant from the transport truck;
- Randomly select the sample locations within each lot,
- Verify the daily application rate of the Polymer Modified Emulsion Membrane by dividing the volume used by the area paved each day;
- Test asphalt content in accordance with OHD L-26; and
- Test aggregate gradation in accordance with AASHTO T 30.

Stop production if the running average of three consecutive gradation and asphalt content test results varies from the Job-Mix Formula (JMF) by more than the quality control tolerances specified in Subsection 707.03, "Tolerances" as directed by the Resident Engineer. Identify the cause of the discrepancies, adjust the JMF, and document the corrective actions. If the adjusted JMF meets the mixture requirements of the Contract and the Resident Engineer approves, replace the current JMF with the adjusted JMF and continue production.

If directed by the Resident Engineer, remove defective areas and replace with acceptable material at no additional cost to the Department.

404.05 METHOD OF MEASUREMENT

The Resident Engineer will measure completed micro-surfacing as the relevant mineral aggregate pay item, by the dry weight (including mineral filler); and as *Polymer-Modified Emulsified Asphalt* by the volume or weight of residual asphalt cement.

The Resident Engineer will include the aggregate, polymerized performance grade binder, mineral fillers, and other ingredients as specified in the JMF in the measurement for the relevant UTBWC pay items. The Resident Engineer will not include the weight of Polymer Modified Emulsified Membrane in the measurement of the relevant UTBWC pay items.

404.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) POLYMER-MODIFIED EMULSIFIED ASPHALT	Gallon [Liter] or Ton [Metric Ton]
(B) TYPE I MINERAL AGGREGATE	Ton [Metric Ton]
(C) TYPE II MINERAL AGGREGATE	Ton [Metric Ton]
(D) TYPE III MINERAL AGGREGATE	Ton [Metric Ton]
(E) ULTRA-THIN BONDED WEARING COURSE, TYPE A	Ton [Metric Ton]
(F) ULTRA-THIN BONDED WEARING COURSE, TYPE B	Ton [Metric Ton]
(G) ULTRA-THIN BONDED WEARING COURSE, TYPE C	Ton [Metric Ton]

The Department will consider the cost of Polymer Modified Emulsified Membrane to be included in the contract unit price for the relevant UTBWC pay items.

SECTION 405
PERMEABLE FRICTION COURSE

405.01 DESCRIPTION

This work consists of mixing aggregate, bituminous material, and fibers in a central plant, and spreading and compacting the mixed material on a prepared roadbed.

405.02 MATERIALS

Provide materials in accordance with Section 708, "Plant Mix Bituminous Bases and Surfaces."

405.03 EQUIPMENT

Provide equipment in accordance with Subsection 411.03, "Equipment." Use a Material Transfer Vehicle (MTV) to place Permeable Friction Course (PFC).

Provide a fiber supply system to uniformly distribute the specified proportions of fiber into the PFC. Ensure the fiber supply system has the following characteristics:

- Low level and no-flow indicators;
- A printout or data file that records the feed rate; and
- A section of transparent pipe that allows observation of flow and feed consistency.

The Resident Engineer will review and approve mineral filler feeder systems.

405.04 CONSTRUCTION METHODS

A. Stockpiling Materials

Stockpile aggregates in accordance with Subsection 106.8, "Storage and Handling of Materials."

B. Preparation of Materials

Ensure the discharge temperature of the PFC does not exceed 350 °F [177 °C]. Dispose of dust collected from this operation or return it to the mixture as required to meet the job-mix formula.

Maintain the aggregate stockpiles in a reasonably dry condition so that drum mixing will drive out all remaining moisture.

C. Mixing

Mix the aggregate and bituminous material in accordance with Subsection 411.04.E, "Mixing."

D. Loading and Hauling

Coordinate loading and hauling of the PFC with laydown operations to:

- Ensure PFC placement within the temperature range in accordance with Subsection 406.04.G., "Spreading and Finishing," and
- Prevent separation of the bituminous material and aggregate in the PFC.

E. Tack Coat

Apply a tack coat in accordance with Section 407, “Fog Seal and Tack Coat.” Apply the tack coat at a rate of 0.2 gal/yd² [0.9 L/m²] of diluted emulsion (SS-1), diluted with water at a ratio of 1:1, unless otherwise required by the Contract.

F. Weather Limitations

Place PFC on a dry surface. Ensure the prepared roadbed surface is at least 60 °F [15 °C] measured away from artificial heat sources. Ensure weather conditions allow proper leveling and consolidation of the PFC.

G. Spreading and Finishing

Before placing PFC, remove foreign material from the prepared roadbed. Ensure that the temperature of the PFC at the time of placement is 300 °F ±25 °F [149 °C ±14 °C].

Do not windrow the PFC before spreading and finishing. Place the PFC using a MTV. The Resident Engineer may exempt isolated areas of the project from use of an MTV.

Continuously remix the material using one of the following methods:

- Internally, in the transfer device,
- In a paver hopper insert, or
- In the paver’s hopper.

Use remixing augers or paddles capable of continuously blending the PFC.

Ensure the MTV, the haul units, and the pavers provide a continuous, uniform, segregation-free flow of material. To avoid stopping and restarting operations, coordinate the following:

- The number of haul units,
- The speed of the paver,
- The plant production rate, and
- The speed of the MTV.

Do not raise (dump) the wings of the paver's receiving hopper during the paving operation.

If an MTV unit malfunctions, stop laydown operations until the equipment is repaired or replaced.

Ensure the placed material is free of segregation, inconsistent texture, bleeding, fat spots, and cracking.

For MTV units that exceed 20,000 lb [9,000 kg] per axle, adhere to the following guidelines when crossing bridges. If the bridge is in good condition:

- Empty the MTV hopper,
- Travel at a crawl speed, and
- Ensure the MTV wheels are positioned over the underlying bridge beam lines.

If the bridge is in poor condition or posted for load limits, additional limitations may be necessary. The Resident Engineer will consult the ODOT Bridge Division.

H. Joints

Place the longitudinal PFC joint at the lane lines, and offset this joint from the underlying joint by at least 3 in [75 mm]. Ensure the joints are tight, smooth, butt-type joints.

I. Compaction

Immediately after placing PFC material, roll the surface with two or three passes with a non-vibratory steel-wheeled, self-propelled roller. The Department will not allow pneumatic rollers.

Construct a smooth finished surface in accordance with Subsection 401.04.A(1), "Surface Elevation and Smoothness," and Subsection 401.04.A(2), "Width". Ensure the finished PFC is at least as thick as the thickness shown on the Plans but no thicker than the thickness shown on the Plans plus ¼ in [6.4 mm]. Remove and replace defective areas immediately, at no additional cost to the Department.

Restrict traffic from the finished PFC pavement until the surface temperature is within 10 °F [6 °C] of the ambient temperature, or 2 hr after the final rolling.

405.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the weight of *Permeable Friction Course* not exceeding the calculated weight obtained by multiplying the unit weight from the job mix formula by the completed length of PFC and the area of the typical cross section shown on the Plans.

405.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
PERMEABLE FRICTION COURSE	Ton [Metric Ton]

The Department will pay for tack coat in accordance with Section 407, "Fog Seal and Tack Coat."

SECTION 406
OPEN-GRADED FRICTION SURFACE COURSE

406.01 DESCRIPTION

This work consists of mixing aggregate and bituminous material in a central plant, and spreading and compacting the mixed material on a prepared roadbed.

406.02 MATERIALS

Provide materials in accordance with Section 708, “Plant Mix Bituminous Bases and Surfaces.”

406.03 EQUIPMENT

Provide equipment in accordance with Subsection 411.03, “Equipment.”

406.04 CONSTRUCTION METHODS

A. Stockpiling Materials

Stockpile aggregate in accordance with Subsection 106.08, “Storage and Handling of Materials.”

B. Preparation of Materials

Dry and heat the aggregate to a temperature no greater than 260 °F [127 °C]. Collect resulting dust, and remove or return it to the mixture required to meet the Job-Mix Formula (JMF).

Ensure the aggregate used in the Open-Graded Friction Surface Course (OGFSC) is free of oily or carbonaceous coatings.

Ensure the temperature of bituminous material does not exceed 350 °F [177 °C] before and during mixing.

C. Mixing

Mix the aggregate and bituminous material in accordance with Subsection 411.04.E, “Mixing.”

D. Loading and Hauling

Coordinate loading and hauling the OGFSC with laydown operations to:

- Ensure OGFSC placement within the temperature range in accordance with Subsection 406.04.G., “Spreading and Finishing,” and
- Prevent separation of the asphalt and aggregate in the OGFSC.

E. Tack Coat

Apply a tack coat in accordance with Section 407, “Fog Seal and Tack Coat.” Apply the tack coat at a rate of 0.2 gal/yd² [0.9 L/m²] of diluted emulsion (SS-1), diluted with water at a ratio of 1:1, unless otherwise required by the Contract.

F. Weather and Seasonal Limitations

Place OGFSC on a dry surface. Ensure the prepared roadbed surface is at least 60 °F [15 °C] measured away from artificial heat sources. Ensure the weather conditions allow proper leveling and consolidation of the OGFSC.

Place OGFSC between April 1 and October 31, unless otherwise approved by the Resident Engineer.

G. Spreading and Finishing

Before placing OGFSC, remove foreign material from the prepared roadbed. Ensure the temperature of the OGFSC at the time of placement is in accordance with the temperature required by the JMF ±25 °F [±14 °C].

During paving, ensure the paver moves continuously. If paving stops, remove all material from the paver and restart the paving operation.

H. Joints

Place the longitudinal OGFSC joint at the lane lines, and offset this joint from the underlying joint by at least 3 in [75 mm]. Ensure that the joints are tight, smooth, butt-type joints.

I. Compaction

Immediately after placing OGFSC, roll the surface with two or three passes with a non-vibratory, steel-wheeled, self-propelled roller.

Construct a smooth finished surface in accordance with Subsection 401.04.A(1), “Surface Elevation and Smoothness,” and Subsection 401.04.A(2), “Width”.

Restrict traffic from the finished OGFSC pavement until the surface temperature is within 10 °F [6 °C] of the ambient temperature, or 2 hr after the final rolling.

J. Tolerance

Ensure the finished OGFSC is at least as thick as the thickness shown on the Plans, but no thicker than the thickness shown on the Plans plus ¼ in [6.4 mm]. Remove and replace defective areas immediately, at no additional cost to the Department.

406.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the weight of *Open-Graded Friction Surface Course* not exceeding the calculated weight obtained by multiplying the unit weight from the job mix formula by the completed length of OGFSC and the area of the typical cross section shown on the Plans.

406.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit**
OPEN-GRADED FRICTION SURFACE COURSE	Ton [Metric Ton]

The Department will pay for tack coat in accordance with Section 407,“Fog Seal and Tack Coat.”

SECTION 407
FOG SEAL AND TACK COAT

407.01 DESCRIPTION

This work consists of preparing and treating an existing bituminous or concrete surface with bituminous material.

Original Emulsion. A mixture of asphalt, water, and a small amount of emulsifying agent to maintain uniformly blend. An SS-1 emulsion, the product typically used for fog seal and tack coat, contains up to 43 percent water. Unless otherwise approved by the Resident Engineer, use SS-1 original emulsion.

Diluted Emulsion. An original emulsion diluted with additional water to reduce the viscosity and to allow easier spraying.

Residual Asphalt Content. The amount of asphalt remaining on the pavement surface after all of the water, both in the original emulsion and any additional water, has evaporated.

407.02 MATERIALS

Provide materials in accordance with Subsection 708.03, “Asphalt Materials.”

407.03 EQUIPMENT

Provide distributors, heating equipment, and supply tanks in accordance with Subsection 401.03, “Equipment.”

407.04 CONSTRUCTION METHODS

A. General

Clean the existing roadbed surface before placing tack coat. Paint a thin, uniform tack coat on all surfaces of curbs and gutters, manholes, and other structures that will come in contact with hot mix asphalt. Ensure the tack coat applications minimize damage and inconvenience to traffic and allow one-way traffic without pickup or tracking the bituminous material.

Do not apply tack coat during wet or cold weather, or in windy conditions that would cause the tack coat emulsion to drift. Do not apply tack coat to wet surfaces with free standing water. The Department will allow tack coat application to damp surfaces.

Before application, the Resident Engineer must approve of the following:

- Quantity,
- Rate of application,
- Temperature, and
- Areas to be treated.

B. Fog Seal

Apply the fog seal at a rate of 0.1 gal/yd² [0.44 L/m²] of diluted emulsion (SS-1) diluted at 5:1 water to original emulsion. Alter the application rate as directed by the Resident Engineer (based on the pavement surface texture).

C. Tack Coat

Apply the tack coat at a rate of 0.15 gal/yd² [0.66 L/m²] of diluted emulsion (SS-1), diluted with water at a ratio of 1:1, unless otherwise required by the Contract. Alter the application rate as directed by the Resident Engineer (based on the pavement surface texture).

Ensure the tack coat breaks before the application of the next surfacing layer.

If the tack coat loses its adhesive properties or is exposed to traffic before being covered by the next surfacing layer, reapply the tack coat at a rate that ensures proper adhesion, as directed by the Resident Engineer, at no additional cost to the Department.

407.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the volume of SS-1 Emulsion for *Fog Seal* and *Tack Coat*, as delivered, before dilution.

407.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) FOG SEAL	Gallon [Liter]
(B) TACK COAT	Gallon [Liter]

The Department considers the cost of water for dilution to be included in the contract unit price for *Fog Seal* and *Tack Coat*.

SECTION 408
PRIME COAT

408.01 DESCRIPTION

This work consists of preparing and treating a surface with bituminous and blotter material.

Cutback. A mixture of asphalt and petroleum solvent.

Residual Asphalt Content. The amount of asphalt remaining on the pavement surface after the petroleum solvent evaporates.

MC-30 and MC-70. Cutbacks with residual asphalt contents of at least 50 percent and 55 percent, respectively.

408.02 MATERIALS

Provide materials in accordance with Subsection 708.03, "Asphalt Materials," for MC-30 and MC-70.

408.03 EQUIPMENT

Provide distributors, heating equipment, and supply tanks in accordance with Subsection 401.03, "Equipment."

408.04 CONSTRUCTION METHODS

A. Weather Limitations

Apply the prime coat when the ambient temperature is above 50 °F [10 ° C] as weather allows. Measure ambient temperature in the shade, 4 ft [1.2 m] above the ground, and away from artificial sources of heat.

B. Preparation of Surface

Before applying the prime coat, remove loose material from the roadbed (subgrade or base) to ensure maximum penetration of the prime coat.

C. Priming Subgrades or Bases That Are Non-Cohesive

Subject to the approval by the Resident Engineer, when friable or non-cohesive materials are encountered in the surface to be primed, the bituminous material shown on the Plans may be changed to an asphalt emulsion. The bituminous materials shown on the Plans may also be changed to an asphalt emulsion in those areas of the State in which the use of cutback asphalt is prohibited. Sprinkling water with asphalt emulsion added may be used in the final operations of sprinkling, manipulation, shaping, and rolling of the subgrade or base. Additional applications may be made if necessary to form a firm, bonded working table.

D. Application of Bituminous Material

Uniformly spread the as-delivered MC-30 or MC-70 bituminous material on the roadbed surface as shown on the plans using a pressure distributor at a rate from 0.1 gal/yd² to 0.4 gal/yd² [0.45 L/m² to 1.8 L/m²] as directed by the Resident Engineer.

If maintaining traffic on the roadway surface, apply prime coat to no more than half the roadway width at one time. Blot excess prime coat with sand or screened material.

Maintain one-way traffic on the untreated portion of the roadbed surface. As soon as the surface and blotter sand absorb the bituminous material, transfer traffic to the treated portion, and apply prime coat to the remaining section of roadbed surface.

Correct deficiencies in prime coat application at no additional cost to the Department.

Do not apply successive applications of bituminous materials or other layers until the prime coat penetrates the roadway surface and hardens.

E. Application of Blotter Material

If the bituminous material fails to penetrate within the specified time, and traffic must use the roadway surface, spread blotter material on the roadway surface to absorb excess bituminous material in accordance with Subsection 403.04.J, "Maintenance."

408.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the volume of prime coat as delivered to the project.

408.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
PRIME COAT	Gallon [Liter]

The Department will consider the cost of blotter material to be included in the contract unit price for *Prime Coat*.

SECTION 409
FABRIC REINFORCEMENT FOR HOT MIX ASPHALT PAVEMENT

409.01 DESCRIPTION

This work consists of applying reinforcement fabric for hot mix asphalt (HMA) pavement.

409.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Reinforcement Fabric	712.01
Asphalt Cement	708.03

409.03 EQUIPMENT

A. Distributors

Provide distributors in accordance with Subsection 401.03, "Equipment." Ensure the distributors have hand sprayers.

B. Fabric Laydown Equipment

Provide mechanical fabric laydown equipment capable of handling and placing full or partial rolls of fabric smoothly.

C. Miscellaneous Equipment

Provide miscellaneous equipment, including:

- Stiff bristle brooms, to smooth the fabric;
- Scissors or blades, to cut the fabric; and
- Brushes, to apply bituminous binder to fabric overlap at spliced joints.

D. Pneumatic-Tired Rollers

Provide pneumatic-tired rollers in accordance with Subsection 401.03, "Equipment."

409.04 CONSTRUCTION METHODS

A. Surface Preparation

Remove foreign material, such as dirt, dust, water, or oil, from the prepared surface.

B. Application of Bituminous Binder

Heat the bituminous binder material. Use an asphalt distributor to uniformly spray the area to be covered with fabric. Hand-spray areas inaccessible to the distributor. Use paper or roofing felt to provide neat cutoff lines at locations where the distributor application of bituminous binder starts or stops.

During application, keep the bituminous binder at a temperature of at least 290 °F [143 °C]. If fabric is over-sprayed, ensure that the application temperature does not exceed 325 °F [163 °C] to avoid damaging the fabric. Estimate the quantity of

bituminous binder using an approximate rate of 0.20 gal/yd² to 0.25 gal/yd² [0.9 L/m² to 1.1 L/m²]. Apply the bituminous binder in accordance with the minimum recommended rate as specified by the fabric manufacturer and as directed by the Resident Engineer.

Apply the binder from 2 in to 6 in [50 mm to 150 mm] wider than the fabric. During binder application, avoid spills or excessive application causing flushing of the bituminous material.

C. Placement of Reinforcement Fabric

Mechanically place the fabric before the bituminous binder cools and loses tackiness. The Department will not allow manual placement. Unroll and place the fabric on the binder with the unfused, fuzzy side down. Lay the fabric as smoothly as possible. Broom the fabric to remove air bubbles, and to maximize contact with the pavement. Cut wrinkles and lay fabric flat. If the fabric becomes misaligned, cut, realign, and joint the fabric as directed by the Resident Engineer.

Overlap fabric at joints from 4 in to 6 in [100 mm to 150 mm]. To prevent the paver from disturbing the fabric, overlap transverse joints in the direction of paving (ending edge of the old fabric roll over leading edge of new fabric roll). Apply additional binder to joints as directed by the Resident Engineer. Mop, brush, or hand-spray transverse joints. Spray longitudinal joints with the distributor.

Use self-propelled pneumatic-tired rollers to embed reinforcement fabric into the bituminous binder and bond it to the pavement.

Before placing traffic directly on the fabric, blot the fabric with clean, dry sand. If excess binder bleeds through the fabric before placing pavement overlay, blot the excess binder by spreading sand on the affected area as directed by the Resident Engineer.

D. Weather Limitations

For fabric installation, apply bituminous binder when the ambient air temperature is at least 50 °F [10 °C], unless otherwise approved by the Resident Engineer. Do not place bituminous binder application if it is raining or rain is imminent.

E. Tack Coat

If required by the Contract, apply a tack coat in accordance with Section 407, “Fog Seal and Tack Coat.” The Resident Engineer will approve the bituminous material type, grade, rate of application, and temperature. Do not use cutback asphalt or emulsified asphalt that contain petroleum distillate.

F. Pavement Overlay

Place the pavement overlay immediately after placing the fabric, unless directed otherwise by the Resident Engineer.

Ensure the pavement overlay temperature does not exceed 325 °F [163 °C] to prevent damage to the fabric. To avoid damaging the fabric, minimize turning movements. If necessary, turn pavers and vehicles gradually and broadcast clean, dry sand ahead of trucks and pavers to prevent fabric damage. Remove excess sand ahead of paving operations.

Repair damage to or debonding of the fabric reinforcement caused by traffic, wet weather conditions, improper installation, or equipment, at no additional cost to the Department.

409.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the area covered by *Fabric Reinforcement* after placement, not including overlaps.

409.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) FABRIC REINFORCEMENT	Square Yard [Square Meter]
(B) BITUMINOUS BINDER	Gallon [Liter]

The Department will consider the cost of the tack coat and sand used for blotting to be included in the contract unit price for *Fabric Reinforcement*.

SECTION 411
HOT MIX ASPHALT

411.01 DESCRIPTION

This work consists of constructing one or more courses of bituminous mixture on the prepared foundation (roadbed or base).

Hot Mix Asphalt (HMA) includes Superpave, Stone Matrix Asphalt (SMA), and Rich Bottom Layer.

411.02 MATERIALS

Provide materials in accordance with Section 708, “Plant Mix Bituminous Bases and Surfaces.”

411.03 EQUIPMENT

A. Mixing Plants

Provide hot mix asphalt (HMA) preparation plants in accordance with AASHTO M 156 and the Department’s certification requirements.

Avoid exposing reclaimed asphalt paving material to the burner flame or high temperature combustion gases. Ensure plants modified for this purpose meet the manufacturer’s requirements for the specific modifications.

Allow the Resident Engineer access to the mineral filler feeder systems for approval before use.

For mixtures with mineral fillers, provide a closed system for storing and feeding that maintains a constant material supply with minimal loss throughout the mix production system. Ensure the mineral filler measuring device provides a consistent percentage of filler. Provide a system that includes flow indicators or sensing devices to automatically stop mix production if mineral filler introduction ceases.

For mixtures with cellulose fibers, provide a separate system to feed fibers into the mixture to obtain a uniform distribution. Ensure the fiber supply system includes low level, no-flow indicators and a file or printout that tracks the feed rate. Include a section of transparent pipe in the fiber supply for observing consistency of flow or feed.

The Department will inspect plants every six months, or after every move.

B. Scales

Provide digital scales to weigh the bituminous mixture. For approved automatic printer systems with an automatic batching and mixing control system, use the printed batch weights or truck scales. Provide a weigh ticket for each load to record the weights. Provide certification of scales every six months, or after every move, unless otherwise directed by the Engineer.

C. Pavers

Provide self-contained, self-propelled HMA pavers equipped with an activated heated screed, and an automatic control device for placing the mixture to the slopes and grades shown on the Plans. Ensure the pavers can spread and finish HMA courses on lanes, shoulders, and similar construction to the widths and thicknesses shown on the Plans.

Equip the paver with a receiving hopper and a distribution system to uniformly place and spread the HMA in front of the screed without causing HMA segregation. The Department will not allow equipment designed to pick up HMA from windrows.

Ensure the paver can operate at forward speeds to consistently place the mixture.

Use a heated strike-off assembly to produce a finished surface that meets the specified evenness and uniform texture without tearing, shoving, or gouging the mixture or causing HMA segregation.

D. Trucks and Transports

Ensure trucks hauling HMA comply with legal load limits and have tight, clean, smooth metal beds thinly coated with a minimum amount of soap solution, lime solution, or other material that prevents the mixture from adhering to the beds as approved by the Resident Engineer. Prevent ponds of these anti-adhesive solutions from forming in truck beds.

Refrain from using solutions that contain diesel fuel or other contaminating solvents during material delivery.

Provide trucks with a canvas cover or other material large enough to protect the HMA from the weather. If necessary, insulate the truck beds and fasten the covers so that the mixture remains at the specified temperature until delivery.

Provide transports to haul liquid asphalt materials in accordance with Subsection 708.03, “Asphalt Materials.” Keep a record of the following:

- Delivery date,
- Asphalt grade,
- Source,
- Quantity,
- Invoice number, and
- Material hauled in the previous load.

Provide these records to the Resident Engineer upon request.

E. Sampling Device

Provide an aggregate sampling device that can obtain a representative sample from a belt or bin discharge in accordance with AASHTO T 2. Allow the Engineer access to the device for approval before use. Ensure the device obtains the sample before the aggregate enters the dryer drum or drum mixer without stopping plant production.

F. Material Transfer Vehicle

The Department defines a Material Transfer Vehicle (MTV) as equipment that transfers HMA from the hauling units directly to the spreading and finishing machine.

Provide an MTV to place the top two lifts of HMA for pavements designed for a minimum of 10 million ESALs unless otherwise specified in the Contract.

Equip the MTV with remixing augers or paddles to continuously remix asphalt in the transfer device, the paver hopper insert, or the paver's hopper.

The Department will only allow MTVs that exceed 20,000 lb [9,100 kg] per axle to cross bridges if the unit's hopper is empty, the vehicle travels at crawl speed, and the wheels are placed over the underlying beam lines. For bridges in poor condition or posted for load limits, the Resident Engineer will consult the Bridge Division to determine additional limitations.

Ensure the MTV, the haul units, and the paver provide a continuous, uniform, non-segregated flow of material. Coordinate the number of haul units, the paver's speed, the plant production rate, and the MTV's speed to avoid stop-and-go operations. Do not raise the wings of the paver-receiving hopper while paving.

If an MTV malfunctions, continue asphalt mix lay-down operations to place quantities in transit or in silos and to safely maintain traffic. Stop operations after that until the equipment is repaired.

Place a 500 ton [450 metric ton] test strip. The Resident Engineer will evaluate the MTV's performance by measuring the temperature profile of the mat immediately behind the paver screed using a non-contact thermometer at intervals of 50 ft [15 m]. Each temperature profile consists of three surface temperature measurements taken transversely across the mat from 1 ft to 3 ft [0.3 m to 1 m] from the screed during the paving operations. Each profile will include three temperature measurements; one in the middle of the mat and two at the edges (1 ft [0.3 m] inside each edge).

Stop producing asphalt mix if two of the temperature measurements in any profile differ by more than 10 ºF [6 ºC]. Adjust operations before restarting the paving operation. The Resident Engineer may take additional surface temperature profiles during the project.

Shoulders are excluded from these requirements.

G. Compactor

Use self propelled, steel wheel, and pneumatic tired compactors. Ensure the steel wheeled compactors weigh at least 10 ton [9 metric ton]. Ensure the pneumatic tired compactors have at least seven pneumatic tires of equal size and diameter. Ensure the total weight of the tires produces an operating weight of at least 3,500 lb [1,588 kg] per tire. Inflate the tires to at least 90 percent of the maximum pressure recommended by the tire manufacturer. Maintain the tire pressure for at least 1 hr after the start of

operations and ensure the range in pressure among the tires does not exceed 10 psi [68 kPa].

411.04 CONSTRUCTION METHODS

A. Stockpiling Materials

Deliver and stockpile aggregates in accordance with Subsection 106.08, "Storage and Handling of Materials." Ensure sufficient material is on-site for each day's operation. Provide the Resident Engineer with daily quality control results.

B. Preparation of Materials

(1) Bituminous Material and Aggregate

Heat bituminous material and aggregate to temperatures in accordance with Subsection 708.03, "Asphalt Materials." Provide a continuous supply of bituminous material to the mixer. Avoid localized overheating.

(2) Dried and Heated Aggregate

Adjust heater unit flames to avoid damaging or depositing soot on the aggregate.

(3) Hot Dry Aggregates

For plants that control the gradation of hot dry aggregates, screen the aggregate and store for use as follows:

- At least two bins for Type S5 and Type S6 mixtures, and
- At least three bins for all other mixtures.

C. Plant Startup Requirements for New Construction and Overlays

Before placing the HMA, use the mix design created for mainline construction to produce enough HMA to calibrate the plant, testing equipment, and testing procedures. The Resident Engineer will sample and test the HMA for asphalt cement content, aggregate gradation, air voids, and voids in mineral aggregate (VMA). Compare Contractor test results with the Resident Engineer's; make adjustments if necessary.

Use HMA from the plant startup operation to meet control strip requirements on temporary construction only; do not place HMA from the startup operations on the mainline. Make adjustments until all requirements are met. If no temporary locations are available, the plant startup mixture becomes the Contractor's property at no additional cost to the Department. The Resident Engineer may waive plant startup requirements if the same plant and location have successfully produced the same HMA mix design before.

D. Control Strip Requirements

If the contract requires less than 5,000 ton [5,000 metric ton] of an HMA type, the Department will not require a control strip for that type of HMA, unless otherwise shown on the Plans.

After meeting the plant startup requirements, construct at least one control strip on a detour to verify the required production mix characteristics and establish rolling patterns. If a detour is unavailable, construct on the shoulder; if a shoulder is unavailable, construct on the mainline. Place an initial HMA control strip not exceeding 500 ton [500 metric ton]. With the Resident Engineer, sample and test this

mixture for asphalt cement content, aggregate gradation, air voids, VMA, and roadway density. Place additional HMA after evaluating the results and adjusting production and placement procedures as necessary.

If the Resident Engineer determines the initial placement of the HMA control strip to be acceptable in accordance with Subsection 411.04.N(2)(a), "Basis of Acceptance and Payment," the Department will pay for the control strip quantities in accordance with Subsection 411.04.N(2)(a), "Basis of Acceptance and Payment," and allow the Contractor to proceed with production paving operations.

The Department will not allow unacceptable HMA to remain in the mainline or the shoulder. Remove and replace unacceptable HMA at no additional cost to the Department.

If the placement of the initial HMA control strip produces failing results, make adjustments to production and placement procedures, and repeat the test process for a second control strip. The Department will make pay adjustments for deviations on the second HMA control strip at the pay factor rate in accordance with Subsection 411.04.N(2)(a), "Basis of Acceptance and Payment." If required, create additional HMA control strips on the shoulder until an acceptable mixture is produced (within the 100 percent pay factor range). The Department will make pay adjustments for HMA control strips after the second HMA control strip placement in accordance with Subsection 411.04.N(2)(a), "Basis of Acceptance and Payment."

E. Mixing

Combine aggregates in the mixer in accordance with the mix design. Measure or gauge the bituminous material in accordance with the mix design, and load into the mixer. Ensure the moisture content of the HMA is no more than 0.75 percent at the point of mixture discharge. The Department will not accept uncoated or non-uniform mixtures.

During daily startup or shutdown of plant operations, ensure deliveries to the storage silo or roadway are in accordance with the mix design. Empty the plant and fill the cold feed bins with the proper aggregates before changing mixtures.

F. Mat Irregularities

Ensure the mat is free of segregation, non-uniform texture, bleeding, fat spots, and cracking.

G. Tack Coat

If required by the Contract, provide a tack coat in accordance with Section 407, "Fog Seal and Tack Coat."

H. Temperature and Weather Limitations

Ensure the minimum surface temperature of the foundation is in accordance with the following table:

Table 411:1
Compacted Lift Thickness and Surface Temperature

Lift Thickness, *in [mm]*	**Surface Temperature, *°F [°C]***
>3 [>75]	40 [4]
2 – 3 [50 – 75]	45 [7]
<2 [<50]	50 [10]

Do not place HMA if frost exists in or on the foundation. Stop operations if the material becomes too cold to be leveled and consolidated. If it starts raining, stop plant production immediately. During adverse weather conditions, the Contractor may place material already in transit; however, the Contractor shall assume the risk of weather related impacts.

Do not place SMA if the surface temperature is below 60 ºF [16 ºC].

I. Spreading and Finishing

Before placing HMA, remove foreign material from the surface of the foundation. Place the HMA on a dry surface with a paver in accordance with Subsection 411.03.C, "Pavers." Establish the alignment along one pavement edge with a string or wire line.

Do not windrow HMA. Deliver the HMA to the paver at the optimum temperature shown on the mix design ±25 °F [±14 °C].

In areas inaccessible to mechanical spreading and finishing equipment, use hand tools to dump, spread, rake, and compact the HMA to the compacted thickness shown on the Plans.

To ensure a continuous operation, operate the spreading and finishing machine at a uniform forward speed consistent with the plant production rate, hauling capacities, and roller train capability. Maintain a paver speed that will minimize stopping and starting between trucks. If the Resident Engineer determines that sporadic material delivery is adversely affecting the mat quality, the Resident Engineer may direct paving operations to suspend until the Contractor makes adjustments.

Spread the HMA mixture uniformly adjacent to curbs, gutters, manholes, and other structures so that the compacted surface is ¼ in [6 mm] above the edges of the structures. Before placing the mixture against these structures, clean and coat them with a thin, uniform tack coat in accordance with Section 407, "Fog Seal and Tack Coat."

Immediately correct unsatisfactory HMA mat. The Resident Engineer may suspend paving operation until the Contractor produces a satisfactory result. Remove and replace unsatisfactory HMA as directed by the Resident Engineer, at no additional cost to the Department.

J. Joints

Stagger longitudinal and transverse joints on succeeding layers by 6 in [150 mm].

Construct longitudinal joints within 1 ft [0.3 m] of the lane lines, and ensure the longitudinal joints in the top HMA layer, or in the layer upon which an open-graded friction course will be placed, are at the lane lines.

Bond and seal longitudinal and transverse joints. If making joints between old and new pavements, or between successive days' work, create a continuous bond between the surfaces. Cut back the transverse edge of the previous course to its full depth to expose a fresh surface. Paint the edge with a tack coat and place the HMA mixture directly against it. Rake the mixture to the depth and grade shown on the Plans.

K. Compaction

(1) General

Operate compactors (rollers) in accordance with the manufacturer's recommendations.

For each placed layer of HMA mixtures, perform the initial compaction using steel-wheel rollers and follow with self-propelled pneumatic-tired rollers. Finish with a steel-wheel roller. The Department requires at least two coverages with the pneumatic-tired roller on each layer.

If mat displacement occurs during rolling, use rakes and additional fresh material to correct the surface. Avoid displacing the line and grade of the edges of HMA. Ensure the mixture does not adhere to the compactors.

For areas inaccessible to compaction equipment, compact the mixture using hot hand tampers, smoothing irons, or mechanical tampers. If approved by the Resident Engineer, use a trench compactor to transmit compression to depressed areas.

Remove mixture that is defective, loose, broken, or mixed with dirt, and replace with new HMA, at no additional cost to the Department. Compact to conform to the surrounding area.

Ensure the HMA immediately behind the paver is at least 250 °F [121 °C]. Before the temperature of the HMA drops below 180 °F [82 °C], compact thicker layers to the target density and thinner layers to the optimum density in accordance with Subsection 411.04.K(2)(a), "Layers At Least 1½ in [38 mm] Thick," and Subsection 411.04.K(2)(b), "Layers Less Than 1½ in [38 mm] Thick."

(2) Acceptance

The Resident Engineer will accept layers at least 1½ in [38 mm] in nominal thickness on the basis of density in accordance with Subsection 411.04.K(2)(a), "Layers At Least 1½ in [38 mm] Thick."

The Resident Engineer will accept layers less than 1½ inch [38 mm] in nominal thickness on the basis of compactive effort in accordance with Subsection 411.04.K(2)(b), "Layers Less Than 1½ in [38 mm] Thick."

The Resident Engineer will accept layers of all thicknesses on a lot-by-lot basis. The Department considers a lot to be 1,000 ton [1,000 metric ton] of HMA. The Resident Engineer may terminate a lot and designate a new one if the Contractor makes adjustments to the material or production and placement procedures.

(a) Layers At Least 1½ in [38 mm] Thick

Ensure the target density of each lot is 94 percent of the Maximum Theoretical Density at the Job Mix Formula (JMF) asphalt content, determined by using the most recent specific gravity of the HMA in accordance with AASHTO T 209.

The HMA density for each lot is the average of three random samples from the lot. At times and locations directed by the Resident Engineer, saw or core samples from the pavement of at least 6 in [150 mm] on the cut side or diameter. The Department will perform tests on the samples or on the mat using a nuclear or non-nuclear density gauge that has been correlated with roadway cores in accordance with OHD L-14.

The Department will base acceptance and pay adjustments on Department-approved tests in accordance with the following schedule:

Table 411:2 Pay Adjustments for Lot Density	
Pay Adjustment Factor (PAF) [a] % of Maximum Theoretical Density *(Calculated at the JMF AC Content)*	**Average Lot Density (ALD)**
>97.0	Unacceptable [b]
92.0 – 97.0	1.00
91.0 – 91.9	1.00 − (0.07)(92.0 − ALD)
88.1 – 90.9	0.93 − (0.15)(91.0 − ALD)
<88.1	Unacceptable [b]

[a] Use PAF for Roadway Density in the Combined Pay Factor equation in accordance with Subsection 411.04.N(2)(a), "Basis of Acceptance and Payment."
[b] Unless otherwise directed by the Resident Engineer, remove and replace unacceptable lots at no additional cost to the Department.

(b)Layers Less Than 1½ in [40 mm] Thick

Use test strips and monitor asphalt placement daily to obtain approval for rolling patterns generating optimum compaction. While the Department considers the target to be 94 percent of Maximum Theoretical Density, the Resident Engineer will base acceptance on the Contractor's performance, as approved by the Resident Engineer, to obtain optimum compaction.

Compaction test strips consist of 500 yd² [500 m²] of HMA pavement.

To obtain the acceptable density, construct enough strips to determine the number, size, and weight of compactors, and the number of coverages made by the compactors. Use an approved a nuclear or non-nuclear density gauge to determine the density of the test strip.

Construct a new compaction test strip if directed by the Resident Engineer or at least one of the following conditions exists:

- There is a change in the material or mix design;
- There is reason to believe a compaction test strip density is not representative of the material being placed; or
- The foundation material has changed significantly.

Compact the HMA in accordance with the approved rolling pattern. Ensure the rolling sequence, the type of compactor, and the maximum roller speed are in accordance with Table 411:3.

Table 411:3 Rolling for Compaction		
Rolling Sequence	**Type of Compactor**	**Maximum Roller Speed, *ft/s [m/s]***
Initial	Steel-Wheel Or Pneumatic-Tired	3.7 [1.1]
Intermediate	Pneumatic-Tired	4.4 [1.3]
Finish	Static Steel	4.4 [1.3]

Lower the production rate or add rollers to the paving operation to avoid exceeding the maximum roller speeds.

(3) Documentation

If required by the Contract, document HMA pavement work in accordance with Subsection 411.04.K(2)(b), "Layers Less Than 1½ in [38 mm] Thick." Include records of the Resident Engineer's directions and the resulting corrective actions. Ensure the records include a detailed description of the equipment, including weight, tire pressure, speed, and the number of coverages. Ensure the roller operators and superintendent (or other Contractor representative), sign the records at the end of each day's operation. Immediately after signing, submit the records to the Resident Engineer for inspection. Submit the records to the Resident Engineer at the conclusion of work on each day in accordance with Subsection 411.04.K(2)(b), "Layers Less Than 1½ in [38 mm] Thick."

L. Tolerances

(1) Surface

Construct a finished pavement surface as shown on the Plans and in accordance with Subsection 401.04.A(1), "Surface Elevation and Smoothness."

(2) Width and Thickness

Construct a finished pavement structure in conformance to the widths and thicknesses of individual layers and the total thicknesses of HMA shown on the Plans or directed by the Resident Engineer.

M. Opening to Traffic

Do not allow traffic on the pavement until after final rolling and the pavement has cooled sufficiently to ensure traffic will not damage the pavement surface. Use water or other artificial means to assist in cooling, as approved by the Resident Engineer.

N. Mix Properties

(1) General

Provide quality control personnel to ensure the production of acceptable products. Ensure the quality control personnel oversee the process control of HMA materials during handling, mixing, and placing operations.

At no time will the Resident Engineer provide instructions to the Contractor or producer as to the setting of dials, gauges, scales, or meters; however, the Resident Engineer may advise the Contractor or producer against continuing any operations or sequences of operations that will result in non-compliance with the Contract requirements.

(2) Acceptance

The Resident Engineer will accept and pay for, or reject, each lot of HMA pavement as defined in accordance with the following:

(a) *Basis of Acceptance and Payment*

The Resident Engineer will consider asphalt cement content, air voids, and roadway density to determine acceptance and payment for HMA pavement.

The Resident Engineer may use several test methods to determine acceptability of asphalt cement content, air voids, and roadway density (in accordance with Subsection 411.04.K, "Compaction"). The Resident Engineer will only use one test method, but may perform several tests using that method

to measure each characteristic. The Resident Engineer will calculate the average deviation for each characteristic in accordance with Table 411:4, "Acceptance Schedule," and use the average to determine acceptance and calculate pay factors. For the characteristics of asphalt cement content and air voids, the Resident Engineer will disregard algebraic signs of the deviations to calculate averages. The Resident Engineer will address deviations above or below the target for these characteristics.

Perform sieve analyses in accordance with Subsection 708.04, “Composition of Mixtures,” or as modified by the special provisions. If a sieve analysis result does not fall within the tolerances specified in the JMF, provide test results that demonstrate that the HMA mixture meets the following requirements in accordance with Subsection 708.04, “Composition of Mixtures”:

- The gradation falls within the broad band; and
- The air voids at N_{des} and VMA fall within the ranges.

The Department will require a new mix design if the broad band gradation, air voids at N_{des}, or VMA requirements are not met.

The Resident Engineer will apply calculated pay factors for asphalt cement content, air voids, and roadway density to all acceptable HMA pavement. The Resident Engineer may consider additional pay factors for other characteristics including but not limited to smoothness. The Resident Engineer will base the total pay adjustments for deficiencies on the following:

- All pay adjustments will be based on the individual pay factors shown in Table 411:2, “Pay Adjustments for Lot Density” and Table 411:4, “Acceptance Schedule.”
- Except for smoothness, pay factors will be applied on a lot by lot basis.
- For smoothness, pay factors will be applied on an extent by extent basis.

Pay adjustments on lots, (all characteristics except smoothness) as each 1,000 ton (1,000 metric ton) lot is complete, will be made for deficiencies in asphalt cement content, roadway density, and air voids using the following formulas. If test results are incomplete at that time, an interim adjustment will be made assuming pay factors of 1.00 for the then unknown characteristics and corrected later when testing is completed.

The Resident Engineer will determine the total pay adjustment (combined pay factor) for HMA pavement with deviations, using the following equation:

$$CPF = \frac{4RD + 3AC + 3AV}{10}$$

where

CPF = Combined pay factor,
RD = Pay factor for roadway density,
AC = Pay factor for asphalt cement content, and
AV = Pay factor for air voids.

For layers less than 1½ in [38 mm] thick, the Resident Engineer will use a pay factor of “one" for roadway density. For permeable friction course, open-graded friction surface course, and open-graded bituminous base mixes,

that do not have a target roadway density or target for air voids, the Resident Engineer will use pay factors of "one" for both roadway density and air voids.

(b)*Resident Engineer's Acceptance Procedures*

Once a lot has been defined, maintain its identity throughout the mixing and placement process.

The Resident Engineer may perform varying amounts of the following sampling and testing per lot.

- Asphalt cement content: one sample, randomly selected for each characteristic.
- Roadway density: three samples, randomly selected, averaged, and considered as one test in accordance with Table 411:2.
- Air voids (lab-molded): two samples, randomly selected, averaged, and considered as one test in accordance with Table 411:4.

The Resident Engineer will use Table 411:4 for determining acceptance and calculating pay factors:

Table 411:4
Acceptance Schedule

Characteristics	1 Test	Pay Factor
Deviation from JMF (Without Regard to Sign)		
Asphalt Cement Content (Extraction, Nuclear or Ignition Oven) Target JMF Percent	0.00 – 0.40	1
	0.41 – 0.80	1.40 - (Deviation from JMF)
	>0.80	Unacceptable [b]
Asphalt Cement Content (Digital Printout from Hot-Mix Plant) Target JMF Percent	0.00 – 0.20	1
	0.21 – 0.30	1.80 - 4 x (Deviation from JMF)
	>0.30	Unacceptable [b]
Average of Deviations from Target (Without Regard to Sign)		
Air Void (Lab Molded Samples) [a] Target (Superpave, SMA) = 4% Target (RBL) = 2%	0.00 – 1.50	1
	1.51 – 2.50	$-0.16X^2 + 0.24X + 1.00$
	>2.50	Unacceptable [b]

[a] X is the average of deviations.
[b] Unless otherwise directed by the Resident Engineer, remove and replace unacceptable lots at no additional cost to the Department.

O. Patching

Patch existing asphalt pavement as shown on the Plans or as directed by the Resident Engineer.

411.05 METHOD OF MEASUREMENT

The Resident Engineer will measure HMA pavement as a combined mixture including the aggregate, liquid asphalt, and other materials required in accordance with the mix design.

411.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) SUPERPAVE, TYPE S2	Ton [Metric Ton]
(B) SUPERPAVE, TYPE S3	Ton [Metric Ton]
(C) SUPERPAVE, TYPE S4	Ton [Metric Ton]
(D) SUPERPAVE, TYPE S5	Ton [Metric Ton]
(E) SUPERPAVE, TYPE S6	Ton [Metric Ton]
(F) STONE MATRIX ASPHALT	Ton [Metric Ton]
(G) RICH BOTTOM LAYER	Ton [Metric Ton]
(H) SUPERPAVE, TYPE S3, (PATCHING)	Ton [Metric Ton]
(I) SUPERPAVE, TYPE S4, (PATCHING)	Ton [Metric Ton]

The Department will pay for HMA by the lot, in accordance with Subsection 411.04.N(2), “Acceptance,” on the basis of acceptance test results.

The Department will pay for HMA used for control strip requirements in accordance with Subsection 411.04.D, “Control Strip Requirements,” and Subsection 105.03, “Conformity with Plans and Specifications.”

The Department will consider the cost of startup operations to be included in the contract unit price for the relevant asphalt pavement pay item.

The Department will consider the cost of cutting samples and replacing sample materials to be included in the contract unit price for the relevant HMA pay item.

The Department will pay for tack coat in accordance with Section 407, “Fog Seal and Tack Coat.”

SECTION 412
COLD-MILLING PAVEMENT

412.01 DESCRIPTION

This work consists of cold-milling and removing pavement surfaces to the specified depth, and removing ridges, ruts, and imperfections.

412.02 MATERIALS — VACANT

412.03 EQUIPMENT

Provide a milling machine that:

- Can plane at least 1½ in [40 mm] deep in a single pass;
- Is self-propelled;
- Has the power, traction, and stability to maintain accurate depth of cut and slope;
- Automatically establishes profile grades along each side of the milling machine by referring to the existing pavement with a ski or matching shoe, or by an independent grade control;
- Automatically controls cross slope; and
- Has an integral loading mechanism to remove the material cut from the pavement surface and discharge it into a truck in one operation.

412.04 CONSTRUCTION METHODS

Mill the existing pavement to the line, grade, and cross section shown on the plans, and provide a milled surface that has a uniform texture and a smooth riding surface for traffic. Ensure no deviations are greater than $^{3}/_{16}$ in in a 10 ft [5 mm in a 3 m] section. Make corrections as approved by the Construction Engineer.

Make passes to remove irregularities and to profile the surface to the depth and cross slope shown on the Plans. Prevent traffic hazards. At the end of the daily milling operation, ensure that milled surface is smooth. Immediately apply fog seal to the milled areas, in accordance with Section 407, "Fog Seal and Tack Coat," unless overlaying the milled area with bituminous material on the same day.

Dispose of removed materials in accordance with Subsection 104.09, “Removal and Disposal of Salvaged Materials, Structures, and Obstructions.”

412.05 METHOD OF MEASUREMENT — VACANT

412.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
COLD MILLING PAVEMENT	Square Yard [Square Meter]

The Department will pay for fog seal in accordance with Section 407, “Fog Seal and Tack Coat.”

SECTION 413
RUMBLE STRIP

413.01 DESCRIPTION

This work consists of constructing noise-generating rumble strips in the hot mix asphalt (HMA) or portland cement concrete (PCC) pavement on driving lanes or the roadway shoulders.

Rumble strips categories are defined as follows:

Method HMA-CON. Continuous rumble strips cut in HMA shoulders.

Method HMA-CYC. GROUP A cyclic pattern of rumble strips cut in HMA pavement for intersection safety improvements.

Method PCC-CON. Continuous rumble strips cut in PCC shoulders.

Method PCC-CYC. GROUP A cyclic pattern of rumble strips cut in PCC pavement for intersection safety improvements.

413.02 MATERIALS — VACANT

413.03 EQUIPMENT

Provide a machine that produces incised grooves to the specified pattern and dimensional tolerances shown on the Plans.

413.04 CONSTRUCTION METHODS

After completing the pavement surface, machine-cut or rout the rumble strips. Produce rumble strips with the spacing, length, depth, and rumble section shown on the Plans. Use a single pass of a multi-cutter machine or multiple passes of a single-cutter machine to construct the grooves.

Remove millings and debris before opening the roadway surface to traffic.

Apply fog seal to the rumble strips cut in HMA pavement in accordance with Section 407, “Fog Seal and Tack Coat.”

413.05 METHOD OF MEASUREMENT — VACANT

413.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) RUMBLE STRIP-METHOD HMA-CON	Linear Foot [Meter]
(B) RUMBLE STRIP-METHOD HMA-CYC GROUP	Each Group
(C) RUMBLE STRIP-METHOD PCC-CON	Linear Foot [Meter]
(D) RUMBLE STRIP-METHOD PCC-CYC GROUP	Each Group

The Department will consider the cost of the fog seal on rumble strips in hot mix asphalt pavement to be included in the contract unit price for *Rumble Strip Method HMA-CON* or *Rumble Strip Method HMA-CYC GROUP*.

SECTION 414
PORTLAND CEMENT CONCRETE PAVEMENT

414.01 DESCRIPTION

This work consists of constructing the following types of portland cement concrete (PCC) pavement on a prepared base:

- Plain jointed (doweled or undoweled),
- Continuously reinforced,
- Bonded overlay (over existing PCC or hot mix asphalt (HMA) pavements), and
- Unbonded overlay (over existing PCC or HMA pavements).

414.02 MATERIALS

Provide materials in accordance with the following sections and subsections:

Materials:	Section or Subsection:
Portland Cement Concrete	701
Fly Ash	702.01
Ground Granulated Blast Furnace Slag	702.02
Steel Reinforcement, Dowel Bars & Tie Bars	723

Provide bent tie bars in accordance with AASHTO M 31, “Deformed Billet-Steel Bars for Concrete Reinforcement,” Grade 40.

Obtain written approval from the Department if using reclaimed PCC materials. The Department will allow the use of reclaimed PCC materials only on temporary pavement. Provide the materials in accordance with Section 701, “Portland Cement Concrete.”

414.03 EQUIPMENT

Ensure the equipment is at the job site before construction begins.

A. Plants and Equipment

Ensure the batching plant includes bins, weighing hoppers, and scales for each size of fine and coarse aggregate. If using cement in bulk, include a bin, hopper, and separate scale for cement. Seal and vent the weighing hoppers to prevent dusting. Ensure gauges and dials function properly.

Give the Department documented evidence that the batching plant produces quality concrete. Ensure the mixing plant is in accordance with AASHTO M 157, “Concrete Uniformity Requirements.”

Regularly clean the mixers. Repair or replace the pickup and throw-over blades that are worn one-sixth or more of the original blade width. Provide the manufacturer’s design or permanent marks on the blades to show the blade’s dimensions and configurations in reference to original height and depth. The Department recommends drilling holes with a diameter of ¼ in [6 mm] near the ends and midpoint of each blade as reference points.

Vent storage silos for cementitious materials during filling or use. If using a pressurized air system for discharge, ensure that it has moisture traps to reduce caking of materials during storage.

The Department will inspect the plants every six months or after every move. Provide certification of scales every six months or after every move, unless otherwise directed by the Resident Engineer.

B. Placing and Finishing Equipment

Provide a slip form paver or fixed form method to spread, strike-off, and finish concrete, unless otherwise approved by the Resident Engineer.

(1) Slip Form Paver

Provide a slip form paver to spread, consolidate, screed, and float-finish the concrete in one pass of the machine, to minimize hand-finishing. Provide a machine that uses vibrating tubes or arms working in the concrete or with a vibrating screed or pan operating on the surface. Ensure the machine vibrates for the full width and depth of the pavement.

Provide vibrating machines with following frequency ratings:

Table 414:1
Vibrator Frequencies

Vibrator Type	Minimum Frequency Rating, *Impulses/min*
Surface Vibrators	3,500
Internal Type Tube Vibrators	5,000
Spud Vibrators	7,000
Spud Type Internal Vibrators	3,500

Ensure the spud vibrators do not come into contact with the joint, load transfer devices, subgrade, or side forms.

Prevent sliding forms from spreading using a rigid, lateral connection.

(2) Fixed Form Method

(a) *Finishing Machine*

Provide a finishing machine equipped with at least two oscillating-type transverse screeds for finishing the surface to the tolerances required by the Contract.

Provide surface pan-type vibrators for pavement thicknesses no greater than 8 in [200 mm] or internal-type vibrators with immersed tubes or multiple spuds to consolidate the full width and depth of the pavement. Attach vibrators to the spreader or the finishing machine, or mount them on a separate carriage. Ensure the frequency ratings are in accordance with Table 414:1, "Vibrator Frequencies."

Ensure the vibrators do not come into contact with the joint, load transfer devices, subgrade, or side forms.

(b) *Vibrating or Rotary Strike-Off Screeds*

Provide forms and vibrating or rotary strike-off screeds to construct radii, inlet basins, gore areas, lane tapers, intersection quadrants, and areas inaccessible to mainline paving equipment. The Resident Engineer will not

allow segregation or grout buildup. To achieve thorough consolidation and uniformity of the pavement, ensure the spud-type hand operated vibrators have a frequency rating of at least 3,500 impulses per minute.

(3) Texturing Equipment

Provide fabric texturing equipment that consists of a drag of seamless strips of burlap or cotton that produces a uniform, gritty texture. Ensure a strip of fabric with a width of at least 3 ft [1 m] is in contact with the full width of the pavement during texturing. Ensure the drag consists of at least two layers of fabric. Ensure the bottom layer of fabric is 6 in [150 mm] wider than the top.

Provide a texturing machine that is a vibrating roller or a comb, equipped with steel tines. Ensure the machine is self-propelled and automatically lifts the roller or tine comb bar near the edge of the pavement. The Resident Engineer will allow hand-texturing in areas inaccessible to mechanical equipment.

C. Concrete Saw

Provide a concrete saw that is conventional wet cut type or early entry dry cut type. Provide at least one standby saw. Maintain an ample supply of saw blades at the work site during sawing operations. Provide artificial lighting for night sawing.

D. Forms

Provide metal straight-side forms with thicknesses of at least $^{7}/_{32}$ in [5 mm] and lengths of at least 10 ft [3 m]. Construct forms to a depth equal to the concrete thickness shown on the Plans, and capable of supporting equipment operating on the forms.

For curves with a radius of 100 ft [30 m] or less, use flexible or curved forms with devices for secure settings capable of withstanding equipment impact and vibration.

Ensure the flange braces extend out on the base at least two-thirds of the form height. Remove damaged forms, and use repaired forms that the Resident Engineer has inspected and approved. Ensure the top face of the form varies no more than ⅛ in in 10 ft [3 mm in 3 m] from a true plane, and alignment varies no more than ¼ in in 10 ft [6 mm in 3 m]. Clean the forms of concrete, grout, and other materials. Before use, cover the forms with a form-release agent.

E. Header Boards

If stopping paving operations and header boards are used, set header boards, cut to the cross section of the paving slab, parallel to the transverse joint. Design the boards to ensure accurate installation of dowels or tie bars as shown on the Plans.

F. Floats

Provide mechanical or hand operated floats to smooth the concrete after strike-off and consolidation. Ensure the trowel blade of hand-operated floats are rigid, straightedge, from 12 ft to 18 ft [3.6 m to 5.4 m] long, and 8 in to 12 in [200 mm to 300 mm] wide. Ensure the float is capable of working longitudinally or transversely.

The Department will allow a finishing machine with the float pan type finisher in place of a mechanical or hand-operated float if this method obtains the surface tolerances required by the Contract.

G. Hand Tools

Provide work bridges, 10 ft [3 m] straightedges, and other hand tools to complete the pavement as required by the Contract. Replace warped floats or straightedges and defective finishing tools.

H. Spraying Equipment

Provide fully atomizing equipment to apply the white-pigmented curing membrane. Ensure it is equipped with a tank agitator that will keep the compound mixed. Ensure the Resident Engineer can verify the application rate based on tank capacity. Use pressure tank hand sprayers to apply the curing membrane to vertical surfaces, irregular areas, or edges after form removal.

I. Joint Sealing Equipment

Provide joint sealing equipment in accordance with Subsection 415.03, “Equipment.”

J. Milling Machine

Provide a milling machine in accordance with Subsection 412.03, “Equipment.”

K. Shot Blasting Equipment

Provide shot blasting equipment capable of collecting used shot and waste material. The Department will allow the use of recycled shot. Dispose of materials removed in the cleaning operation in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

414.04 CONSTRUCTION METHODS

A. Preparation of Existing Surface or Grade

(1) General

After grading and compacting the roadbed, trim the grade to the elevation shown on the Plans, extending the work at least 3 ft [0.9 m] beyond the edges of the concrete pavement. Ensure that subgrades and bases are in accordance with Subsection 301.04.A, “Tolerances.” Ensure that HMA base, bond breaker, and leveling course are in accordance with Subsection 401.04.A, “Tolerances.” Ensure the milled surfaces are in accordance with Section 412, “Cold-Milling Pavement.”

Correct the alignment and grade elevations of the forms and string lines immediately before placing the concrete. Reset and check disturbed forms or string lines.

Fill low areas with concrete during paving operations, not with material trimmed from bases or subgrades. Keep the grade smooth and compacted until pavement placement.

Unless waterproof subgrade or base course cover material is required by the Contract, ensure the subgrade or base is uniformly moist when placing the concrete.

(2) Unbonded Concrete Overlays

Construct specified HMA base, bond breaker, or leveling course in accordance with Section 411, “Hot Mix Asphalt.” Clean the pavement surface before placing the HMA. If required by the Contract, mill the surface before concrete placement

in accordance with Section 412, "Cold-Milling Pavement." After milling, tight blade the surface to remove ridges and loose material. The Department considers fine particles beneficial to the bond-breaking process; evenly distribute them. Notify the Resident Engineer if milling operations expose underlying concrete pavement. Spray exposed concrete with tack coat and cover with separator fabric.

Identify the location of transverse joints on both sides of existing concrete pavements before cold milling or placing asphalt bond breakers.

Place new transverse contraction joints at least 3 ft [1 m] upstream and at least 5 ft [1.5 m] downstream of an existing joint. Ensure the slab is from 12 ft to 16 ft [3.6 m to 4.8 m] long. Place a transverse contraction joint at the interface of overlaying and new pavement sections.

(3)Bonded Concrete Overlays

(a)*Bonded Overlays on Concrete Pavement*

Before surface preparation and placement of the PCC overlay, remove medium and high severity pavement cracking and replace as shown on the Plans. High severity pavement cracks are defined as shattered slabs, D-cracks into the wheel paths, broken slab corners into wheel paths, and cracks wider than ½ in [13 mm] that are faulting, spalled or scaled. Determine pavement-patching limits as approved by the Resident Engineer.

1) *Surface Preparation*

Prepare the entire surface to be overlayed by thoroughly cleaning the surface by milling and then shotblasting, or just shotblasting. The Department will not allow the use of water to clean the coldmilled debris from the surface as a slurry may develop and weaken the bond between the overlay and the surface. Remove all dirt, oil, laitance, or loose material from the surface and edges. Remove excess joint sealant on the surface; leave joint sealant in the joint slot. Remove pavement markings, raised pavement markers, and adhesives. Dispose of materials removed in the cleaning operation in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

2) *Surface Cleaning*

Before applying the overlay to the surface, clean the entire surface with an oil-free, compressed air blast. The Department will allow the use of water for final cleaning only after the shotblasing operation, as approved by the Resident Engineer. Remove all freestanding water before placing concrete. After cleaning, the Department will only allow the paving machine and the concrete delivery trucks to use the cleaned surface. Ensure the concrete trucks drive on the prepared surface directly in front of the paving machine. Prevent contamination of the cleaned pavement surface before placing the overlay. If the concrete becomes contaminated during concrete placement, stop production until the contamination is removed.

If a concrete truck contaminates the cleaned surface with oil, grease, water, mud, or other foreign objects, remove the truck from the cleaned surface, remove the contaminants, and ensure the truck is clean and repaired before returning to the project.

3) *Joint Identification*

Identify the exact location of both sides of contraction, expansion, and longitudinal joints in the existing pavement for sawing locations.

(b)*Bonded Overlays on Asphalt Pavement*

Prepare the surface to be overlaid by cleaning and milling. Remove dirt, oil, laitance, and loose material from the surface and edges. Remove pavement markings, raised pavement markers, and adhesives. Dispose of materials removed in the cleaning operation in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

B. Handling, Measuring, and Batching Materials

Ensure the batch plant and hauling equipment continuously supply material to the work site. Deliver fine and coarse aggregate to the plant in advance to allow time for sampling and testing. Ensure the concrete plant contains enough material for a full day of paving operations. Deliver and stockpile materials in accordance with Subsection 106.08, “Storage and Handling of Materials.”

Measure and batch materials for concrete in accordance with AASHTO M 157, unless otherwise required by the Contract. Weigh different aggregate sizes in separate hoppers. Measure cementitious material by weight. Use separate scales and hoppers with devices that indicate the complete discharge of the batch.

Use an electronically-controlled automatic batch weight and printer system that indicates the net batch weight of material delivered to the transporting truck. Ensure the weights are printed on a ticket that includes the quantities of admixtures and the volume of water incorporated into the load. Ensure the system is calibrated, inspected, and certified in accordance with Subsection 109.01.A, “Measurement of Quantities, General.” Ensure the combined weights of the materials, when converted to a volume, are within 2 percent of the volume on the ticket, minus the target air content.

C. Mixing Concrete

Mix and deliver concrete in accordance with AASHTO M 157, unless otherwise required by the Contract. Mix the concrete at the work site, in a central-mix plant, or in truck mixers. Obtain the Resident Engineer’s approval for the type of truck mixer. Do not exceed the manufacturer recommended capacity. Place the mixed concrete no more than 1 hr after the water, cement, and aggregate are combined.

Mix the concrete from 45 seconds to 90 seconds if at the work site or a central mixing plant. Mixing time ends when the discharge chute opens. For multiple drum mixers, include the transfer time as part of the mixing time. Remove the contents of the mixer drum before starting the next batch.

Control the mixer's drum speed in accordance with the manufacturer’s recommendations. The Resident Engineer may allow 10 percent overload of the mixer if the concrete does not spill and the concrete test data are satisfactory.

Ensure that a portion of the mixing water enters the drum before the cement and aggregates. Keep a uniform flow of water, and ensure that all water is in the drum within the first 15 seconds of the mixing. Keep the throat of the drum free from accumulations that restrict the flow of materials.

Adjust water to improve workability if transit mixers or agitators deliver the PCC. Increase mixing by 30 revolutions when adding water, and maintain the water to cementitious material ratio.

D. Light and Weather Limitations

Mix, place, and finish concrete when there is enough natural light, unless using artificial lighting approved by the Resident Engineer.

(1) Concrete Temperature

Ensure the temperature of the mixed concrete is from 50 °F to 90 °F [10 °C to 32 °C] during mixing, delivery, and placement. Protect the concrete quality through all weather conditions.

(2) Base Surface or Foundation Course Temperature

When placing an unbonded overlay, place the concrete when the base temperature is below 110 °F [43 °C]. Reduce the temperature by spraying a fine water fog on the base. Ensure water does not pond in front of the plastic concrete. For waterproof bases, the Department will also allow the following temperature control measures:

- Apply white curing compound, or
- Apply lime slurry.

Do not place concrete if frost exists in the base.

If using bonded overlays, place the concrete when the base temperature is below 110 °F [43 °C]. Cease paving operations if the base temperature exceeds 110 °F [43 °C]; do not attempt to reduce the base temperature because water and other agents prevent proper concrete bonding.

E. Setting Forms

If using formed paving equipment, set the forms to line and grade by shimming, or other methods approved by the Resident Engineer. Correct variations in the foundation course that prevent placing forms to the line or grade shown on the Plans. Stake forms in place with at least three pins per 10 ft [3 m] section. Place a pin at each side of the joints. Tightly lock form sections, and ensure that there is no movement. Ensure the forms do not deviate from true line by more than ¼ in [6 mm]. The Resident Engineer will not approve forms that move under the finishing machine. Clean and oil forms before placing the concrete.

F. Placing Concrete

(1) General

When placing concrete on the grade, minimize rehandling. Discharge concrete into a spreading device and mechanically spread onto the grade to prevent segregation. Use truck mixers, truck agitators, or non-agitating hauling equipment capable of discharging concrete without segregation. Between transverse joints, place the concrete continuously without using intermediate bulkheads. Hand spread concrete with appropriate tools; do not use handheld vibrators to spread concrete. Ensure soil or foreign materials are not tracked onto the recently placed concrete.

Ensure concrete cures for at least 3 days before allowing finishing equipment on it for placement of adjacent lanes. Before allowing other equipment onto the pavement, ensure that the concrete attains a strength in accordance with Subsection 414.04.N, "Opening to Traffic."

If using a slip-form paver, ensure continuous forward movement. Coordinate mixing, delivering, and spreading operations to provide uniform progress, minimizing stopping and starting. Stop vibratory and tamping elements if the forward movement of the paver stops.

Consolidate concrete against the grade, face of the forms, and joint assemblies. Minimize the operation of vibrators in a single location to that required for consolidation.

Deposit concrete near expansion and contraction joints without displacing the joint assemblies.

Remove foreign materials that fall onto the completed slab as approved by the Resident Engineer.

Do not place concrete without an inspector present, unless otherwise approved by the Resident Engineer.

(2) Continuously Reinforced Concrete Pavement (CRCP)

To disrupt the bond between the HMA and the CRCP, use a standard, white, wax-based curing compound on the HMA at the rate of 1 gal per 150 ft² [1 L per 3.7 m²]. Allow the bond breaker to dry before placing the reinforcing steel bars.

(a) ***Preparation of Steel Reinforcement***

Remove dirt, oil, paint, grease, mill scale, and loose or thick rust from the reinforcing steel. The Department does not consider minor, thin, powdery rust that does not reduce the effective cross section to be detrimental.

(b) ***Placement of Reinforcement for Continuously Reinforced Concrete Pavement***

Place reinforcement on chairs or high chair bars. Ensure the horizontal position is within ½ in [12 mm] of the longitudinal dimensions and within 2 in [50 mm] of the transverse dimensions shown on the Plans. Place the quantity of longitudinal and transverse members as shown on the Plans. Ensure the vertical position is within ½ in [12 mm] of the longitudinal and transverse dimensions shown on the Plans. Handle the reinforcement so that the bars remain flat and undistorted during concrete placement. Ensure the bars are free from kinks or bends that prevent assembly or installation. If using forms, oil before placing reinforcement.

Install the chairs or high chair bars to support reinforcement as shown on the Plans. Arrange the chairs to ensure the reinforcement is not permanently displaced during placement and consolidation. Ensure the base supports the chairs, and prevents overturning and penetration into the base.

Space high chair bars adjacent to other transverse members to allow for proper concrete placement; especially important at reinforcement laps.

The Department will allow welding of the chairs to transverse bars in a manner approved by the Resident Engineer.

If requested, provide the Resident Engineer with a sample of the chair or high chair bar. Show the chairs and layout on the Working Drawings. If the chairs do not support the reinforcement during concrete placement and finishing, take corrective action to ensure the final position of the steel as required by the Contract.

If the reinforcement consists of loose bars constructed on the grade, secure the longitudinal bars to the transverse bars using wire ties or clips to maintain the horizontal and vertical positions shown on the Plans.

(c) ***Lap Splices in Reinforcing Steel***

To ensure continuous reinforcement, lap the longitudinal reinforcing bars in a staggered pattern as shown on the Plans. Secure laps in the longitudinal reinforcement by tying, fastening with clips, or otherwise securely fastening.

(3) Unbonded Concrete Overlays

Place concrete on the grade to the minimum thickness shown on the Plans. The Department will only allow deviations for profile adjustments, cross-section adjustments, or both to be above the nominal thickness. When adjustments are necessary for grade or yield improvement, the thickness shall not, in any case, be less than the minimum thickness shown on the Plans.

G. Test Specimens

Provide concrete necessary for acceptance testing.

H. Joints

Construct joints perpendicular to the surface of the slab of the type, dimensions, and locations shown on the Plans. Align the joints using guidelines or devices approved by the Resident Engineer.

Ensure the sawed joints are straight and true to line; repair joints that are not. Seal the sawed joints in accordance with Subsection 415.04, “Construction Methods.”

(1) Longitudinal Joints

Only saw and seal longitudinal contraction joints. Place deformed steel tie bars of a length, size, spacing, and material shown on the Plans, perpendicular to the longitudinal joint. Place tie bars using mechanical equipment after concrete placement, or secure tie bars using supports to prevent displacement during concrete placement. Repair or replace loose bars at no additional cost to the Department. The Department will not allow bars to be painted, coated, or enclosed in tubes or sleeves.

Saw the longitudinal contraction joint to the depth shown on the Plans, without damaging the pavement or joint. Clean the sawed areas of dust, chalk, and contaminants and fill with an approved joint-sealing material.

Allow the joint sealant to cure before allowing construction equipment and other vehicles on the pavement. Adjacent surfaces should not vary by more than ⅛ in [3 mm] using a 10 ft [3 m] straightedge.

(2) Transverse Joints

(a) *Expansion or Isolation Joint*

Make the expansion joint filler continuous from form to form. Shape it along the form from the base to the keyway. Provide lengths of joint filler equal to the width of the pavement, or the width of one lane.

Use joint filler that is not damaged or repaired.

Punch premolded joint filler to the diameter of the dowels. Unless otherwise directed by the Resident Engineer, use lengths equal to the width of the pavement. If placing two or more traffic lanes of pavement, use premolded filler in sections equal to the width of one lane. Clip or lace joint filler sections together if there is more than one section per joint. Extend the bottom edge of the filler to below the bottom of the slab. Unless otherwise required b the Contract, ensure the top edge is 1 in [25 mm] below the surface of the pavement. While the concrete is being placed, protect the top of the filler using a metal channel cap of at least 10-gauge material, with flanges at least 1½ in [38 mm] deep.

After striking off and placing the concrete on both sides of the joint, withdraw the installing bar, and leave the premolded filler in place. Before removing the installing bar and channel cap, vibrate the concrete and incorporate additional, freshly mixed concrete into depressions left by the installing bar. Expose the filler for the full width of the slab. Clean and re-oil the installing bar before installing the next joint. After removing the side forms, open the ends of the transverse joints at the edges of the pavement for the depth of the slab. Before opening the pavement to traffic, seal or top out premolded joints with joint-sealing filler required by the Contract. Leave a uniform strip of joint-sealing filler slightly below the surface of the pavement.

For concrete curbing that cannot be sawed, use steel templates or other joint-forming dividers to construct joints and install them at the location shown on the Plans during concrete placement.

(b) *Contraction Joints*

Form transverse contraction joints by sawing to the depth shown on the Plans without damaging the pavement or joint. Saw succeeding joints consecutively from the beginning to the end of the day's run, and saw all transverse joints soon enough to prevent uncontrolled transverse cracking.

Clean and dry the sawed area. Keep it free from dust, chalk, contaminants, and spalling. Fill the sawed area with joint sealing material. Ensure the curing period for joints is complete before allowing construction equipment and vehicles on the pavement.

(c) *Transverse Construction Joints for Jointed Pavement*

Unless otherwise directed by the Resident Engineer, construct transverse construction joints when concrete operations are interrupted for more than 30 min, or as field conditions require during concrete operations. Ensure transverse construction joints are not constructed within 10 ft [3 m] of expansion or contraction joints. If, at the time of interruption, not enough concrete has been placed to form a slab at least 10 ft [3 m] long, remove the concrete to the

preceding joint and dispose of in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

Provide a rigid header with holes or slots for dowel bars with the same spacing and dimensions of an expansion joint. Submit alternative header construction methods to the Resident Engineer for approval.

(d)*Transverse Construction Joints for Continuously Reinforced Concrete Pavement*

Install a transverse construction joint at the end of each work day or when paving operations are interrupted for more than 30 min, or as field conditions require during concrete operations. Form the joint by placing the concrete against a header board. Extend the longitudinal reinforcing steel through the header board and support from the base to prevent deflections.

Cover the reinforcement that extends beyond the header board with sheets of plywood or other material so that workers can walk on the steel without displacing it and concrete does not spill on the base during screeding operations.

Make construction joints and lap splices as shown on the Plans.

Use hand vibrators to consolidate pavement areas adjacent to the sides of transverse construction joints and refinish the surface. Extend these areas at least 10 ft [3 m] from the joint. Ensure the adjacent surfaces do not vary by more than ⅛ in [3 mm] using a 10 ft [3 m] straightedge.

(3)Lightweight Early-Entry Saw Joints

The Department will allow the construction of transverse joints using a lightweight, early-entry saw. Ensure the blade is ⅛ in [3 mm] thick and the sawed joint is at least 1½ in [38 mm] deep. Saw joints in accordance with the manufacturer’s recommendation. Begin sawing the joint when the concrete is hard enough to cut without raveling, chipping, spalling, or tearing. The Resident Engineer will inspect the sawed faces to ensure that early cutting does not cause joint undercutting. Delay sawing if undercutting is deep enough to cause structural weakness or excessive joint roughness. Saw the joints consecutively at the spacing required by the Contract. Immediately after sawing, clean the cut and adjacent concrete surface. Respray damaged membrane-cured surfaces. Inspect the lightweight early-entry saw joints the next day. If a crack is not evident within 24 hr, re-saw the joint to a depth of T/3. Clean and seal joints in accordance with the manufacturer's recommendations, unless otherwise required by the Contract.

For bonded concrete overlays, saw joints directly over existing transverse and longitudinal joints, and using the following methods:

- Overlay sections equal to or less than 4 in [100 mm] thick; saw the joints ½ in [12 mm] deeper than the overlay concrete; and
- Overlay sections thicker than 4 in [100 mm]; saw joints to a depth of T/3.

Saw the joints without causing excessive raveling, chipping, spalling, or tearing. Clean and seal joints in accordance with the manufacturer's recommendations, unless otherwise required by the Contract.

(4) Load Transfer Devices

The placement method of load transfer devices is optional. Hold or mechanically place load transfer devices as shown on the Plans. Place dowels parallel to the surface and centerline of the slab and vary no more than ⅜ in [9 mm] from the position shown on the Plans. Cap expansion joint dowels as shown on the Plans. Check the placement of mechanically injected dowel bars using a SOILTEST Model CT-4950A Micro-Covermeter, or an equivalent.

I. Final Strike off, Consolidation, and Finishing

(1) General

Perform strike off, consolidation, and finishing in the following sequence:

- Strike off and consolidate,
- Float and remove laitance,
- Straightedge, and
- Finish the final surface.

The Department will not allow the application of water to the concrete surface to assist in finishing operations, unless the Resident Engineer approves otherwise. If the application of water is approved, apply as a fog spray using approved spray equipment.

(2) Finishing at Joints

Using mechanical vibrators, compact the concrete adjacent to the joints to prevent voids between the concrete and the joint material, load transfer devices, and joint assembly units.

(3) Slip-Form Paving

Use the slip-form paver to strike-off, consolidate, and initially finish the concrete. At the beginning of the day's paving operation, straightedge the construction joint and the initial slab longitudinally and transversely until the machine produces slab smoothness in accordance with Subsection 401.04.A, "Tolerances."

To ensure the edge of the pavement slab meets the elevations shown on the Plans, test using a 10 ft [3 m] straightedge perpendicular to the centerline of the roadway. Ensure the outer 6 in [150 mm] of the pavement does not deviate more than ¼ in [6 mm] from the bottom of the straightedge. Test for compliance throughout the paving operation.

Correct valleys or depressions that do not drain, at no additional cost to the Department.

Limit hand-finishing to correction of surface defects.

(4) Fixed-Form Paving

(a) *Machine Finishing*

Strike-off and screed freshly placed concrete using a finishing machine. Ensure the machine consolidates the pavement and creates a uniform texture. Keep the tops of the forms clean. To prevent an irregular finish, ensure the machine travels on the forms without lifting, wobbling, or moving unnecessarily.

During the first pass of the finishing machine, maintain a uniform ridge of concrete in front of the screed. Use a vibrator in accordance with Subsection 414.03.B, "Placing and Finishing Equipment," to vibrate the full width of concrete paving slabs.

(b)*Hand Finishing*

The Resident Engineer will allow hand-finishing methods under the following conditions:

- If the paving equipment breaks down, the concrete deposited on grade and in transit; and
- In narrow or irregular areas.

Hand finish in accordance with Subsection 401.04.A, "Tolerances."

Strike-off and screed the freshly placed concrete using a portable screed.

Use a screed at least 2 ft [0.6 m] longer than the maximum width of the slab. Use a vibrator or other equipment to consolidate the pavement.

Move the screed on the forms in the same direction as the paving operation with combination of longitudinal and transverse shearing motions. Ensure the ends of the screed do not rise from the side forms during strike-off. Repeat this process to produce a uniform surface and texture, free of porous areas.

(c)*Floating*

After consolidating and striking-off the concrete, use a float to smooth, true, and consolidate.

Use long-handled floats to smooth and fill-in porous areas. Maintain the crown in the pavement. After floating, remove excess water and laitance with a straightedge. Lap successive passes one-half the length of the float blade.

(5)Straightedge Testing and Surface Correction

After floating and removing excess water, and while the concrete is still plastic, use a 10 ft [3 m] straightedge to test the smoothness of the concrete surface. Hold the straightedge against the surface parallel to the road centerline. Advance the straightedge in successive stages of no more than one-half the length of the straightedge. Fill depressions with freshly mixed concrete, then strike-off, consolidate, and refinish. Cut and refinish high areas. Ensure that the adjacent surfaces across joints are smooth. Continue straightedge testing and surface corrections until the entire surface conforms to the grade and typical section shown on the Plans.

(6)Texturing

Use a texture drag before the pavement final finish to produce a uniform surface of gritty texture on the entire pavement surface. For pavement at least 16 ft [4.8 m] wide, mount the drag on a bridge. Clean the drag of encrusted mortar. Replace permanently encrusted drags with new ones.

(a)*Final Groove Finish*

When dragging is complete, mechanically groove and texture the driving lanes and ramps in a transverse direction as approved by the Resident Engineer.

Unless otherwise required by the Contract, the Department will not require transverse grooves on shoulders.

On any roads or streets with a posted speed limit of 45 mph or less, tine the surface as specified here, or obtain written approval from the appropriate local official to provide an alternate finish. At least 14 days before beginning paving, submit the proposal with documentation of local support to the Resident Engineer. Written approval from the Resident Engineer replaces the need for a change order, price adjustment, or both.

1) *Transverse Finish*

Construct transverse grooves perpendicular to the centerline of the pavement. Transverse grooving consists of creating transverse grooves from ⅛ in to $^{3}/_{16}$ in [3 mm to 4.8 mm] wide, from ⅛ in to $^{3}/_{16}$ in [3 mm to 4.8 mm] deep, and spaced on a rake as shown on the Plans.

Repeat the grooving pattern across the pavement. Form the grooves in the plastic concrete without tearing or bringing the coarse aggregate to the surface. Ensure the machine automatically lifts the roller or tines near the edge of pavement. Ensure the overlap between grooving passes is less than 3 in [75 mm].

Use hand-groove methods in areas inaccessible to mechanical grooving equipment.

Before tining transverse grooves, identify the location of transverse contraction joints and ensure the nearest grooves are from 1 in to 3 in [25 mm to 75 mm] from the contraction joints.

(b)*Edging at Forms and Joints*

After the final finish, but before the concrete sets, round the edges of the pavement along the sides of the slab to the radius shown on the Plans. Produce a well-defined and continuous radius and obtain a smooth, dense mortar finish. At the joints, broom the surface to eliminate tool marks adjacent to the joints without damaging joint edges.

Test the joint smoothness before the concrete has set and make corrections in accordance with Subsection 414.04.H, "Joints."

J. Curing

Immediately after completing the texturing operations and as soon as marring of the concrete will not occur, cover and cure the entire surface of the newly placed concrete in accordance with one of the following methods:

- Cotton or burlap mats,
- Impervious membrane method,
- White polyethylene sheeting, or
- Curing for cold weather.

Failure to provide sufficient cover material, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concrete operations. The Department will not allow the concrete to be left exposed for more than 30 min between stages of curing or during the curing period.

(1) Cotton or Burlap Mats

Cover the pavement surface with mats. Use mats long enough or wide enough to extend beyond the edges of the slab by at least twice the thickness of the pavement. Saturate the mats with water. Secure the mats to keep in contact with the surface. Ensure the mats are moist for 72 hr after concrete placement, unless otherwise required by the Contract or directed by the Resident Engineer.

(2) Impervious Membrane

Immediately after texturing operations and before the concrete sets, uniformly spray the pavement with white-pigmented curing compound in accordance with Subsection 701.07.C, "Liquid Membrane Curing Compounds." If the pavement is initially cured with cotton or burlap mats, apply the curing compound after removing the mats. Avoid applying the curing compound during rain.

Using a mechanical sprayer, in accordance with Subsection 414.03.H, "Spraying Equipment," apply the curing compound at a minimum rate of 1 gal per 200 ft² [1 L per 5 m²]. If the temperature on the roadway is more than 100 °F [38 °C], apply the curing compound at a minimum rate of 1 gal per 150 ft² [1 L per 3.75 m²].

Ensure the compound is thoroughly mixed and the pigment is uniformly dispersed. The Resident Engineer will allow hand spraying irregular widths, shapes, and surfaces exposed by removed forms. Ensure the curing compound is not applied to the inside faces of joints.

Ensure the curing compound creates a film that will harden within 4 hr of application. Use additional compound to repair damage to the membrane that occurs during the curing period.

Upon removing the side forms, apply curing compound to the sides of the slabs.

For bonded overlays, apply the curing compound immediately after texturing operations at a minimum rate of 1 gal per 100 ft² [1 L per 2.5 m²], or as recommended by the manufacturer, to prevent moisture loss.

(3) White Polyethylene Sheeting

Cover the surface and sides of the pavement with polyethylene sheeting. Use sheeting long enough or wide enough to extend beyond the edges of the slab by at least twice the thickness of the pavement. Overlap adjacent sheeting units at least 18 in [450 mm]. Secure the sheeting to keep it in contact with the surface. Ensure

the sheeting remains in place for 72 hr after concrete placement, unless otherwise required by the Contract or directed by the Resident Engineer.

(4) Curing for Cold Weather

Maintain the quality and strength of the concrete during cold weather. Replace frost-damaged concrete at no additional cost to the Department.

K. Removing Forms

Avoid damaging the pavement while removing forms. Cure the sides of the slab in accordance with Subsection 414.04.J(2), "Impervious Membrane." Repair honeycombed areas.

L. Sawing and Sealing Joints

Saw and seal joints in accordance with Subsection 415.04, "Construction Methods." Provide joints as shown on the Plans.

M. Protection of Pavement

Protect the pavement from damage due to any traffic. If damage occurs to the pavement before the area is open to traffic, repair or replace the damaged sections at no additional cost to the Department.

N. Opening to Traffic

Do not allow traffic on the pavement for at least 14 days after concrete placement, unless otherwise approved by the Resident Engineer. The Resident Engineer may approve opening the pavement to traffic when it reaches the strength requirement in accordance with Subsection 701.01, "Mix Design and Proportioning." With the approval of the Resident Engineer, the Contractor may use maturity meters for the basis of form removal or opening roadways to traffic, at no additional cost to the Department. Submit a plan for the use of maturity meters.

O. High-Early-Strength Concrete Pavement

Use high early-strength concrete pavement in accordance with Section 701, "Portland Cement Concrete." Do not allow traffic on the pavement until it reaches the strength requirement in accordance with Subsection 701.01, "Mix Design and Proportioning."

P. Protection Against Rain

Protect the surface from rain. Repair or replace damage due to rain, at no additional cost to the Department.

Q. Tolerances

(1) Surface

Construct a finished pavement surface as shown on the Plans and in accordance with Subsection 401.04.A(1), "Surface Elevation and Smoothness."

(2) Width

Construct a finished pavement width as shown on the Plans and in accordance with Subsection 401.04.A(2), "Width."

(3) Thickness

After grinding operations, determine the thickness of the pavement using the average of three caliper measurements of cores, tested in accordance with AASHTO T 148. Thickness will be in accordance with Subsection 414.04.R, "Acceptance of Pavement."

R. Acceptance of Pavement

While the Contractor shall be fully and exclusively responsible for producing an acceptable product, acceptance responsibility rests with the Engineer.

Determination of acceptability and pay factors for gradation, air content, strength, and thickness will be made in accordance with Table 414:2, "Acceptance Schedule." The pay adjustments for the characteristics will be based on the following equations:

$$CPF = \frac{4(S+T)+G+AC}{10}$$

$$PA = (CPF - 1)(Q_C \times CUP_C + Q_P \times CUP_P)$$

where

CPF = Combined pay factor,

S = Pay factor for strength,

T = Pay factor for thickness,

G = Pay factor for gradation,

AC = Pay factor for air content,

PA = Pay adjustment,

Q_C = Cubic yards [cubic meters] of concrete in a 2,500 yd² [2,500 m²] lot (partial lots prorated),

CUP_C = Contract unit price of concrete only ($/yd³ [$/m³]),

Q_P = Square yards [square meters] of concrete in a 2,500 yd² [2,500 m²] lot (partial lots prorated), and

CUP_P = Contract unit price of concrete placement ($/yd² [$/m²]).

Note: CUP_C and Q_C include only the concrete material. CUP_P and Q_P include all other labor and materials required in the concrete pavement (reinforcing steel, dowels, curing compound, etc.).

The Resident Engineer will base pay adjustments on the individual pay factors shown in Table 414:2 on a lot to lot basis. A lot will normally be defined as 2,500 yd². To ensure the overall quality of the material and workmanship, the Resident Engineer may reduce the size of a lot when multiple concrete placements occur. If test results are incomplete at that time, the Resident Engineer will make an interim adjustment assuming pay factors of 1.00 for the then unknown characteristics and will correct later when testing is complete. The total adjustment in pay for the four characteristics in the Table 414:2—gradation, air content, strength, and thickness—will be the sum of the pay adjustments on individual lots.

The Department will use random samples to test concrete and will test for all control test characteristics except smoothness on a lot to lot basis in accordance with

the following requirements. Determination of acceptability and pay adjustments for smoothness, when applicable, will be covered by separate specifications. However, the Resident Engineer will reject any load of mixture that is visually unacceptable for reasons of being too wet, excessively segregated, or otherwise obviously deficient. Furthermore, the Department will extensively test sections of completed pavement that appear to be seriously inadequate based on visual observation or knowledge of other deficiencies. The Department will not use the results of such tests for pay adjustment purposes, but will use them to determine whether the section is totally unacceptable and must be removed. The Resident Engineer may reject pavement slabs with unsound concrete, uncontrolled cracking, malfunctioning sawed joints, spalling, honeycombing, surface irregularities, insufficient thickness, or other deficiencies associated with poor quality pavements.

(a)*Engineer's Acceptance Procedures*

Once a lot has been defined, maintain its identity throughout the mixing and placement process. The Department will use pay factors, determined from random sampling and testing of a lot at the appropriate locations, in computing its pay adjustment.

In general the Engineer will use Table 414:2 for acceptance purposes, however, depending on the available time and the Engineer's confidence in the Contractor's process control, the Engineer may elect to perform more or less sampling and testing.

Table 414:2
Acceptance Schedule

Characteristics	1 Test	Pay Factor [a]
Gradation [c] - Deviation from the target (without regard to signs):		
Coarse or fine aggregates % passing No. 200 sieve Target Spec. Range, %	0	1.00
	0.01–0.60	$1-0.10x$
	0.61–1.80	$1.03-0.15x$
	>1.80	Unacceptable [b]
Air content [c] - Deviation from the target (without regard to signs):		
Target = 6.0%	0–1.50	1.00
	1.51–3.00	$-0.10x^2+0.29x+0.79$
	>3.00	Unacceptable [b]
Strength [d] – Deviation from minimum strength of target (considering signs):		
Target = 3,000 psi	0–1,000 psi	Pay Factor=(Actual Strength/Specified Strength)
	>1,000 psi	Unacceptable [b]
Thickness [e] – Deviation from minimum (considering signs) (English):		
% Deficient	0–2.0	1.00
	2.1–4.0	$1.10-0.05(PD)$
	4.1–6.0	$1.30-0.10(PD)$
	6.1–8.0	$1.60-0.15(PD)$
	>8.0	Unacceptable [b]

Table 414:2
Acceptance Schedule

Characteristics	1 Test	Pay Factor [a]

[a] Where *x* is the Average of Deviations and *PD* is Percent Deficient.
[b] Unless otherwise directed by the Engineer, products testing in this range are unacceptable and shall be removed and replaced at no additional cost to the Department.
[c] Gradation and air content – 1 specimen and 1 test for each characteristic per sublot.
[d] Strength – 3 cylinders per lot averaged and considered as 1 test in Table 414:2.
[e] Thickness – After grinding operations, determine the thickness of the pavement using the average of 3 cores at times and locations directed by the Engineer.

To determine the average thickness for a lot, the Department will only consider the minimum thickness plus 2 percent for core thicknesses greater than 2 percent thicker than the minimum thickness (e.g. if the minimum thickness shown on the Plans equals 10 in [250 mm], the Department will only consider 10.2 in [255 mm] for the average thickness determination for a core thickness of 10.3 in [257.5 mm]).

The Department will not include in its average thickness determination measurements that are more than 8 percent thinner than the minimum thickness shown on the Plans, or the measurements from exploratory cores. If the measurement of any core is thinner than the minimum thickness shown on the Plans by 8 percent or more, take exploratory cores at intervals of at least 10 ft [3 m], parallel to the centerline until the Department finds a core that is less than 8 percent thinner than the minimum thickness.

Fill core holes with concrete as required by the Contract.

(b)*Unacceptable or Rejected Work*

Replace rejected slabs with new pavement at no additional cost to the Department. When replacing rejected slabs, remove a width of at least one lane and a length of at least 15 ft [4.5 m]. If the removal is within 15 ft [4.5 m] of any transverse joint, remove the slab to the joint. If a deficient unit does not warrant removal, as directed by the Resident Engineer, the Department will not pay for the deficient unit.

414.05 METHOD OF MEASUREMENT

The Resident Engineer will measure PCC placement, of the type shown on the Plans, by the area of accepted and complete-in-place pavement.

The Resident Engineer will measure the volume of PCC used for new pavement construction (except for detours and crossovers), without regard to thickness, type of cement, or type of pavement, based on the on the actual length paved multiplied by the theoretical cross section show on the Plans. The Resident Engineer will measure the volume of PCC used for overlaying existing pavement, bonded or unbonded, using the ticket count, or other documentation approved by the Resident Engineer.

The Resident Engineer will measure detours and crossovers as shown on the Plans.

414.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) P.C. CONCRETE PAVEMENT (PLACEMENT)	Square Yard [Square Meter]
(B) DOWEL JOINTED P.C.C. PAVT. (PLACEMENT)	Square Yard [Square Meter]
(C) CONT. REINF. P.C.C. PAVT. (PLACEMENT)	Square Yard [Square Meter]
(D) BONDED P.C.C. OVERLAY (PLACEMENT)	Square Yard [Square Meter]
(E) FULL DEPTH P.C.C. PATCH (PLACEMENT)	Square Yard [Square Meter]
(F) PARTL. DEPTH P.C.C. PATCH (PLACEMENT)	Square Yard [Square Meter]
(G) P.C. CONCRETE FOR PAVEMENT	Cubic Yard [Cubic Meter]
(H) P.C. RAILROAD APPROACH SLABS	Square Yard [Square Meter]
(I) TERMINAL JOINT	Each
(J) TERMINAL JOINT SLEEPER SLAB	Square Yard [Square Meter]

The Department will consider the cost of placing concrete pavements, including relevant labor and material (except the PCC), and the cost of reinforcing steel, load transfer devices, joint fillers, and joint sealants to be included in the contract unit price for the relevant “Placement” pay items.

The Department will not pay for substitutions of high early-strength concrete for standard PCC.

The Department will consider steel, concrete, and materials needed for approach slab construction to be included in the contract unit price for *P.C. Railroad Approach Slabs*.

The Department will consider steel, concrete, and other materials needed for joint construction to be included in the contract unit price for *Terminal Joints*.

The Department will consider steel, concrete, and other materials needed for slab construction to be included in the contract unit price for *Terminal Joint Sleeper Slabs*.

The Department considers the cost of filling core holes to be included in the contract unit price for the relevant portland cement concrete pavement pay items.

The Department will pay adjusted prices for deficient units of pavement in accordance with Subsection 414.04.Q(3)(d), “Payment Adjustment.”

SECTION 415
CONCRETE JOINT SEALING

415.01 DESCRIPTION

This work consists of sawing, cleaning, and sealing joints in existing portland cement concrete pavement.

415.02 MATERIALS

Provide materials in accordance with Subsection 701.08, “Joint Fillers and Sealer.”

415.03 EQUIPMENT

Provide the following equipment:

A. Concrete Saw

Provide concrete saws capable of sawing concrete joints to the dimensions shown on the Plans.

B. High-Pressure Water Pumping System

Provide high-pressure water pumping systems capable of flushing concrete slurry from sawed joints.

C. Sand Blasting Unit

Provide compressed air sand blasting units capable of cleaning joint surfaces as specified. Ensure the units include traps to remove free water and oil from the compressed air.

D. Air Compressor

Provide air compressors capable of delivering compressed air with a pressure of at least 90 psi [620 kPa]. Ensure the compressors include traps to remove free water and oil from the compressed air.

E. Extrusion Pump

Provide air-powered extrusion pumps to apply joint sealer. Ensure the pump output is capable of delivering the volume of the joint sealer to the joint as specified.

F. Injection Tool

Provide a mechanical injection device to insert the sealer into the joint.

G. Joint Sealer Kettle

If the joint sealant requires heating, provide a double-bottom oil-bath indirect-flame type kettle. Ensure the kettle is capable of mixing, heating, delivering, and maintaining the specified temperature.

415.04 CONSTRUCTION METHODS

A. Sawing Joints

Saw the joints to the dimensions shown on the Plans. Produce a joint of uniform width with cut faces on both sides along its full length.

B. Flushing Joints

After sawing, remove the slurry from the joint area by flushing it with a high-pressure water system and other necessary equipment.

C. Cleaning Joint Faces

(1) General

Before installing the joint sealer or filler, clean the sawed faces of the joints of foreign material

Do not blow dry the joints with compressed air or use portable hand saws to clean joint faces.

(2) Sandblasting

Sandblast joint faces after they dry. Attach the sandblaster nozzle to a mechanical aiming device to direct the sandblast at a 45° angle and maintain sandblasting at less than 2 in [50 mm] from the joint faces.

After sandblasting, blow out the joints using filtered (oil and moisture free) compressed air at least 90 psi [620 kPa] and 120 ft^3/min [3.4 m^3/min]. Use a blow tube that fits into the joint. Repeat the sandblasting and blowing until no residual dust or coating remains in the joint.

(3) Joint Contamination

Before sealing joints, clean the joints of any contaminates due to traffic or weather.

D. Backer Rod

If shown on the Plans or recommended by the sealant manufacturer, install a backer rod before applying the joint sealant. Use a backer rod of the type recommended by the sealant material manufacturer. Install backer rod to the dimensions shown on the Plans.

E. Sealing Joints

Clean, or reclean, and seal joints on the same day.

(1) Approval of Joints for Sealing

The Department's inspectors will examine joints prepared for sealing. The Resident Engineer will not approve joints for sealing if the joints are contaminated or wet.

(2) Installation of Joint Sealers and Fillers

The Resident Engineer may require that a representative of the joint filler manufacturer, joint sealer manufacturer, or both be on the job site at the beginning of the joint-sealing. The representative shall demonstrate the manufacturer's installation standards.

(3) Application of Joint Sealers

Apply the joint sealer using a Resident Engineer approved mechanical injection tool.

Apply the joint sealer when the joint temperature is above 40 °F [4 °C] and joints are clean and dry.

Inject sealers into the joint. Ensure that the sealers bond to the joint face surfaces. For surfaces of joint sealers that require tooling, use an approved mechanical device to make a concave surface from ¼ in to ½ in [6 mm to 12 mm] below the pavement surface. Complete the tooling before a skin forms on the surface of the sealer. Do not use soap or oil as a tooling aid.

For self-leveling joint sealers, tooling is not required.

(4)Bonding Failures

Repair sealants that fail to bond to sawed concrete joint surfaces, at no additional cost to the Department.

F. Traffic

Ensure the freshly applied joint sealant is no longer sticky before allowing traffic on it.

415.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of concrete joint sealing after the joint sealant is in place.

415.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
CONCRETE JOINT SEALING	Linear Foot [Meter]

SECTION 416
DOWEL BAR RETROFIT

416.01 DESCRIPTION

This work consists of restoring load transfer in existing portland cement concrete (PCC) pavement by installing epoxy coated dowel bars across transverse joints or cracks.

416.02 MATERIALS

A. Dowel Bars

Provide epoxy-coated dowel bars in accordance with Subsection 723.08, "Epoxy Coated Reinforcement Bars," of the dimensions shown on the Plans. Provide tight-fitting, nonmetallic end caps that allow the bar to move ¼ in [6.25 mm] at each end.

B. Foam Core Board

Provide foam core board ¼ in [6.25 mm] thick, constructed of closed cell foam, and faced with poster board material on each side.

C. Dowel Bar Chairs

Provide nonmetallic dowel bar chairs to keep the dowel bars from moving during concrete placement. Place dowel bar chairs at the locations shown on the Plans, within the vertical and horizontal tolerances.

D. Portland Cement Concrete Patching Material

Provide PCC patching material to backfill retrofit slots in accordance with Section 701.16. Mix, place, and cure PCC patching material in accordance with the manufacturer's recommendations. The PCC patching material may be extended by using aggregate in accordance with Subsection 701.05, "Fine Aggregate," and Subsection 701.06, "Coarse Aggregate," excluding the gradation requirements. Provide and use a PCC mix design for the patching material (including additives) that develops a compressive strength of at least 4,000 psi [27.6 MPa] in 6 hr.

Provide curing compound in accordance with Subsection 701.07, "Curing Agents."

416.03 EQUIPMENT — VACANT

416.04 CONSTRUCTION METHODS

A. Slot Sawing

Use a gang saw capable of sawing at least three slots in the pavement at one time. Center the slots over the cracks and transverse joints, and align the slots so that the longitudinal axis of each dowel bar is parallel to the pavement centerline and the surface of the lower of the two panels. Ensure the vertical and horizontal alignment does not exceed ¼ in [6.25 mm].

B. Concrete Removal

Remove concrete from the slot area with a jackhammer no larger than the 30 lb [13.6 kg] class. If this jackhammer damages the pavement, discontinue its use and replace with a lighter jackhammer. Before installing the dowel, sandblast exposed surfaces and cracks in the slots, and clean slots of saw slurry and loose material.

Dispose of loose material in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

C. Foam Core Board

Place the foam core board to maintain the continuity of the existing transverse joint or crack. Size the foam core board to fit tightly around the dowel bar and to the bottom and sides of the slots. Caulk existing transverse joints or cracks with approved sealant at the bottom and sides of the slots, as specified, to prevent patch mix from entering the joint or crack. Remove excess caulking to create a smooth, level joint or crack surface. Install the foam core board so that it remains in position and tight to all edges during patch material placement. The Contractor may use tabs to hold the foam core board in place and may cut or remove existing joint sealant to accommodate the tabs. If the foam core board shifts during the placement of concrete patching material, remove and replace at no additional cost to the Department.

D. Dowel Bars

Before beginning the placement of concrete patching material over the dowel bars, cover the dowel bars with a thin coat of form release oil. The Department will not allow oil to contaminate concrete surfaces to be overlaid or the surfaces of the slots.

Place the dowel bar assembly (with chairs and foam core board attached) across the transverse joint or crack as specified. Ensure that chairs hold the dowel bars in place and provide at least ½ in [12.5 mm] clearance between the bottom of the dowel and the bottom of the slot. Remove and replace dowel bars that shift during the placement of concrete patching material, at no additional cost to the Department.

E. Existing Concrete Surfaces

Ensure existing concrete surfaces in the slots are clean and dry, or prepared in accordance with the manufacturer recommendations. Remove excess water from the slots before placing the concrete patching material.

F. Concrete Placement

Place concrete patching material into the slot, and vibrate to completely encase the dowel bar. The vibrator head's diameter shall not exceed 1¼ in [37.5 mm]. Obtain the Resident Engineer's approval before placing concrete in ambient temperatures below 50 °F [10 °C].

G. Damage

Repair damage to the existing pavement caused by Contractor operations, at no additional cost to the Department.

H. Slot Surface

Trowel-finish the top surface of the filled slot flush with the existing concrete surface, and allow the surface to cure. If the Contract requires diamond grinding, leave the top surface of the fill slot not more than ¼ in [6.25 mm] higher than the existing concrete surface. Do not under fill the slots. Apply curing compound before the final set of the mortar in the concrete patching material.

Saw the new joint within 24 hr, or as directed by the Resident Engineer.

I. Testing Concrete Patching Material

Test the concrete patching material once for each 4 hr of production, or at least once a day. Ensure the concrete patching material has a compressive strength of at least 4,000 psi [27.6 MPa] in 6 hr. The Contractor may test for compressive strength up to 24 hr after making the cylinders. If the compressive strengths are not met, cease production, and resubmit a concrete mix design that corrects the problems. Do not open lanes to traffic until the patch material achieves a compressive strength of at least 3,000 psi [20.7 MPa].

416.05 METHOD OF MEASUREMENT — VACANT

416.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
DOWEL BAR RETROFIT	Each

SECTION 425
DIAMOND GRINDING CONCRETE PAVEMENT

425.01 DESCRIPTION

This work consists of grinding portland cement concrete (PCC) pavement to restore drainage and riding characteristics to the pavement surface.

425.02 MATERIALS — VACANT

425.03 EQUIPMENT

Provide power-driven, self-propelled grinding equipment designed to smooth and texture PCC pavement with diamond blades. Provide a machine with an effective wheel base of at least 12 ft [3.6 m]. Ensure the front of the machine has a set of pivoting tandem bogey wheels, and the rear wheels travel in the track of the cut pavement. Place the center of the grinding head no more than 3 ft [0.9 m] ahead of the center of the back wheels.

Provide equipment that can cut or plane at least 4 ft [1.2 m] wide to avoid a seam in the wheel path of a travel lane. Ensure the machine's shape and dimension do not encroach on traffic movement outside the work area. Do not use equipment that causes excessive ravels, aggregate fractures, spalls, or cracks, or disturbs transverse and longitudinal joints.

425.04 CONSTRUCTION METHODS

A. Grinding Pavement

Grind the surface of pavement areas shown on the Plans. Grind longitudinally, beginning and ending at lines transverse to the pavement centerline. Ensure the ground pavement surfaces of adjacent sides of transverse joints and cracks are on the same plane. The Department will allow less than 100 percent grinding within specified areas if minor depressions occur in the pavement.

Make multiple passes as necessary to achieve acceptable results.

Ensure the pavement surface grinding produces a uniform, finished surface. Eliminate joint and crack faults. Maintain a constant cross-slope between the edges of grinding operations to provide positive lateral drainage. Transition the grinding of auxiliary or ramp lanes from the mainline edge to provide positive drainage and a smooth riding surface.

For pavement grinding deeper than ¼ in [6 mm], feather-grind adjacent lanes or paved shoulders to maintain motorist safety and proper drainage.

(1) Surface Texture and Grooving

Grind the pavement surface until it has a uniform appearance, with a texture composed of longitudinal ridges and grooves. Create surface grooves from 0.09 in to 0.15 in [2 mm to 4 mm] wide, spaced up to ⅛ in [3 mm] apart. Ensure the ridge peaks are at least $^{1}/_{16}$ in [1.5 mm] higher than the bottom of the grooves.

(2) Slurry Removal

Remove and collect grinding slurry or residue by vacuum or other continuous methods. Dispose of the grinding slurry and residue in accordance with applicable laws, rules, and regulations. Do not distribute the slurry evenly on the sideslopes unless the Resident Engineer approves of the disposal method. Ensure that slurry does not enter drainage inlets and water courses. Prevent the slurry from flowing across lanes used by traffic, or into gutters or other drainage facilities. Conduct a final sweeping before opening the pavement to traffic.

(3) Pavement Smoothness

(a) *Profiling Pavement Surface*

Profile ground surfaces in accordance with ASTM E 1274. Provide a profilograph with wheels variably spaced. Ensure a pavement with a profile index of 5 in [125 mm] or less per mile using a 0.2 in [5 mm] blanking width. Profile ground surfaces in two passes; one at 3 ft [0.9 m] and one at 9 ft [2.7 m] from the edge of each driving lane. Average the profilograph readings from the two passes to obtain the profile index for each lane.

If the profile index exceeds 5 in [125 mm] per mile, grind individual high points in excess of 0.3 in [8 mm] across the entire lane width.

After grinding individual high points, perform additional grinding along lines parallel to the pavement edge to reduce the profile index to the specified values. Grind in neat, rectangular sections with uniform surfaces.

(b) *Straight Edge Tolerance*

As directed by the Resident Engineer, use a 10 ft [3 m] straightedge to measure surface smoothness. Ensure the maximum distance from the bottom edge of the straightedge does not exceed ⅛ in in 10 ft [3 mm in 3 m]. Perform additional grinding at locations in excess of ⅛ in in 10 ft [3 mm in 3 m]. Ensure that the elevation difference between passes does not exceed ⅛ in [3 m].

B. Concrete Joints

After completing diamond grinding, saw and seal joints in accordance with Section 415, “Concrete Joint Sealing.”

425.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the diamond grinding of PCC pavement by the final approved textured surface area regardless of the number of passes necessary to achieve acceptable results, including minor areas of untextured pavement within this area.

If the Resident Engineer determines the need for feathering is not caused by the Contractor, the Resident Engineer may measure the area of feathering as *Diamond Grinding Concrete Pavement*.

425.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
DIAMOND GRINDING CONCRETE PAVEMENT	Square Yard [Square Meter]

The Department will pay for sawing and sealing joints in accordance with Section 415, "Concrete Joint Sealing."

The Department will consider the cost of feathering to be included in the contract unit price for *Diamond Grinding Concrete Pavement*. The Department will not separately measure *Diamond Grinding Concrete Pavement* for pavement unless otherwise specified.

SECTION 426
PRESSURE GROUTING PAVEMENT

426.01 DESCRIPTION

This work consists of pumping a fly ash cement grout under portland cement concrete (PCC) pavement or hot mix asphalt (HMA) pavement to fill the voids beneath the pavement and form a hard, insoluble mass.

426.02 MATERIALS

Provide materials in accordance with Subsection 733.09, "Slurry Grout."

426.03 EQUIPMENT

A. Grouting Equipment

(1)Measuring and Proportioning Equipment

Provide equipment capable of measuring and proportioning grout components by weight. Use prepackaged materials as approved by the Resident Engineer.

(2) Batch Mixing Tank

Provide a watertight batch mixing tank with a high speed mixer to blend the materials into a homogenous mixture. Ensure the mixer includes a rotor operating in close proximity to a stator, creating a high shearing action with a mixing speed from 800 rpm to 2,000 rpm. Ensure the mixing pump continuously circulates the materials through the mixer and the mixing tank.

(3) Holding Tank

Provide a holding tank with a paddle-type agitator placed between the batch mixing tank and the grout pump for continuous operation. Ensure the agitator maintains complete circulation of the grout to keep it in suspension and remove air bubbles from the mix.

(4) Grout Pump

Provide a grout pump with a single action plunger pump with a high speed backstroke. Provide a pump with precise pressure and capacity control valves, to independently preset maximum pressure and flow. Ensure a pump capacity range from 0 gal/min to 30 gal/min [0 L/min to 110 L/min] and a pressure range from 0 psi to 100 psi [0 kPa to 689 kPa].

(5) Discharge Line

Provide a discharge line with a positive cutoff valve at the nozzle end. Ensure the nozzle remains securely sealed in the cored holes to prevent leaks.

(6) Pavement Monitoring Device

Provide pavement-monitoring equipment that determines movement, to prevent lifting pavement or overfilling cracks. Use a standard Benkelman Beam, or other equipment approved by the Resident Engineer.

B. Coring Equipment

Provide coring equipment capable of cutting 2 in [50 mm] diameter holes through the pavement. Prevent damage to the pavement from excessive down pressure on the core. Use an air compressor and rock drills or other devices capable of drilling the injection holes through the pavement.

The Department will not allow air-driven or hydraulic impact drills.

426.04 CONSTRUCTION METHODS

A. General

Protect the pavement from breaking and cracking.

Replace concrete slabs and pavement damaged during pressure grouting operations, at no additional cost to the Department.

B. Weather Limitations

Begin pressure grouting when the ambient temperature is at least 35 °F [2 °C] and rising. Ensure a pavement temperature of at least 35 °F [2 °C] during pressure grouting.

C. Coring Holes

For PCC pavements, drill 2 in [50 mm] diameter core holes through the pavement as shown on the Plans. The Resident Engineer may modify the pattern and spacing of the holes.

For hot mix asphalt pavements, drill core holes at an angle of 45° towards the bottom of the crack, deep enough to penetrate the cavity. Drill at least two core holes for each 12 ft [3.6 m] wide travel lane, and one hole for every 4 ft [1.2m] of shoulder width. Drill the core holes from 4 in to 12 in [100 mm to 300 mm] from the crack. Place the holes along one side of the crack or alternate along both sides of the crack. The Resident Engineer may modify the hole pattern and spacing. The Resident Engineer will approve the location of the core holes, and determine if additional holes are necessary to fill the cracks.

Temporarily plug irregular or unsatisfactory holes, or fill them with grout at no additional cost to the Department. Drill core holes and grout in the same day, unless otherwise approved by the Resident Engineer.

D. Clearing Holes

After drilling the core holes to the specified depths, and within 10 min before injecting the grout, clean the holes of debris to provide a passage for the grout.

E. Grouting

While injecting grout, ensure the flow rate at the pump head does not exceed 7 gal/min [26.5 L/min]. Secure the nozzle of the grout discharge hose in the core hole to provide a seal and maintain the grout pressure.

For PCC pavement, prevent the nozzle end from extending below the bottom of the concrete. Continue injecting grout into each core hole until the slab corner lifts from 0.032 in to 0.036 in [0.825 mm to 0.925 mm], or until the pressure at the discharge nozzle exceeds 60 psi [414 kPa]. If no slab lift or no pressure buildup occurs, continue injecting grout until the amount of clear grout flowing up through joints or cracks equals the amount of grout injected. Repeat this procedure in other holes to fill voids. If necessary, temporarily plug adjacent core holes during grout injection operation.

For hot mix asphalt pavement, continue injecting grout into the core holes until the cracks are filled. Continue pumping until the amount of clear grout flowing up through joints or cracks equals the amount of grout injected. Repeat this procedure in other holes to fill voids. If necessary, temporarily plug adjacent core holes during grout injection operations.

During pumping, watch the pavement monitoring device to prevent excessive lifting of the pavement or rising of the adjacent shoulders. Correct lifted joints as directed by the Resident Engineer. If lifted pavement joints create unsafe conditions for the traveling public, close lanes and make repairs. Complete repairs and joint corrections at no additional cost to the Department.

F. Permanently Sealing Holes in Concrete Pavement

Remove grout from the core holes and fill the holes with a stiff sand-cement mortar made of one part portland cement to three parts fine aggregate (by volume), or a commercial premixed rapid set mixture, as approved by the Resident Engineer.

Repair filled holes that ravel or become damaged at no additional cost to the Department.

G. Regrouting

Drill new core holes and regrout slabs as directed by the Resident Engineer.

For hot mix asphalt pavement, drill new core holes and regrout cracks that may require additional filling, as directed by the Resident Engineer. Provide excess grout to hand-finish into cracks to fill the voids as directed by the Resident Engineer.

H. Clean Up

Remove deposits of grout on the pavement or shoulder. Clean the pavement surface before allowing traffic on the completed sections. Remove other debris, bags, and spillage from the right-of-way each day.

I. Opening to Traffic

Restrict traffic from the grouted areas for 3 calendar days, or as directed by the Resident Engineer.

426.05 METHOD OF MEASUREMENT

The Resident Engineer will not include the weight of water or sand in the measurements of *Portland Cement* or *Fly Ash*.

426.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) CORED HOLES	Each
(B) PORTLAND CEMENT	Ton [Metric Ton]
(C) FLY ASH	Ton [Metric Ton]

The Department will consider the cost of water and sand to be included in the contract unit price for *Portland Cement* or *Fly Ash*.

SECTION 433
RUBBLIZING PORTLAND CEMENT CONCRETE PAVEMENT

433.01 DESCRIPTION

This work consists of rubblizing and seating existing portland cement concrete pavement (PCCP).

433.02 MATERIALS — VACANT

433.03 EQUIPMENT

A. Pavement Breaker

Use a self-contained, self-propelled, resonant frequency pavement rubblizing unit capable of fracturing the pavement. Ensure the unit produces low amplitude blows of 2,000 lb [9 kN] at a rate of at least 44 cycles per second. Equip the unit with a water mist system to suppress dust. Provide a screen to protect vehicles in adjacent lanes from flying chips, as approved by the Resident Engineer.

B. Roller

Use a vibratory, steel wheel roller weighing at least 10 ton [9 metric ton] to compact the rubblized pavement. Provide a self-propelled unit capable of varying the vibration amplitude and frequency.

433.04 CONSTRUCTION METHODS

A. General

Remove asphalt pavement overlay to the PCCP.

Rubblize and seat PCCP across the panel width and to the full depth of the pavement. Where rubblizing abuts PCCP specified to remain on ramps or mainline, cut joints or load transfer devices at an existing joint.

Except at restricted crossovers and ramp crossings, ensure the overlay is complete before opening the pavement to traffic.

To protect underground utilities and drainage facilities while operating the resonant breaker, do not exceed a maximum amplitude of 1 in [25 mm].

Remove asphalt pavement patches with a surface area of at least 1 yd^2 [0.84 m^2] and replace with traffic-bound surface course Type E in accordance with Subsection 703.05, “Aggregates for Traffic Bound Surface Course,” materials shown on the Plans, or both.

B. Rubblizing of Portland Cement Concrete Pavement

In breaking the existing PCCP, ensure no more than 20 percent of the material is larger than 6 in [150 mm], and individual fragments do not exceed 8 in [200 mm]. The Resident Engineer will determine the extent of the breakage based on a visual inspection of the cracks on a dry pavement surface. The Resident Engineer will not allow the use of water to detect additional cracks.

Begin rubblizing at the edge of pavement and work toward the centerline of the roadway. If overlaying one lane at a time, extend rubblizing of each lane at least 6 in [150 mm] beyond the width of the lane.

If the pavement cannot be rubblized, remove the pavement, subexcavate the base material to 2 ft [600 mm], and replace the base material with compacted Aggregate Base Type A in accordance with Section 303, "Aggregate Base." Debond steel reinforcement from the pavement, and leave it in place. Cut exposed steel below the surface.

Adjust the striking pattern, striking energy, number of passes, or other factors to achieve acceptable fracturing.

C. Test Section

Before rubblizing operations begin, the Resident Engineer will designate a test section. Rubblize the test section using a variety of energy and striking patterns, and repeat passes until the test section is fractured in accordance with Subsection 433.04.B, "Rubblizing of Portland Cement Concrete Pavement." Use the test section breakage results as a guide for breaking the pavement on the remainder of the project. If the rubblized fragments exceed the size requirements during the rubblizing operation, the Resident Engineer may direct additional test sections.

D. Seating of Rubblized Portland Cement Concrete Pavement

After rubblizing, seat the broken concrete with at least three passes of a steel-wheel roller in the vibratory mode at a maximum speed of 4 mph [6 km/h], as approved by the Resident Engineer.

E. Leveling Course

Place a hot mix asphalt leveling or base course as shown on the Plans, immediately following the pavement rubblizing and seating operations.

433.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Rubblizing Pavement* by the width of the existing PCCP and the horizontal length along the centerline of each roadway or ramp.

433.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
RUBBLIZING PAVEMENT	Square Yard [Square Meter]

The Department will pay for asphalt pavement patch removal and replacement with a traffic-bound surface course Type E in accordance with Section 402, "Traffic-Bound Surface Course." If the pavement cannot be rubbilized, the Department will pay for removal of pavement and replacement with Aggregate Base Type A in accordance with Section 303, "Aggregate Base Type A."

CHAPTER 500
STRUCTURES

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SECTION 501
EXCAVATION AND BACKFILL FOR STRUCTURES

501.01 DESCRIPTION

A. General

This work consists of excavating material for the construction of major structures and backfilling, stockpiling, or disposing of excess excavated material.

If not otherwise provided for in the Contract, provide equipment, and construct and remove necessary cofferdams, shoring, and water control systems for the excavation work. If the Contract does not include a separate pay item for such work, excavation work will include all necessary clearing and grubbing and the removal of existing structures within the area to be excavated.

When backfilling, place necessary backfill material, stockpile excavated material that will be used in the backfill, and dispose of excess excavated material that will not be used in the project, unless otherwise specified in the Contract.

Excavate and backfill in reasonably close conformity with the lines, grades, and typical cross sections shown on the Contract or as directed by the Engineer.

Comply with applicable environmental regulations, including the United States Army Corp of Engineers 404 Permit, and Section 220, "Management of Erosion, Sedimentation, and Storm Water Pollution Prevention and Control."

B. Classification

The Department classifies excavation and backfill as follows:

Unclassified Excavation Material, of whatever nature, removed to construct box culverts, channels, ditches at culvert inlets and outlets, and other ditches shown in the Plans in accordance with Section 202, "Earthwork."

Structural Excavation, Unclassified Material, of whatever nature, removed below the level of Unclassified Excavation to construct box culverts.

Substructure Excavation, Common Material removed to construct substructures, piers, and abutments, except material classified as Substructure Excavation, Rock.

Substructure Excavation, Rock Solid rock, redbed, shale, slate, or hard material that requires loosening or breaking by blasting, sledging, or drilling for the construction of substructures, piers, and abutments. The Department will classify rock ledges above the foundation material and boulders or pieces of concrete with a volume of at least ½ yd^3 [½ m^3] as Substructure Excavation, Rock.

Unclassified Backfill, **Select Backfill**, and **Granular Backfill** Supplying, placing, and compacting unclassified borrow, select borrow, and granular backfill material in accordance with Section 202, "Earthwork."

Controlled Low-Strength Material (CLSM) Backfill Supplying and placing CLSM in excavations, or confined or formed spaces.

C. Obstructions

The Department will consider the removal and disposal of obstructions (buried natural or man-made objects) to be additional work and will pay the Contractor in accordance with Subsection 501.06, "Basis of Payment." The Department defines obstructions as objects meeting the following conditions:

- Requiring the introduction of methods or equipment not already used on the Project;
- Not shown on the Plans;
- Not ascertainable by investigation, including contact with identified utilities; and
- The Contractor notifies the Engineer in writing within 24 hr of discovering the obstruction and before its removal.

501.02 MATERIALS

Provide backfill materials with no frozen lumps or degradable or hazardous matter, and a gradation that can be consistently compacted.

Provide materials in accordance with the following sections and subsections:

Material:	Section or Subsection:
Unclassified Excavation	202
Select Borrow	705
Granular Backfill not for Mechanically Stabilized (MSE) Walls	703.07
Granular Backfill for MSE Walls	510.02.D
Standard Bedding Material	703.06
Controlled Low-Strength Material (CLSM)	701.19

501.03 EQUIPMENT — VACANT

501.04 CONSTRUCTION METHODS

A. Excavation

(1) Depth of Footings

The bottom of footing elevations shown on the Plans are approximate. The Engineer may issue written orders to change the footing dimensions or elevations. Boring logs shown on the Plans were made for designing the foundation. Interpret and confirm the boring information for construction as needed.

(2) Foundation Preparation and Control of Water

(a) *General*

Construct substructures in open excavations. Ensure safe excavations by using cofferdams, shoring, or bracing in accordance with Subsection 502.04.D "Temporary Retaining Structures."

If cofferdams are unnecessary, the Department will allow omission of footing backforms and filling of the excavation with concrete, as approved by the Engineer.

Construct temporary water control systems in accordance with Subsection 502.04.E, "Temporary Water Control Systems."

Vertically cut or step excavations adjacent to abutments, wings, and retaining walls before backfilling. Remove existing structures in accordance with Subsection 619.04.B, "Removal of Bridges, Culverts, and Other Existing Structures."

(b)*Excavation in Channels*

Clear the right-of-way in accordance with Section 201, "Clearing and Grubbing," for the full length of the bridge, unless otherwise required by the Contract.

Avoid encroaching into creeks and riverbanks, and maintain the existing natural condition. The Department will not allow excavating or cutting of banks unless required by the Contract. Submit proposed work road locations for Engineer's approval, and construct only in the approved location. Restore bank cuts and work roads to the original shape, density, and condition, unless otherwise required by the Contract.

Obtain approval from the Engineer before excavating or dredging outside caissons, cribs, cofferdams, steel piling, or sheeting, and before disturbing the natural streambed. Backfill and compact excavation outside these structures in accordance with Subsection 501.04.B, "Backfilling," at no additional cost to the Department. Remove excess excavated material within the stream area, and restore the stream to the existing condition.

(c)*Foundations on Rock*

Excavate solid rock or other hard foundation material to the depth shown on the Plans or as directed by the Engineer. Remove loose and disintegrated material from the excavation. Level the final surface or make level steps as shown on the Plans, or as directed by the Engineer. Do not disturb solid rock outside the neat lines of the footing. Clean seams and fill with concrete or CLSM before placing the footing.

Where blasting is necessary to reach footing elevation, remove and replace loose, fractured rock caused by overbreak below the bearing level with concrete at no additional cost to the Department.

(d)*Foundations Not on Rock*

If placing a foundation on an excavated surface other than rock, do not disturb the bottom of the excavation. Remove foundation material to grade just before placing the footing reinforcing steel and concrete.

Remove disturbed material at the bottom of footings not supported by piles. Fill the area with concrete or CLSM, at no additional cost to the Department. Replace and compact disturbed material at the bottom of footings supported by piles as directed by the Engineer.

For box culvert excavation, remove unsuitable foundation material below the footing bottom slab and aprons and replace with approved bedding material. Replace material removed below designed elevation with approved bedding material. Open outlets for the effective width of the structure before constructing slab and aprons of box culverts to allow for drainage.

(e)*Approval of Foundation*

Notify the Engineer when the excavation is ready for inspection. Place the footing concrete after the Engineer approves the excavation and foundation material. Unless otherwise approved by the Engineer, do not place concrete under water.

B. Backfilling

(1)General

Place and compact backfill (to the existing ground line) and embankments in accordance with Section 202, "Earthwork," unless modified by Subsection 501.04.B(1). If excavation does not yield enough suitable material for backfill, provide additional backfill material in accordance with Subsection 501.02, "Materials."

Unless otherwise required by the Contract, backfill excavated spaces unoccupied by permanent structures up to the surface of the surrounding ground and allow for settlement. Uniformly backfill around the sides of the structure to ensure equal density of the surrounding ground, and neatly grade its top surface. Do not place rocks larger than 3 in [75 mm] against concrete surfaces.

Place and compact fill for retaining walls, abutments, wingwalls, and bridge bents in layers no greater than 6 in [150 mm] thick. Uniformly backfill around the sides of the structure to ensure equal loading. Compact backfill within, or beneath, embankments within roadways in excavated areas, or in front of abutments and retaining walls or wingwalls to the same density required for the embankments. Unless otherwise required by the Contract, compact fill in embankments to at least 95 percent of standard density in accordance with AASHTO T 99.

Place backfill against structure concrete only when the concrete reaches the required compressive strength in accordance with Subsection 509.04.I(2), "Earth Loads."

To prevent horizontal movement of abutments and wingwalls, place backfill on the outside faces before backfilling the inside faces. The Department will not allow jetting the backfill behind abutments or wingwalls. Operate rollers, vibrators, or other compactors parallel to the outside lines of box culverts and cross-drain wingwalls. Compact areas inaccessible to rolling equipment with mechanical tampers.

(2)Placing CLSM

Fill the excavation with approved CLSM uniformly around the structure to the elevation shown on the Plans. Place CLSM in lifts no deeper than 4 ft [1.2 m]. Subsequent lifts of CLSM may be placed when the preceding lift supports foot traffic. Begin placing specified fill material over the CLSM when the water is gone from the surface of the CLSM, or as directed by the Engineer.

(3)Disposal of Surplus

Clean construction areas in accordance with Subsection 104.10, "Final Cleanup." Do not place excess material in the streambed. Remove obstructions that may collect drift, induce scour, or endanger the work as approved by the Engineer. Dispose of excess excavated and removed materials.

501.05 METHOD OF MEASUREMENT

A. General

The Engineer will measure the volume of excavation for structures based on the following:

- Quantities shown on the Plans,
- A calculation of the actual quantities removed, or
- Quantities directed by the Engineer.

The Engineer will not measure additional volumes of excavation resulting from slips, slides, cave-ins, silting, or filling due to the action of the elements or carelessness that is the responsibility of the Contractor. The Department will not classify water as excavated material. The Department will not measure and separately pay for the disposal of excess material. The Department considers the disposal of excess material as incidental to the various classes of excavation and removal. The Department will not measure or separately pay for the disposal of excess material. The Department will consider the disposal of excess material as incidental to the various classes of excavation and removal. The Department will not measure for payment any additional concrete necessary to fill excavation outside the neat lines shown on the Plans.

The Engineer will measure the volume of backfill for structures in accordance with Subsection 501.05.E, "Backfilling."

B. Excavation for Box Culverts

(1) Unclassified Excavation

For box culverts, the Engineer will calculate the theoretical volume of the trapezoidal prism of *Unclassified Excavation* in accordance with the following:

- The depth using the difference between the elevation of the existing ground line and the elevation of the flow line shown on the Plans;
- The base width of the excavation 4 ft [1.2 m] wider than the outside dimensions of each side of the barrel of the box culvert as shown on the Plans;
- The top width using 2H:1V side slopes from the limits of the design flow line to the existing ground line; and
- The length along the centerline of the box culvert between a point on a line connecting the wingwall ends on each side of the culvert, plus 15 ft [5 m] on each end of the structure.

(2) Structural Excavation, Unclassified

The Engineer will calculate the volume of *Structural Excavation, Unclassified* based on the volume of the box culvert base slab (the volume of box culvert slab below the flow line shown on the Plans) using the width and thickness shown on the Plans, and the length along the centerline of the box culvert between a point on a line connecting the wingwall (outer) ends on each side of the culvert. The Engineer will not measure additional volumes of excavation for curtain walls, wingwall footings, aprons, sheeting, shoring, or Contractor convenience beyond the theoretical dimensions defined above.

If the Contractor encounters and removes soft and yielding material at the bottom of the footing and replaces it with suitable bedding material at the direction

of the Engineer, the Engineer will measure the volume of unsuitable material removed and pay for it in accordance with Subsection 501.06, "Basis of Payment."

C. Excavation for Substructures Supported on Piling

The Engineer will measure excavation for substructures, piers, and abutments supported on piling as *Substructure Excavation, Common*. The Engineer will calculate the excavation volume in accordance with the following:

- The depth from the existing ground line to the bottom of the substructure footing;
- The width 6 ft [2 m] wider than the width of the substructure shown on the Plans; and
- The length 6 ft [2 m] longer than the length of the substructure shown on the Plans.

If the Contract requires channel excavation, the Department will consider the existing ground line to be the bottom of the excavated channel.

D. Excavation for Substructures Supported on Natural Foundation Materials

The Engineer will measure excavation for substructures, piers, and abutments supported on natural foundation materials as *Substructure Excavation, Common* or *Substructure Excavation, Rock*. The Engineer will calculate volumes of excavation for substructures and piers in accordance with Subsection 501.05.C, "Excavation for Substructures Supported on Piling," except the Engineer will calculate the volume of excavation below the top of the approved foundation material based on the neat lines of footings shown on the Plans or directed by the Engineer. The Engineer will calculate the volume of excavation for abutments based on the abutment dimensions shown on the Plans.

E. Backfilling

The Engineer will calculate the volumes of each type of backfill required by the Contract, above the existing ground line based on the neat lines shown on the Plans, or as directed by the Engineer.

F. Obstructions

The Engineer will measure the volumes of removed obstructions in accordance with Subsection 501.01.C, "Obstructions."

501.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) STRUCTURAL EXCAVATION, UNCLASSIFIED	Cubic Yard [Cubic Meter]
(B) SUBSTRUCTURE EXCAVATION, COMMON	Cubic Yard [Cubic Meter]
(C) SUBSTRUCTURE EXCAVATION, ROCK	Cubic Yard [Cubic Meter]
(D) UNCLASSIFIED BACKFILL	Cubic Yard [Cubic Meter]
(E) SELECT BACKFILL	Cubic Yard [Cubic Meter]

Pay Item:	**Pay Unit:**
(F) GRANULAR BACKFILL	Cubic Yard [Cubic Meter]
(G) CLSM BACKFILL	Cubic Yard [Cubic Meter]

The Department will pay for the volumes of *Unclassified Excavation*, calculated in accordance with Subsection 501.05.B(1), "Unclassified Excavation," in accordance with Section 202, "Earthwork."

The Department will consider the cost of removal and disposal of obstructions, as defined in Subsection 501.01.C, "Obstructions," to be included in the Contract unit price for the relevant excavation pay item, unless specifically included in other pay items. The Department will pay for volumes of removed obstructions at twice the Contract unit price for the relevant excavation pay item for which the obstruction was encountered.

The Department will consider the cost of removing volumes of water, disposing of excess material, and excavation for placing sway bracing, sash bracing, and bulkheads on timber substructures to be included in the Contract unit price for the relevant excavation pay item.

The Department will pay for the volume of soft and yielding material removed and a like volume for replacement material from the bottom of box footings as *Structural Excavation, Unclassified* at the Contract unit price.

The Department will consider backfilling around structures below the existing ground line to included in the contract unit price for the relevant excavation pay item.

The Department will not pay for excess concrete when the Contractor omits footing backforms and fills the excavation with concrete in accordance with Subsection 501.04.A(2)(a), "General."

SECTION 502
FORMS, FALSEWORK, AND TEMPORARY WORKS

502.01 DESCRIPTION

This work consists of designing, constructing, and removing temporary structures used for highway bridge structures.

The Department defines formwork, falsework, and temporary structures as follows:

Temporary Structures. Falsework, formwork, temporary retaining structures, temporary water control systems, and detour bridges.

Falsework. Temporary construction used to support a permanent structure until it becomes self-supporting.

Formwork. Temporary structure or mold used to contain plastic or fluid concrete in the shape shown on the Plans until the concrete reaches the compressive strength required by the Contract.

Temporary Retaining Structure. A temporary structure that holds the surrounding earth and water out of an excavation and protects adjacent property during construction of the permanent work.

Temporary Water Control System. A system to divert water from and prevent it from entering an excavation.

Detour Bridge. A conveyance for traffic during construction of permanent work.

502.02 MATERIALS

A. Falsework

(1) General

The Department will allow the use of new or used manufactured components, or both in falsework construction.

Provide materials in accordance with the following sections:

Material:	Section:
Structural Steel	506
Structural Concrete (Class A)	509
Reinforcing Steel for Structures	511

If the Contract requires, provide certification for new materials.

Perform concrete tests in accordance with Section 701, “Portland Cement Concrete.”

(2) Salvaged Steel

For salvaged steel in good condition with an identifiable grade, provide steel meeting ASTM A 6 criteria for surface imperfections at the allowable working stresses for new steel of the same grade. For salvaged steel with an unidentifiable grade, provide steel in accordance with Section 506, “Structural Steel.”

(3) Timber

All wood species assigned allowable stresses in the *National Design Specification for Wood Construction* (NDS) Supplement, as published by the National Forest Products Association are acceptable for use in falsework construction.

(4) Used Lumber

For used lumber in good condition with an identifiable grade, provide lumber with stresses that do not exceed those for new lumber of the same grade. For used lumber with an unidentifiable grade, provide lumber with the lowest NDS allowable stresses for the species, with appropriate reductions for condition.

(5) Manufactured Components

The Department will allow manufactured components of the following classes:

- Vertical shoring systems, including tubular welded frame shoring, tube and coupler shoring, and related components; and
- Assemblies manufactured for commercial use, including single-post shores, brackets, jacks, joists, clamps, and similar devices.

B. Forms

(1) General

Provide mortar-tight concrete forms with sufficient strength to resist deflection during concrete placement.

(2) Sheathing

For exposed concrete surfaces, provide U.S. Product Standard PS 1 for Exterior B-B (Concrete Form) Class I Plywood, or another material that produces a smooth, uniform concrete surface, as approved by the Engineer. Provide form panels in good condition with no surface defects. If using a form panel material other than plywood, ensure the properties are equal to or exceed the properties for the type of plywood required by the Contract.

(3) Structural Support

Provide materials for structural form support in accordance with Subsection 502.02.A, "Falsework." The Department considers vertical side forms, wall forms, column forms, and related studs, walers, and other form features to be formwork or structural support for formwork.

(4) Prefabricated Formwork

If providing prefabricated formwork, submit the following to the Engineer:

- Shop drawings in accordance with Subsection 105.02, "Plans and Working Drawings," and
- Technical data substantiating the load-carrying capacity, detailing the application instructions, and describing the limitations of use.

Provide prefabricated formwork in accordance with the manufacturer recommendations.

(5) Stay-in-Place Steel Deck Forms

Provide stay-in-place steel deck forms only if allowed by the Contract or approved by the Engineer.

Ensure stay-in-place steel deck forms meet the requirements for prefabricated formwork in accordance with Subsection 502.02.B(4), "Prefabricated Formwork." Submit shop drawings to the Engineer, including related deck design calculations. Fabricate stay-in-place steel deck forms and supports using steel in accordance with ASTM A653, Grade 40(275), and Grade 50(340) with a coating class of G 165 in accordance with ASTM A 525.

(6)Stay-in-Place Prestressed Concrete Deck Forms

Provide stay-in-place prestressed concrete deck forms only if allowed by the Contract or approved by the Engineer.

Ensure stay-in-place prestressed concrete deck forms meets the requirements for prefabricated formwork in accordance with Subsection 502.02.B(4), "Prefabricated Formwork." Submit shop drawings to the Engineer, including related deck design calculations. Fabricate stay-in-place deck forms in accordance with Section 503, “Prestressed Concrete Bridge Members.”

502.03 EQUIPMENT — VACANT

502.04 CONSTRUCTION METHODS

A. Falsework

If the falsework is taller than 14 ft [4.3 m] or traffic will travel under the falsework, ensure a professional engineer registered in Oklahoma designs the falsework.

(1)Working Drawings

Submit falsework drawings in accordance with Subsection 105.02, “Plans and Working Drawings.” Submit separate falsework drawings for each structure. The Department will allow one set of drawings for identical structures with identical falsework design and details. Begin falsework construction only after the Engineer approves of the working drawings. Ensure the working drawings include the following:

(a)*General*

Design the falsework and provide design details showing the following characteristics:

- Provides the necessary rigidity,
- Supports the imposed loads, and
- Produces a finished structure to the lines and grades shown on the Plans.

Ensure the design calculations show the stresses and deflections in load-supporting members.

(b)*Submission Sets*

Submit three sets of falsework drawings and one set of design calculations.

(c)*Design Details*

Include the information and details necessary to enable falsework construction without reference to source documents. Provide design-controlling dimensions, including those that control falsework design and erection.

(d)*Foundation Loads*

Show the maximum applied structural load on the foundation material. Include a drainage plan or a description of the plan to protect foundations from saturation, erosion, and scour.

(e)*Materials Specifications*

Describe proposed falsework material. Use manufacturer's tests and recommended working loads to describe materials that standard nomenclature cannot define (such as AASHTO or ASTM). Determine whether the physical properties and conditions of the falsework material can support the assumed design loads.

(f) *Concrete Placement*

Provide a plan for the proposed concrete placement operation, including details of the equipment, labor, and procedures. For each concrete pour, include placement rates and design pressures. Include a superstructure placing diagram showing the concrete placing sequence and construction joint locations.

(g) *Settlements*

Show anticipated total settlements of falsework and forms, including falsework footing settlement and joint take-up. Design falsework and forms so anticipated settlement does not exceed 1 in [25 mm]. Design and construct the falsework to elevations that anticipate settlement during concrete placement and allow for camber needed to compensate for falsework member deflections during construction.

(h)*Traffic*

Show the locations of openings in the falsework intended for traffic. Provide details showing horizontal and vertical clearances and locations of temporary railing. Describe the sequence of falsework erection and removal.

(2)Design

Base design of the temporary works on AASHTO LRFD Bridge Design Specifications load factors specified in Articles 3.4.1 and 3.4.2. Investigate all applicable load combinations including construction loads. Base member capacity on field conditions.

Ensure design limitations are in accordance with the current edition of the AASHTO *Guide Design Specifications for Bridge Temporary Works*.

(3)Falsework Foundations

Field-verify ground elevations at proposed foundation locations before design.

Determine the soil-bearing capacity if using spread footing foundations. The maximum allowable bearing capacity for foundation material, with the exception of rock, is 2 ton/ft² [200 kPa].

Do not place the edge of footings closer than 12 in [300 mm] to the intersection of the bench and the top of the slope. If the excavation is not supported by shoring, place the footing edge no closer to the edge of the excavation than the greater of a distance of 4 ft [1.2 m] or a distance equal to the excavation depth.

Construct pile type foundations in accordance with Section 514, "Driven Foundation Piles." For falsework supported by footings placed on paved slopes, do

not strut the falsework to columns unless the columns are founded on rock or supported by piling.

Size spread footings to support the footing design load at the soil bearing capacity without exceeding anticipated settlements. Provide steel reinforcement in concrete footings.

If steel towers have maximum leg loads greater than 30 kips [130 kN], provide a design that allows for uniform settlement under all legs or each tower under all loading conditions. Inform the Engineer of foundation protection plans.

(4) Proprietary Shoring Systems

If using proprietary shoring systems, submit to the Engineer a letter of certification from the shoring manufacturer indicating that the shoring system is being used in accordance with the manufacturer recommendations for loads and conditions of use.

(5) Falsework Over or Adjacent to Roadways and Railroads

Design and construct falsework to protect it from vehicle impact.

Provide protection for the following:

- Falsework supports for members crossing over a roadway or railroad, and
- Falsework supports where the horizontal distance, from the traffic side of the falsework to either the pavement edge or a point 10 ft [3 m] from the centerline of track, is less than the total height of the falsework.

Increase vertical design loads by 150 percent for falsework supports including posts, columns, and towers, but not footings. Install temporary concrete traffic barriers before erecting falsework towers or columns adjacent to an open public roadway. Place barriers so falsework footings or pile caps clear concrete traffic barriers by at least 3 in [75 mm], and all other falsework members clear the barriers by at least 12 in [300 mm]. Do not remove barriers until approved by the Engineer.

Use steel falsework columns with a minimum section modulus of 10 in^3 [150,000 mm^3] around every axis, or sound timbers with a section modulus of at least 250 in^3 [4,000,000 mm^3] around every axis.

Mechanically connect the base of each column or tower frame that supports falsework over or adjacent to a public road to its supporting footing. Alternatively, apply other lateral restraints capable of withstanding a horizontal force of at least 2,000 lb [9 kN] applied to the base of the column in any direction. Mechanically connect columns or frames to the falsework cap or stringer to resist a horizontal force of at least 1,000 lb [4.5 kN] in any direction. Neglect the effects of frictional resistance.

Mechanically connect the following to the falsework cap or framing:

- Exterior falsework stringers,
- Stringers adjacent to the end of discontinuous caps,
- Stringers over points of minimum vertical clearance, and
- Every fifth remaining stringer.

Ensure these mechanical connections are capable of resisting a load of at least 500 lb [2.2 kN] in any direction, including uplift on the stringer. Install connections before allowing traffic to pass beneath the span.

Use bolts at least ⅝ in [16 mm] in diameter to connect timber members to brace falsework bents adjacent to roadways or railroads. Solid sheath falsework bents within 20 ft [6 m] of the centerline of a railroad track in the area from 3 ft to 16 ft [1 m to 5 m] above and on the side facing the track. Construct sheathing using plywood at least ⅝ in [16 mm] thick or lumber at least 1 in [25 mm] thick. Provide bracing so the bent resists the required assumed horizontal load or 5,000 lb [22 kN], whichever is greater, without sheathing.

Provide the minimum vertical and horizontal clearances as required by the Contract.

(6) Falsework for Steel and Precast Concrete Beams and Girders

Do not erect beams over traffic. Use falsework design loads consisting of all loads supported by the falsework. Do not apply loads to existing, new, or partially completed structures that exceed the load carrying capacity of any part of the structure in accordance with the AASHTO *LRFD Bridge Design Specifications*.

Build supporting falsework to accommodate the erection method without overstressing the beams and girders. Ensure the supporting falsework produces the final structural geometry, intended continuity, and structural action. Block and brace beams and girders to ensure lateral stability.

Brace or tie exterior girders that support overhanging bridge deck falsework brackets to adjacent interior girders to prevent exterior girder rotation and overstressing of the girder web. Alternatively, use needle beams clamped to the bottom flanges of the exterior girder and the adjacent interior girder to prevent exterior girder rotation and overstressing of the girder web. The Department will not allow welding forms or falsework to structural steel.

Design falsework and forms for concrete supported on steel structures to apply loads to girder webs within 6 in [150 mm] of a flange or stiffener. Distribute the loads to prevent local distortion of the web. Space bracing and supports no more than 8 ft [2.5 m] apart.

(7) Falsework Construction

Build camber into the falsework to compensate for falsework and structure deflection. Camber shown on the Plans is only for structure deflection. Attach tell-tales to the soffit of concrete forms that will allow a determination, from the ground, of the total structure settlement during concrete placement. Do not apply dead loads to falsework, other than forms and reinforcing steel, until approved by the Engineer. Discontinue concrete placement and make corrections if deviations occur that are greater than ⅜ in [10 mm] from the falsework drawings. If corrections are not made before initial set, remove unacceptable concrete.

(8) Inspection and Certification

After installing the falsework and before placing or removing concrete, have a registered professional engineer, proficient in structural design, inspect the falsework. Submit to the Engineer before concrete placement, written certification that the installation meets the Contract requirements.

B. Forms

(1) General

Make concrete forms mortar-tight and strong enough to prevent deflection during concrete placement. Unless otherwise required by the Contract, comply with the tolerance requirements in Table 502:1.

Table 502:1
Maximum Dimensional Tolerances for Cast-in-Place Formed Concrete [a]

Item	Tolerance, *in [mm]*
Deviation from plan line [b]	±1 [±25]
Cross-sectional dimensions of columns, piers and beams, slabs, and walls	+1 , −½ [+25, −12]
Bridge deck thickness	+½ , −¼ [+12, −6]

[a] Compare variations with the dimensions as shown on the Plans or as directed by the Engineer.
[b] Tolerance measurements include alignment, plumb, grade, and level, and are perpendicular to the plan line or surface. The Engineer will inspect plumb of retaining walls before and after backfilling.

Place embeds before concrete placement. Clean the inside surfaces of forms. Remove loose material before completing forms for deck slab of cast-in-place box girders or cells, or voids of other members. Do not place concrete until inspection and approval of the forms.

(2) Removable Formwork

Coat forms with form oil to allow easy release. Use form oil that will not discolor the concrete.

Except where the formed member is less than 3 ft [1 m] wide, provide and place form panels for exposed surfaces, in uniform widths of at least 3 ft [1 m] and in uniform lengths of at least 6 ft [2 m].

Arrange panels in symmetrical patterns conforming to the general lines of the structure. For vertical surfaces, place panels with the longer dimension horizontal. Make the horizontal joints level and continuous. Alternatively, for walls with sloping footings that do not abut other walls, place panels with the longer dimension parallel to the footing.

Align form panels on each side of the panel joint with supports or fasteners common to both panels. Provide ¾ in [20 mm] triangular fillets at sharp edges of the concrete.

The Department will allow devices cast into the concrete to support forms or to lift precast members, but will not allow devices driven into the concrete for fastening forms or form supports. Use form ties to prevent the forms from spreading during concrete placement.

Do not use twisted wire loop form ties. Use form ties and anchors that will not damage the concrete surface when removed. Construct metal ties or anchors within the forms to allow removal to a depth of at least 1 in [25 mm] from the face without damaging the concrete. Fill cavities with cement mortar and finish.

Make forms rigid so the formed concrete surface does not vary more than ⅜ in [9 mm] using a 5 ft [1.5 m] straightedge or template, or vary more than $^{1}/_{360}$ of the

center to center distance between studs, joists, form stiffeners, form fasteners, or wales. The Department considers interior surfaces of underground drainage structures as enclosed surfaces. Form exposed surfaces for each element of a concrete structure with the same forming material or with material that produces similar surface textures, color, and appearance.

Support roadway slab forms of box girder type structures on wales or similar supports fastened to the top of the web walls.

(3)Stay-in-Place Steel Deck Forms

(a)*General*

Do not rest form sheets directly on top of girder, stringer, or floor beam flanges. Fasten sheets to form supports with a bearing length of at least 1 in [25 mm] at each end. Place form supports in contact with the girder, stringer, or floor beam flange and attach with bolts, clips, or other methods approved by the Engineer. Do not weld forms to girder, stringer, or floor beam flanges or reinforcing steel.

Clean, wire brush, and paint exposed form metal where the galvanized coating is damaged. Paint with a minimum of 5 mil [130 μm] of zinc rich paint containing at least 90 percent zinc. The Department does not require touch-ups for minor heat discoloration in areas of welds. Replace forms damaged by bending or crimping.

Locate transverse slab construction joints at the bottom of a flute. Field drill ¼ in [6 mm] diameter weep holes at least 12 in [300 mm] on center along the line of the joint. Lap adjacent forms and connect form sheets without welding at a maximum of 18 in [450 mm] centers along the lap. At the lap, place the first panel to be loaded during concrete placement on top.

Use epoxy-coated reinforcing steel in bridge floors that use stay-in-place forms. If epoxy-coated reinforcing steel is not shown on the Plans, provide epoxy coated steel at no additional cost to the Department. The Department will not allow the use of reinforcing steel placed on the forms as support chairs. Provide means for inspection of the underside of forms after concrete placement. At least 48 hr later, test for soundness and bonding of the forms by sounding with a hammer. If soundness testing indicates noncompliant concrete, remove forms as directed by the Engineer. Do not use a cutting torch to remove forms. Repair or replace concrete as required by the Contract.

(b)*Design Requirements*

1) *Design Load*

Use a design load consisting of the weight of the forms, reinforcement, and plastic concrete plus 50 lb/ft² [2,400 Pa] for construction loads.

2) *Allowable Bending Stress*

Limit the unit working stress in the steel form sheet to a maximum of 0.725 times the minimum yield strength of the provided material as required by the Contract, to no greater than 36 ksi [250 MPa].

3) *Allowable Deflection*

Limit the deflection of form sheets to a maximum of $^{1}/_{240}$ of the form span, no greater than ¾ in [20 mm]. Use the calculated design load, less 50 lb/ft² [2,400 Pa] for construction loads, or 120 lb/ft² [5760 Pa], whichever is higher, to calculate the deflection.

4) *Maximum Camber*

Limit the form camber to not exceed the deflection under actual load. Do not use camber to compensate for deflection exceeding the limits required by the Contract.

5) *Design Span Length*

The Department defines the span length of form sheets as the distance between the flanges of the supporting beams minus 2 in [50 mm], measured parallel to the form flutes.

6) *Design Properties*

Calculate physical design properties in accordance with the American Iron and Steel Institute *North American Specification for the Design of Cold-Formed Steel Structural Members*.

7) *Weight Limitation*

Limit the combined load of the forms and additional concrete necessitated by use of stay-in-place forms to a maximum of 5 lb/ft² [0.24 kN/m²] greater than the design dead load of the bridge deck. The Department will not allow the use of plywood sheeting on steel stay-in-place deck forms.

8) *Deck Reinforcement*

Maintain the dimensions of deck reinforcement shown on the Plans from the top surface of the concrete deck, including cover.

9) *Flange Bracing*

The Department does not consider stay-in-place forms as lateral bracing for compression flanges of supporting structural members.

(c)*Shop Drawings*

Prepare shop drawing for stay-in-place steel forms showing the following:

- The layout of the form sheets on the bridge floor, identifying form sheets by piece marks;
- The steel grade, dimensional, and section properties for form sheets and supports;
- The type and spacing of chairs;
- Lap details and planned direction of concrete placement;
- Views of all connections;
- A bill of materials; and
- Installation instructions.

C. Removal of Forms and Falsework

Remove all forms, except stay-in-place forms. Unless otherwise required by the Contract, remove forms and falsework in accordance with the time periods in

Table 502:2. Release falsework for cast-in-place post-tensioned portions of structures after tensioning prestressing steel.

Table 502:2
Form and Falsework Release Criteria

Forms and Falsework	Time
Supporting spans:	
>14 ft [>4.3 m] (i.e. slab spans, pan girders, RCB decks, pier caps)	14 days
≤14 ft [≤4.3 m] (i.e. bridge decks on girders, RCB decks, diaphragms, pile bent pier caps)	10 days
Not supporting dead concrete weight (i.e. columns, walls, side forms for abutments and pier caps)	24 hr
For railings and barriers	12 hr

After removing the forms for the structure, cure in accordance with Section 509, "Structural Concrete." Refer to Section 509, "Structural Concrete," for sequence of placement and application of load requirements.

The time periods in Table 502:2 assume a concrete cure temperature of 50 ºF [10 ºC] or higher. For each day temperatures are below 50 ºF [10 ºC], add a day to the original curing time for form and falsework release period.

If the concrete attains 80 percent of the strength required by the Contract, the Engineer may shorten the time period for falsework release. Determine strengths from test cylinders cured at the work site under similar environmental conditions in accordance with Section 701, "Portland Cement Concrete." If the Contractor proposes to prematurely apply loads to an element, it may be necessary to leave the forms and falsework in place until such time that 100 percent of the strength is obtained and a minimum time has elapsed in accordance with Subsection 504.04.H, "Load on Decks and Approach Slabs" and Subsection 509.04.I, "Application of Loads."

Completely remove falsework. Remove falsework piling at least 2 ft [0.6 m] below the surface of the original ground line or stream bed. If falsework piling is driven within the limits of ditch or channel excavation, remove the piling to at least 2 ft [0.6 m] below the bottom and side slopes of the excavated areas.

D. Temporary Retaining Structures

(1) General

Excavate in accordance with Section 501, "Excavation and Backfill for Structures," and the OSHA Standard outlined in 29CFR 1926, Subpart P.

(2) Vertical-Sided Excavations

Sheet and brace vertical-sided excavations to retain the earth and water pressure and surcharges, and to protect adjacent property and facilities during construction.

Employ a registered geotechnical engineer to identify unknown soils. Employ a registered structural engineer to design temporary retaining structures and prepare working drawings. Submit calculations and drawings for the temporary retaining structure to the Engineer before beginning work.

(3) Cofferdams and Shoring

Size cofferdams to allow pumping outside the concrete forms and concrete placement in dry conditions.

If water cannot be controlled enough to produce dry conditions, use a cofferdam with a Class A-concrete seal placed underwater below the elevation of the footing. Control the water level within the cofferdam during concrete seal placement to prevent water flow through the seal.

Construct cofferdams to protect green concrete from a sudden rise of the stream and erosion. Do not leave bracing inside the permanent concrete structural members.

Before constructing, obtain approval from the Engineer to substitute round pier bases of equal stability for square or rectangular bases as shown on the Plans.

Unless otherwise required by the Contract, remove cofferdams and shoring with all sheeting and bracing after completing the footing.

E. Temporary Water Control Systems

(1)General

Temporary water control systems consist of dikes, bypass channels, flumes, other surface water diversion works, cutoff walls, and pumping systems, including wellpoint and deep well systems, used to prevent water from entering excavations for structures.

(2)Working Drawings

When shown on the Plans, submit working drawings for temporary water control systems in accordance with Subsection 105.02, "Plans and Working Drawings." Include details of the design and equipment, operating procedures, and the discharge locations. Design and operate the system in accordance with water pollution control and environmental requirements.

(3)Operations

Pump from the interior of foundation excavation using a method that will preclude the possibility of water moving through fresh concrete. Stop pumping ground water from an excavation during and at least 12 hr after concrete placement, unless using a sump separated from the concrete work by a watertight wall or other means. Before pumping to dewater a sealed cofferdam, allow the seal to set to withstand the hydrostatic pressure.

Regulate pumping from wellpoints or deep wells to avoid damage by subsidence to adjacent property.

F. Detour Bridges

Construct and maintain the detour bridge as required by the Contract or an alternative design approved by the Engineer.

Use a registered professional engineer to design the alternative detour bridge. Submit signed and sealed working drawings and calculations for approval of the alternative design in accordance with Subsection 105.02, "Plans and Working Drawings." Ensure the alternative design is equivalent to the design shown on the Plans. Use the roadway width and traffic rail shown on the Plans. In the submittal, show the design parameters required by the Contract. Design in accordance with AASHTO *Standard Specifications for Highway Bridges*. Use an HS20-44 live load, unless otherwise required by the Contract.

Verify that used beams satisfy the minimum section modulus required by the approved design. Account for section loss due to corrosion, fatigue life, or bent, cracked, or damaged flanges or webs. Replace unsatisfactory beams at no additional cost to the Department.

Remove detour bridges as required by the Contract or directed by the Engineer. Beams become the Contractor's property at the end of the project.

502.05 METHOD OF MEASUREMENT — VACANT

502.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) ENGINEERED FALSEWORK	Lump Sum
(B) DETOUR BRIDGE	Lump Sum
(C) FALSEWORK AND JACKING	Lump Sum

The cost of Falsework Engineering Services to be included in the contract unit price for the related concrete pay item. Unless specified in the Contract as pay items, the Department will consider the cost of forms and falsework, and *Engineered Falsework* to be included in the Contract unit price for the relevant concrete pay item.

If the Contractor chooses to use stay-in-place forms, the Department will not pay for additional quantities of concrete and reinforcing steel in excess of the quantities shown on the Plans.

The Department will consider the cost of temporary retaining structures and temporary water control systems to be included in the Contract unit price for the relevant excavation pay item.

The Department will pay for piling and drilled shafts for detour bridges in accordance with Section 514, "Driven Foundation Piles," and Section 516, "Drilled Shaft Foundations."

SECTION 503
PRESTRESSED CONCRETE BRIDGE MEMBERS

503.01 DESCRIPTION

This work consists of providing and placing precast, prestressed beams and other precast concrete bridge components in the bridge structure. Post-tensioned concrete bridge members are not covered by Section 503.

Prestressing. The stressing of bridge members in which the stressing forces are placed in the steel strand before the concrete is placed.

Detensioning. The transfer of stress from the steel strand tendons into the hardened concrete.

Sweep. Horizontal deviation from a straight line parallel to the centerline of the member.

Camber. Upward deflection of the member caused by prestressing forces.

503.02 MATERIALS

A. General

Provide materials in accordance with the following sections and subsections:

Material:	Section or Subsection:
Structural Concrete	509
Joint Fillers and Sealants	701.08
Reinforcing Steel for Structures	511
Steel Wire Strand for Prestressing	723.03

B. Concrete

Unless otherwise required by the Contract, provide Class P concrete meeting the minimum strengths required by the Contract. Design concrete to have at least 75 percent of the 28-day strength required by the Contract at the time of detensioning, unless otherwise required by the Contract. Cast all members with the same strength required by the Contract using the same mix design.

C. Strand and Structural Steel

For a structure, provide the same type, grade, and manufacturer of strand. For each member, limit the variation in modulus of elasticity to ±1 percent for all members in the same span.

Tension stress-relieved strand to 70 percent of the ultimate strength. Tension low-relaxation strand to 75 percent of its ultimate strength. If substituting low-relaxation strand for stress-relieved strand, tension it to 70 percent of the ultimate strength. Make strand substitutions for all strands, in all members in the same span. The Department will not allow substituting stress-relieved strand for low-relaxation strand.

Provide strands free of material that may reduce the bond with concrete, including,

but not limited to the following:

- Corrosion that causes pitting or loss of section,
- Scale,
- Flaking,
- Dirt,
- Grease,
- Wax, or
- Oil.

Within members, do not use strands that have been broken, steamed, or fully stressed and relaxed more than twice. The Department will allow no greater than 5 percent of the strand in a pattern to contain one broken wire if the 5 percent stressing tolerance is not exceeded. Do not weld to strand or weld near strand.

503.03 EQUIPMENT

A. Prestressing Equipment

Prestress using jacking equipment approved by the Engineer. Use hydraulic jacks that provide and sustain the Contract required forces, equipped with a pressure gauge or a load cell to determine the jacking stress. Provide plumbing and gauges that prevent fluctuation in the gauge readings before the release of the jacking load.

Measure initial stress using a dynamometer or other graduated device that can be read within a tolerance of ±100 lb [±500 N]. Measure the final stress with a graduated device that can be read within a tolerance of ±2 percent of the stress. The Department will not allow the use of load cells to measure stress less than 10 percent of the cell capacity. Indicate the allowable operating range on or near the measuring device dial or display.

Measure strand elongation within a tolerance of ±0.1 in [±2 mm].

Use jacks and stress measuring gauges calibrated by a testing laboratory approved by the Department. Calibrate each jack and gauge as a unit, with the jack cylinder extended to the position corresponding to final jacking force. Provide a certified calibration chart or curve for each jack and gauge combination. Calibrate annually. Make additional calibrations under the following conditions:

- After major maintenance,
- Stresses and elongations differ more than specified limits, or
- Erratic results are encountered.

B. Forms and Beds

Provide forms and beds in accordance with Section 502, “Forms, Falsework, and Temporary Works,” unless otherwise required by the Contract.

Use only steel forms, except the Department will allow single-use wood bulkheads. The Department will not allow the use of aluminum forms or finishing tools. Provide smooth, mortar-tight forms without surface irregularities. Repair form imperfections that cause the following:

- Reduce the concrete cover by more than ¼ in [6 mm],
- Protrude more than 1 in [25 mm], or
- Cover more than 5 percent of the total surface area.

Provide a ¾ in [19 mm] bevel on the exposed edges of prestressed concrete members except for the top of the top flange. Support forms on unyielding casting beds. Use abutments, beds, and forms designed by a registered professional engineer in the State of Oklahoma. Design beds to minimize differential settlement and movement.

C. Calibration Records

Keep calibration records for equipment. Use calibration records for tensioning.

503.04 CONSTRUCTION METHODS

A. Shop Drawings

Submit shop drawings for prestressed concrete bridge members in accordance with Subsection 105.2, "Plans and Working Drawings." Ensure the shop drawings include the following:

- Title sheet with the following:
  - Index of shop drawing sheets, and
  - General notes;
- Erection sheets showing the following:
  - Location of members, anchor bolts, and diaphragms,
  - Beam lengths and spacing,
  - Bearing centerlines,
  - Span numbers, and
  - Construction phases;
- Detail sheets of each fabricated member and component showing the following:
  - Member dimensions,
  - Pretensioned and mild reinforcement,
  - Plates,
  - Chair and tie requirements,
  - Inserts,
  - Diaphragm holes,
  - Dunnage and handling locations,
  - Piece mark locations,
  - Bills of materials, and
  - Design information.

Ensure the design information on the detail sheets includes the following:

- Casting length adjustment due to elastic shortening,
- Strand specification,
- Stressing data,
- Compressive strength requirements.

If necessary, include detail sheets for fabricated components such as bent rebar, embedded plates, anchor plates, and bearing pads. Show items such as reinforcing steel, strand, anchors, inserts, and diaphragm holes in detail to avoid placement conflicts. Show, in a sketch or note, the lap lengths of reinforcing steel, including steel mesh, maximum strand support (chair) spacing, and reinforcing added to support other reinforcing.

B. Contractor's Quality Control

Provide certified quality control (QC) personnel (separate from production personnel), a production and QC procedures manual, inspection, and testing to ensure prestressed concrete bridge members meet the Contract requirements.

Before fabricating members, submit a production and QC procedures manual to the Engineer for approval. Include step-by-step details of the fabricating methods for member types and controlling quality. Resubmit the manual every two years or when procedures change.

In the manual, describe the following:

- Stressing procedures,
- Concrete mix design,
- Batching and mixing,
- Placement and finishing,
- Curing,
- Materials requirements, and
- Other production practices.

In the stressing procedures, describe the following:

- Initial strand tensioning to equalize stresses and eliminate slack in the strands,
- Uplift and hold-down devices,
- Pretensioning and detensioning methods,
- Elongation and stress measurements, and
- Anchorage details.

In the QC procedures, describe the following:

- Materials sampling and testing procedures,
- Bed and product inspection methods,
- Member identification,
- Record keeping for bed and product inspection,
- Stressing records,
- Materials testing,
- Calibration records, and
- Any other QC functions.

Describe the use of standard testing methods, such as those from ASTM or AASHTO. Submit QC records to the Engineer upon request.

C. Preparation of Beds and Forms

Before each use, clean beds and forms of debris and contaminants. Use commercial quality form oil, or another form release agent approved by the Engineer, that allows the release of the forms and does not discolor the concrete. Prevent build-up of release agents. Prevent contamination of bonded reinforcement, prestressed or non-prestressed, by the form release agent. Clean or replace contaminated reinforcement.

Make form joints smooth and tight to prevent cement paste leakage. Maintain forms and ensure the forms conform to the dimensions of the structure shown on the Plans. Check form alignment and grade before casting in accordance with the

approved production or QC manual. Maintain form alignment during the casting operation.

D. Tensioning Requirements

(1) General

Notify the Engineer before tensioning to allow inspection. Prestress members using the following pretensioning method:

- Tension prestressing strands,
- Place and cure concrete, and
- Stress the concrete by releasing the strands from anchorage after the member reaches the strength required by the Contract.

Complete post-tensioning in accordance with Section 517, "Post-Tensioning."

Tension straight or draped strands using a single or multi-strand stressing method. Design the stressing method to ensure uniform stress among and along the strands. Leave space between members to allow for cutting the strands during release. During stressing, record the stressing measurements, date, time, and ambient temperature.

Inspect the strands after tensioning. Clean or replace strands contaminated by form release agent.

If more than 84 hr has elapsed since stressing, restress the strands as directed by the Engineer before placing the concrete.

(2) Initial Tensioning

Equally tension each strand to eliminate slack before starting elongation readings. Use a tension intensity from 5 to 25 percent of the final jacking force. Mark each strand after initial tensioning (but before final tensioning) and after final tensioning to measure elongation and monitor each anchor wedge for slippage.

(3) Target Stressing Values

Calculate the target force and elongation in accordance with the following:

- The target force equals the total jacking force needed for tensioning;
- The target elongation corresponds to the target force;
- Make appropriate allowances for losses, such as friction, slippage, and relaxation of anchors and splices; and
- Adjust target values if the temperature difference between the strands and the concrete at placement is greater than 30 °F [15 °C].

Limit overstressing of strands to 80 percent of the ultimate strength shown on the manufacturer's mill certification.

(4) Stress Measurement

Measure strand tension using a pressure gauge or load cell. Mark strands, without damaging them, to measure elongations. For single and multi-strand stressing, record the force and elongation measurements for each strand and strand group. Monitor slippage of individual strands for multi-strand stressing, and restress individual strands to meet the Contract requirements. Record each strand heat number.

Tension until the force and elongation are both within ±5 percent of the respective target value. Ensure the control measurements of force and elongation algebraically agree within ±5 percent. Stop tensioning before reaching the targets if the force or elongation exceeds the respective target value by more than 5 percent. If discrepancies occur, check the entire stressing operation, and determine and correct the source of error before proceeding.

(5) Draped Strands

Tension draped strands using one of the following methods.

- Partially jacking the strands in a straight position from one end of the bed and finishing by vertically displacing the strands into their draped positions; or
- If more than two beams are on the casting bed, jacking from both ends of the bed and holding the strands in the draped position using rollers, pins, or other low-friction devices approved by the Engineer.

(6) Strand Splicing

Use no more than one splice per strand. Splice strands of similar physical properties with the same source and "twist" or "lay." During multi-strand stressing, splice either less than 10 percent or 100 percent of the strands. Locate splices outside the prestressed members.

(7) Debonding Strand

Provide debonding on strands as required by the Contract. Use one of the following methods:

- Interlocking plastic tubing,
- Solid plastic tubing,
- Two layers of split plastic tubing with seams greater than 90° apart, or
- Another method approved by the Engineer.

Seal ends and seams of debonding with water resistant tape. Ensure debonding is within 2 in [50 mm] of the target length. Measure the length of debonding to the end of the plastic seal.

E. Concrete

(1) General

Perform concrete work in accordance with Section 509, "Structural Concrete," except as modified in Section 503. Consolidate the concrete internally, or internally and externally. Do not damage or displace reinforcement during consolidation. Replace rejected members, at no additional cost to the Department. The Engineer will not accept concrete containing cement balls or that segregates under normal consolidation.

Place concrete when the concrete temperature is from 50 °F to 95 °F [10 °C to 35 °C]. Use Type I or Type III cement in Class P concrete.

Obtain reinforcing steel cover using plastic coated, epoxy coated, or plastic supports or chairs. Bend uncoated tie wire or metal supports within 1 in [25 mm] of any formed surface away from the form to obtain the cover required by the Contract.

Unless otherwise required by the Contract, finish the top surface of members with a rough float, followed by a transverse finishing with a stiff brush. Finish formed surfaces with a Class 1 finish in accordance with Subsection 509.04.G(1), "Class 1, Ordinary Surface Finish."

(2)Curing

Unless otherwise required by the Contract, cure precast members using the water method, or the steam or radiant heat method in accordance with Section 509, "Structural Concrete." To prevent surface drying, fog exposed concrete surfaces until regular curing starts.

If differential movement between forms and beds causes damage to members during curing, perform the following:

- Anchor the forms to prevent differential movement, or
- Loosen side forms when loosening will not damage the members.

For steam or radiant heat curing, record the temperature surrounding the member using at least three continuous temperature recorders per line.

For water curing, if the expected ambient temperature is less than 40 °F [4 °C], use at least one temperature recorder per line.

(3)Testing

Before casting, notify the Engineer for inspection. Sample and test in accordance with Section 509, "Structural Concrete," except as modified by the following:

- For beams and piles, sample and test each member at least once. Take the sample from a batch of concrete of which more than 50 percent will be incorporated into the member it represents.
- For prestressed stay-in-place form deck panels, sample concrete at a rate of at least one sample for each 10 yd^3 [10 m^3] of concrete. Randomly select batches for sampling in advance. Vary sampling patterns for each casting operation. Determine slump, air content, temperature, and compressive strength from each acceptance sample. Perform additional sampling and testing for quality control.

Before detensioning, cure all cylinders in the same manner as the members they represent in accordance with Section 9.4 of AASHTO T 23. After detensioning, cure the remaining cylinders in accordance with Section 9.3 of AASHTO T 23. From each sample, make and test at least one cylinder for detensioning and three cylinders for 28-day testing. Make additional cylinders for detensioning and early testing of 28-day requirements. Test the 28-day cylinders at 28 days, regardless of any previous testing.

For detensioning, determine sample strength using a cylinder from each concrete member or sample for deck panels. Detension when all sample locations in the line attain the detensioning strength required by the Contract.

For 28-day strength, use the average of three cylinders from the same concrete sample to determine sample strength. The Department will evaluate failed compressive strength tests in accordance with Department policy on acceptance of low strength concrete cylinder tests.

F. Detensioning

Design detensioning procedures to:

- Minimize shock to the members,
- Minimize movement against restrained items such as forms, inserts, and holddowns,
- Prevent members from impacting each other, and
- Prevent overstressing or damaging members.

List the detensioning procedure for each member or reference them on the Shop Drawings. List referenced procedures in the production and QC manual.

Detension after the concrete attains the compressive strength for release required by the Contract. Detension immediately after steam or radiant heat curing while the concrete is still warm and moist. Prevent the temperature surrounding the members from falling below 45 °F [7 °C] before detensioning. Detension within 6 hr of ending water curing.

If transferring the stressing force by jacking, limit the tension force to 5 percent over the target stressing force, or 80 percent of the ultimate strand strength, whichever is less. Cut or release strands in an order that minimizes lateral eccentricity of prestress. If cutting strand with an acetylene torch, minimize shock loading by heating the strand to induce slow yielding and to relieve stress, and then cutting. Correct the strand cutting procedure if indications of shock loading, such as brooming of strand, appear.

Cut strands flush with the end of the member using a saw or other device approved by the Engineer. The Department will not allow the use of an acetylene torch within 6 in [152 mm] of concrete surfaces. Use wire brushing or abrasive blast cleaning to remove dirt and residue. Clean and paint flush-cut strand ends and adjoining concrete within 1 in [25 mm] of the strand. Coat the cut strand ends with at least 5 mil [130 µm] of zinc-rich paint containing at least 90 percent zinc. Thoroughly mix the paint before application. Work the paint into voids with a brush or by spraying. Use an epoxy modified grout to cover the exposed strand ends and zinc-rich paint. Provide epoxy in accordance with Subsection 701.13, “Epoxy Resin and Other Adhesives for General Use With Concrete,” Type E. Ensure the beam ends are vertical to the beam end sole plates within a tolerance of ±⅛ in/ft [±3 mm/0.3 m] of the beam height. The Department will not allow drilling or coring members without the approval of the Engineer.

G. Storage, Inspection, and Transportation

Maintain members in an upright position. Handle members using the lifting eyes or loops. Support beams in storage and transit within 2 ft [0.5 m] of the designed bearing locations. Support stay-in-place panels and piles as shown on the Shop Drawings.

Prevent damage to members during storage, handling, and transportation. Replace damaged members at no additional cost to the Department. Repair minor chipping, spalling, and scars as directed by the Engineer.

Mark members with a piece mark as shown on the Shop Drawings. Include the member mark number, piece number, job identification, and date cast.

The Engineer must inspect, approve, and stamp members at least 48 hr before shipment to the Project. Ship only approved and stamped members. The Contractor is responsible for any defects found after shipment.

Allow members that attain the required 28-day compressive strength to age at least 168 hr before shipment.

H. Tolerances

Correct the production process if member dimensions approach a tolerance limit specified in Table 503:1, Table 503:2, Table 503:3, and Table 503:4. Immediately notify the Engineer of members that do not meet these tolerances.

Check dimensional tolerances before casting and after removal from the forms. Recheck time-dependent tolerances such as length, camber, and sweep, within 3 days before shipment. Check camber and sweep when the thermal effects of sunlight are negligible, on cloudy days or during the early morning. Check local smoothness with a 5 ft [1.5 m] straightedge.

Ensure dimensional tolerances are in accordance with Table 503:1 for AASHTO girders and bulb-tees, Table 503:2 for double-tees, Table 503:3 for prestressed piling, and Table 503:4 for prestressed deck panels:

Table 503:1
Maximum Dimensional Tolerances for AASHTO Girders and Bulb Tees

Dimensions	Tolerance
Length	±1 in [±25 mm]
Width (overall)	+⅜ in, −¼ in [+10 mm, −6 mm]
Width (web)	+⅜ in, −¼ in [+10 mm, −6 mm]
Depth (overall)	+½ in, −¼ in [+13 mm, −6 mm]
Depth (flanges)	±¼ in [±6 mm]
Sweep	⅛ in/10 ft [1 mm/m]
Debonding length	±2 in [±50 mm]
Variation from end squareness or skew	±$^{3}/_{16}$ in/ft [±16 mm/m], ≤±1 in [≤±25 mm]
Camber variation from design camber	
Camber variation from design camber	±⅛ in/10 ft [±1 mm/m]
For spans of 80 ft [25 m] or less	≤±½ in [≤±13 mm]
For spans over 80 ft [25 m]	≤±1 in [≤±25 mm]
Differential camber between adjacent members	⅛ in/10 ft [1 mm/m]
Position of strands	
Individual	±¼ in [±6 mm]
Bundled	±½ in [±13 mm
Draped strand holddown point	±20 in [±0.5 m]
Position of plates	
Sole plates	±⅝ in [±16 mm]
Other plates	±1 in [±25 mm]
Tipping and flushness of plates	
Sole plates	±0.5%, ≤±⅛ in [≤±3 mm]
Other plates	±¼ in [±6 mm]
Position of inserts	
Diaphragm holes	±1 in [±25 mm]
Diaphragm hole variation from squareness or skew	±1 in [±25 mm]
Other inserts	±½ in [±13 mm]

Table 503:1
Maximum Dimensional Tolerances for AASHTO Girders and Bulb Tees

Dimensions	Tolerance
Position of handling devices	
Parallel to length	±6 in [±150 mm]
Transverse to length	±1 in [±25 mm]
Position of stirrups	
Longitudinal spacing	±2 in [±50 mm]
Projection above top	±¾ in [±19 mm]
Local smoothness of any formed surface	±¼ in/10 ft [±6 mm/3 m]

Table 503:2
Maximum Dimensional Tolerances for Double-Tees

Dimension	Tolerance
Length	±1 in [±25 mm]
Width (overall)	±¼ in [±6 mm]
Width (webs)	±⅛ in [±3 mm]
Depth (overall)	±¼ in [±6 mm]
Thickness (flanges)	+¼ in, −⅛ in [+6 mm, −3 mm]
Flange overhang (flange edge to web edge)	±¼ in [±6 mm]
Distance between webs	±¼ in [±6 mm]
Sweep	⅛ in/10 ft [1 mm/3 m)]
Variation from end squareness or skew	±$^{3}/_{16}$ in/ft [±10 mm/m], ≤±1 in [≤±25 mm]
Camber variation from design camber	±⅛ in/10 ft [±1 mm/m], ≤±¾ in [≤±19 mm]
Differential camber between adjacent members	⅛ in/10 ft [1 mm/m], ≤¾ in [≤19 mm]
Position of strands	
Individual	±¼ in [±6 mm]
Bundled	±½ in [±13 mm]
Draped strand holddown point	±12 in [±300 mm]
Position of plates	
Sole plates	±½ in [±13 mm]
Other plates	±1 in [±25 mm]
Tipping and flushness of plates	
Sole plates	±0.5%, ≤±⅛ in [≤±3 mm]
Other plates	±¼ in [±6 mm]
Position of inserts	
Diaphragm holes	±1 in [±25 mm]
Diaphragm hole variation from squareness or skew	±1 in [±25 mm]
Other inserts	±½ in [±13 mm]
Position of handling devices	
Parallel to length	±6 in [±150 mm]
Transverse to length	±1 in [±25 mm]
Position of stirrups	
Longitudinal spacing	±2 in [±50 mm]
Projection above top	±¾ in [±19 mm]
Local smoothness of any formed surface	±¼ in/10 ft [±6 mm/3 m]

Table 503:3
Maximum Dimensional Tolerances for Prestressed Concrete Piling

Dimension	Tolerance
Length	±1 in [±25 mm]
Width or diameter	± ⅜ in [±10 mm]
Variation from longitudinal axis (bow)	±⅛ in/10 ft [1 mm/m]
Variation from end squareness or skew	± ¼ in/ft [±6 mm/0.3 m], ≤±½ in [≤±13 mm]
Position of Individual Strands	± ¼ in [±6 mm]
Position of handling devices	±6 in [±150 mm]
Longitudinal spacing of spiral reinforcement	± ¾ in [±19 mm]
Local smoothness of any formed surface	± ¼ in/10 ft [±6 mm/1.5 m]

Table 503:4
Maximum Dimensional Tolerances for Prestressed Concrete Stay-in-Place Forms

Dimension	Tolerance
Length (in direction of panel strands)	+¾ in, −¼ in [+18 mm, −6 mm]
Width	+¼ in, −½ in [+6 mm, −12 mm]
Thickness	+¼ in, −⅛ in [+6 mm, −3 mm]
Variation from end squareness or skew	±¼ in [±6 mm]
Camber, sweep, and warping	±¼ in/10 ft [±6 mm/3 m]
Position of individual strands	
Vertically	+0 in, −¼ in [+0 mm, −6 mm]
Horizontally	±½ in [±12 mm]
Position of handling devices	
Parallel to length	±3 in [±75 mm]
Transverse to length	±2 in [±50 mm]
Local smoothness of any formed surface	±¼ in/10 ft [±6 mm/3 m]

I. Corrective Actions

Correct members that do not meet the tolerances specified in Table 503:1, Table 503:2, Table 503:3, or Table 503:4, in one of the following ways, at no additional cost to the Department:

- Replace the member.
- Correct the member tolerance problem as directed by the Engineer.
- If unable to correct a usable member, submit the member for review and acceptance at a reduced price in accordance with Subsection 105.3, "Conformity With Plans and Specifications." Include a description of the problem and the proposed corrective action. Provide structural and physical evaluation by an Oklahoma registered professional engineer, as required by the Contract. If the submittal is rejected, replace the member at no additional cost to the Department.

503.05 METHOD OF MEASUREMENT — VACANT

503.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) PRESTRESSED CONCRETE BEAMS	Linear Foot [Meter]
(B) PRESTRESSED CONCRETE DOUBLE TEES	Linear Foot [Meter]
(C) PRESTRESSED CONCRETE DECK PANELS	Square Foot [Square Meter]

If the Contractor chooses to use stay-in-place forms, the Department will not pay for additional quantities of concrete and reinforcing steel in excess of the quantities shown on the Plans.

The Department will pay for prestressed concrete piling in accordance with Section 514, "Driven Foundation Piles."

The Department will consider the cost of embedded plates to be included in the contract unit price for the relevant prestressed member pay item.

SECTION 504
BRIDGE DECKS, APPROACHES, RAILS, AND PARAPETS

504.01 DESCRIPTION

This work consists of constructing concrete bridge decks, approach slabs, and railings and parapets for bridges, roadways, wing walls, retaining walls, and other structures.

504.02 MATERIALS

Provide materials in accordance with the following sections and subsections:

Material:	Section or Subsection:
Structural Concrete (Class AA)	509
Joint Fillers and Sealers	701.08
Reinforcing Steel for Structures	511
Curing Agents	701.07
Metal Bridge Railing Materials	732.03
Aluminum Alloy Tubes for Railings	732.03
Cast Aluminum Alloy Bridge Railing Posts	732.03
Pipe Railing	732.04

Provide a corrosion-inhibiting admixture for cast-in-place bridge deck concrete and precast deck-form concrete, if using stay-in-place prestressed concrete deck forms.

504.03 EQUIPMENT

A. Finishing Machine

Provide an Engineer approved, self-propelled finishing machine supported on rails or steel-clad headers capable of transversely finishing the bridge deck and approach

slabs. Fasten the rails and headers parallel to the deck centerline and set the line and grade with allowance for dead-load deflections. Before placing concrete, submit a machine description that includes the make, model, a finishing plan, and an equipment breakdown plan that lists spare equipment and parts and estimates for down time. Spare equipment will include one engine for the finishing machine. Provide enough equipment and labor to limit down time so that concrete placement can be completed within the time requirements in Table 509:1.

B. Fogging Equipment

Provide a fogging system that creates fog with pressurized water and a series of fogging nozzles (not more than 3 ft [1 m] apart) that will continuously cover the finished concrete with cool, moist air. Provide high pressure equipment capable of generating at least 1,200 psi [8.3 MPa] at a flow rate of 2.2 gpm [8.3 L/min], or low-pressure equipment with nozzles capable of supplying a maximum flow rate of 1.6 gpm [6.1 L/min]. Mount fogging equipment to the trailing edge of strikeoff, work bridges, or both with nozzles positioned to spray above a horizontal plane. Provide hand held foggers for areas which require supplemental fogging. Do not use hand held foggers as the primary fogging equipment or as a finishing aid.

C. Grooving Machine

If saw-cut grooving is required by the Contract, provide a self-propelled grooving machine to groove hardened concrete. Use a grooving machine equipped with the following features:

- Diamond saw blades mounted on a multi-blade arbor at the Contract required spacing,
- A depth control device that detects variations in the concrete surface and adjusts the height of the cutting head to maintain the Contract required depth,
- An alignment control device, and
- A vacuum attachment that removes and collects slurry or residue from the grooving operation.

D. Work Bridges

Provide at least two work bridges to provide access for floating, straight edging, fogging, curing, and finishing the concrete.

504.04 CONSTRUCTION METHODS

Ensure the bridge deck thickness is ±½ in [±12 mm] from the thickness dimensions shown on the Plans. The Engineer may direct removal and replacement of spans or sections between construction joints if the thickness tolerance is not met.

Construct approach slabs in accordance with Section 414, “Portland Cement Concrete Pavement,” except as modified by Section 504.

A. Forming, Bracing, and Finishing Machine Rails

At the pre-work meeting, submit to the Engineer for approval, a Bridge Deck Plan that covers the following:

- Falsework, forming, and bracing details in accordance with Subsection 502.04.A, “Falsework,”

- Stay-in-place form shop drawings, lap details, and methods for sealing corrugations, and method of attachment to beams in accordance with Subsection 502.04.B, "Forms."
- Placing, consolidating, finishing, fogging, and curing equipment and back-up equipment located on-site in accordance with Subsection 504.03, "Equipment."
- Quantities of material and numbers of equipment for rainy, cold, and hot weather protection in accordance with Subsection 509.04.B, "Protection of Concrete from Environmental Conditions."
- Concrete mix design, the plant supplying the concrete, and the expected delivery and placement time in accordance with Subsection 701.01, "Mix Design and Proportioning," and Subsection 509.04.C, "Handling and Placing Concrete."
- Quality control plan for concrete placement that includes the purpose, intent, and interpretation of the QC specifications.
- Identification of checks used to ensure the deck conforms to the dimensions shown on the Plans and quality required by the Contract.
- Process for delivering, placing, consolidating, finishing, and curing the concrete in accordance with Section 504 and Section 509, "Structural Concrete."

Begin falsework after the Engineer approves the Bridge Deck Plan.

Provide forms and bracing for the deck overhang to support the weight of construction loads. Brace exterior steel girders to prevent girder rotation and over stressing the girder web in accordance with Subsection 502.04.A(6), "Falsework for Steel and Precast Concrete Beams and Girders."

Set rails on non-yielding supports outside the concrete placement for the length of the deck to allow the finishing machine float to clear the concrete. Use rails that adjust for elevation. Set rails to allow for settlement, camber, and deflection of falsework. Adjust rails to correct for additional settlement or deflection during finishing operations. If located within the deck, remove the rail supports to at least 3 in [75 mm] below the finished surface when the concrete placement operation no longer requires them. Fill the void with fresh concrete.

B. Construction Joints

Build construction joints in accordance with Subsection 509.04.D, "Construction Joints," or as directed by the Engineer. Where the deck is continuous over abutments or piers, place a construction joint at the end of simple spans. Wait at least 24 hr before placing adjacent deck sections.

After concrete placed on both sides of the joint hardens, saw-cut the top of the joint 1 in [25 mm] deep and ¼ in [6 mm] wide. Seal the joint with sealant shown on the Plans or approved by the Engineer. If sealing construction joints on bridges subject to traffic vibrations, use a rapid cure joint sealant in accordance with Subsection 701.08.G, "Rapid Cure Joint Sealant and Elastomeric Mortar."

C. Expansion Joints

(1) Metal Expansion Joints

Provide metal expansion joints fabricated in accordance with Section 506, "Structural Steel."

Install expansion joint assemblies so the joint surface matches the plane of the adjacent concrete along the length of the assembly. Secure the assemblies in place during concrete placement.

Cut rigid connections between opposite halves of an expansion joint assembly after initial concrete set to prevent damage from joint movement from thermal changes in the superstructure.

Provide an opening in the traffic rail and concrete parapets matching the expansion joint dimension. Before installing the neoprene gland in sealed expansion joints, clean steel surfaces that will contact the neoprene.

(2)Joints Made of Elastomeric Mortar and Rapid Cure Joint Sealant

Provide elastomeric mortar and rapid cure joint sealant in accordance with Subsection 701.08.G, "Rapid Cure Joint Sealant and Elastomeric Mortar." Strip forms and clean the concrete surfaces to ensure proper bond of the elastomeric mortar. For existing concrete surfaces, saw, flush, and clean joints in accordance with the manufacturer's recommendations. Blast-clean steel surfaces in accordance with SSPC-SP10, "Near-White Blast Cleaning." After preparing the surface, notify the Engineer for inspection of the joint before installing the elastomeric mortar.

Install the elastomeric mortar when the joint surface temperature reaches at least 45 °F [7 °C]. If recommended by the manufacturer, apply heat to improve the elastomeric mortar curing time. Before exposing joint to traffic, allow the mortar to cure for at least 2 hr, or if joint surface temperatures fall below 70 °F [21 °C], cure for 4 hr.

After installing the elastomeric mortar, install the rapid cure joint sealant when the joint surface temperature is at least 60 °F [15 °C]. Install the sealant in expansion joints when the joint openings are from ¾ in to 2½ in [19 mm to 63 mm]. If an opening is larger than 2½ in [63 mm], notify the Engineer.

Provide an elastomeric mortar and sealant manufacturer's technical representative at the beginning of work to inspect sealing operations.

D. Reinforcing Steel Placement

Place reinforcing steel in accordance with Section 511, "Reinforcing Steel for Structures." Place transverse reinforcing steel bar ends 2 in [50 mm] from the edge of the deck or slab. Place the ends of longitudinal reinforcing steel bars and parapet bars 1 in [25 mm] from the end of the concrete or expansion device. Ensure tolerances in accordance with Subsection 511.04.B, "Placing and Fastening." Support reinforcing steel with wire supports. Unless otherwise required by the Contract, extend longitudinal reinforcing steel bars through construction joints.

E. Concrete

Place concrete in accordance with Section 509, "Structural Concrete."

If using stay-in-place, pre-stressed concrete deck forms with a corrosion-inhibiting admixture, limit temperature for bridge deck and approach slab concrete to a maximum of 85 °F [30 °C].

(1)Pre-Deck Pour Inspection

At least 24 hr before placing the deck and with the Engineer present, inspect for the following:

- Forms are mortar tight, cleaned, and oiled.
- Stay-in-place steel forms are lapped in the direction required by the Contract.
- Concrete panels are set to allow concrete to flow between the bottom of the panel and the top of the beam in accordance with Section 502, “Forms, Falsework, and Temporary Works.”
- Falsework has been inspected and certified, and tell-tales installed and marked in accordance with Section 502, “Forms, Falsework, and Temporary Works.”
- Reinforcement is clean, coating damage is repaired, ties are tight, support provides a stable mat, and clearances and spacing meet plan dimensions and tolerances in accordance with Section 511, “Reinforcing Steel for Structures.”
- Finishing machine rails are stable.
- Back-up equipment is on site.
- No oil or fuel leaks from machinery.
- The dry run produces cover, clearance, and deck thicknesses in accordance with Table 502:1, "Maximum Dimensional Tolerances for Cast in Place Formed Concrete."
- Equipment and materials for weather protection are in place.
- Temperature reading locations during cure period are identified in accordance with Section 509, “Structural Concrete.”
- Work bridges, curing materials, and equipment are prepared for concrete placement.
- Fogging application equipment is in good working order with no leaks.
- Sufficient quantities, personnel and methods for placement of curing mats, including procedures for pre-wetting and maintaining moisture in curing mats during cure time.
- Identify locations for concrete discharge, sampling, and testing in accordance with Subsection 701.01, “Mix Design and Proportioning.”

Begin placing the deck with the Engineer’s approval.

(2) Placement

Deposit the concrete ahead of the finishing machine and slightly higher than the finished surface. Always maintain excess concrete in front of the screed cutting edge. Carry the excess to the edge of the pour or forms, and remove.

Place concrete at a rate of at least 25 ft/hr [8 m/hr] measured longitudinally along the bridge deck.

During hot weather, place concrete at dawn, at dusk, or at night in accordance with Subsection 509.04.B, “Protection of Concrete from Environmental Conditions.”

(3) Lighting

Place concrete at night in accordance with Subsection 509.04.C(3)(c), “Lighting.”

(4) Finishing

After consolidating the concrete, use the finishing machine to transversely strike-off the concrete to the profile shown on the Plans. Use a float to finish the

concrete to a smooth, even surface along the bridge length. Finish transversely, unless the Contract allows longitudinal finishing.

The Department will not allow spraying water on the concrete surface to assist finishing operations.

While the concrete is plastic, test the surface line and grade with a 10 ft [3 m] straightedge. Fill depressions with fresh concrete and remove high areas. Consolidate, strike-off, and refinish the repaired areas. Ensure the surface across joints is in accordance with Subsection 401.04.A(1), "Surface Elevation and Smoothness."

Finish approach slabs the same as bridge decks. For overlaid approach slabs, use the same final finish as for bridge deck overlays.

(5) Fogging and Curing Requirements

Fog all bridge deck placements. Begin fogging bridge decks behind the finishing operations for the entire deck width. Continue fogging to produce a semi-gloss water sheen on the surface until application of the curing material. Reduce fogging if water accumulates on the surface and begins to run off. Ensure the fogging nozzles atomize the droplets and dampen without creating pools of water. Do not use water from fogging as an aid to finish the concrete.

Continuously cure the concrete immediately after finishing for at least seven days. If using a polozzon, such as flyash, of greater than 10 percent, continuously cure the concrete immediately after finishing for at least 10 days. Cure the bridge deck or approach slab in accordance with Subsection 504.04.E(5)(a), “Water with Waterproof Cover.” Cure pedestrian walkways the same as bridge decks. The Department will not allow the use of curing compounds during the seven day curing period.

(a) *Water with Waterproof Cover*

Continuously apply fog after the concrete strike-off and until covering the concrete with wet burlap. Mount fogging equipment on the finishing equipment. Prevent the water from dripping, flowing, or ponding during fogging, placement of absorbent material, or before the concrete sets.

Apply one layer of wet burlap, or an alternative material approved by the Engineer, within 10 min of concrete strike-off. Apply a second layer within 5 min. Maintain a moist surface after strike-off and during the curing period.

Using a misting hose, keep the burlap saturated until the concrete sets enough to allow foot traffic. When the concrete sets, place soaker hoses on the burlap and supply water to maintain continuous saturation of the burlap over the entire concrete surface.

Place white polyethylene film over the soaker hoses covering the concrete surface. Use the widest available sheets and overlap adjacent sheets at least 6 in [150 mm]. Use a pressure sensitive tape, mastic, glue, or other Engineer approved adhesive to tightly seal and form a waterproof cover. Secure the polyethylene film to prevent displacement by the wind. Repair or replace sheet portions that become damaged before the end of the curing period, or lose waterproofing ability.

(b)*Curing Membrane*

Ensure the curing compound has not expired. Within 30 min of removing the wet burlap and polyethylene (at the end of the seven day curing period or at the end of the 10 day curing period when using pozzolan of greater than 10 percent) apply two coats of curing membrane while the surface is damp. Apply the curing membrane at a coverage rate of at least 1 gal per 200 ft² [1 L per 5 m²] unless otherwise required by the Contract. If the concrete surface dries, fog spray to maintain a damp condition. Spray the second coat of curing membrane immediately after and perpendicular to the first.

Protect the curing membrane for at least seven days. Apply an additional coat to marred areas of the membrane. If the curing membrane is continuously marred, the Engineer may direct the application of wet burlap, polyethylene sheeting, or other impermeable material to ensure Contract required concrete curing.

(6)Removing Forms

Remove forms in accordance with Subsection 502.04.C, "Removal of Forms and Falsework."

F. Surface Correction through Grinding

After curing, test the concrete driving surfaces using a 10 ft [3 m] straightedge or other Contract allowed device. Mark and grind areas with spots higher than ⅛ in [3 mm]. Begin grinding after completion of the curing period, and in accordance with Section 425, "Diamond Grinding Concrete Pavement." Grind areas that do not meet smoothness specifications in accordance with Subsection 401.04.A(1), "Surface Elevation and Smoothness." Do not reduce the concrete cover over reinforcing steel to less than 2 in [50 mm]. Restore the skid-resistant surface in ground areas using saw-cut grooving. Remove and replace, at no additional cost to the Department, bridge decks and approach slabs that cannot be corrected to meet the specified tolerances. The Department will not measure grinding for surface correction for payment.

G. Transverse Grooving

(1) Groove Geometry

Saw-cut grooves to the dimensions and tolerances specified in Table 504:1.

Table 504:1
Dimension and Allowable Size of Saw-Cut Groove

Dimension	Allowable Size, *in [mm]*
Width	⅛ – ¼ [3 – 6]
Depth	⅛ – $^{3}/_{16}$ [3 – 5]
Spacing [a] (c/c)	½ – 1 [6 – 12]

[a] Randomly vary the groove spacing from ¾ in to 1½ in [19 mm to 38 mm] on bridges at least 1,000 ft [300 m] long.

Make the groove cross-sections rectangular for saw-cut grooves. Measure the width tolerance at the mid-depth of the grooves. Cut grooves within 2 ft [0.6 m] of the parapet face, guardrail, or curb. Continuously run the grooves across the width of the bridge to within 2 ft [0.6 m] of the opposite parapet face, guardrail, or curb. The Department will not allow cutting of grooves within 6 in [150 mm] of a

construction joint. Do not overlap parallel grooving patterns. For curved bridges, cut grooves transverse to the curve cord within the spans.

(2) Grooving Hardened Concrete

Provide saw-cut transverse grooves under the following conditions:

- The Department specifies saw-cut transverse grooving as a pay item,
- Replace transverse grooving after grinding, and
- Correct out-of-tolerance transverse grooving.

Begin saw-cut grooving after completion of the concrete curing period and grinding repairs. If spalling occurs, discontinue grooving and correct the cause. During grooving work, if a single blade on a multi-blade grooving machine can no longer cut a groove, repair the damaged blade after completion of the shift. The Engineer will not require the repair of the omitted groove. If more than one blade is damaged, discontinue use and repair the damaged areas as directed by the Engineer.

(3) Slurry Removal

While grooving, continuously vacuum the slurry and residue. Prevent the flow of slurry into open traffic lanes or drainage facilities. After grooving, clean slurry residue from the pavement or bridge deck. Dispose of slurry off the project site at an approved waste site as per Subsection 104.09, "Removal and Disposal of Salvaged Materials Structures and Obstructions," and Subsection 107.01, "Laws, Rules, and Regulations to be Observed," as required by the Contract.

H. Load on Decks and Approach Slabs

(1) General

Do not apply loads to concrete structures until the concrete has attained sufficient strength. Determine strengths from test cylinders cured at the work site under similar environmental conditions in accordance with Section 701, "Portland Cement Concrete." Provide continuous wet cure to any exposed deck throughout the entire seven-day wet cure period (ten days for decks containing fly ash).

(2) Construction Loads

The Engineer will limit construction loads on the new deck to the following:

- Foot traffic during the seven day curing period.
- Reinforcing steel or form placement for the bridge rail or barrier – after the deck concrete has cured sufficiently to not be damaged by the operations.
- Light truck traffic with a gross vehicle weight no greater than 5 ton [4.5 metric ton] or placement of the concrete for the bridge rail or barrier – seven days after the deck concrete placement or when the deck concrete reaches 80 percent of the Contract required compressive strength and the underlying forms and falsework are still in place.
- Legal loads – 14 days after deck concrete placement or when the deck concrete reaches 100 percent of the Contract required compressive strength and the underlying forms and falsework are still in place.
- Heavy stationary loads greater than 5 ton [4.5 metric ton] to less than 10 ton [9.0 metric ton] – 14 days after the deck concrete placement or the deck

concrete reaches 100 percent of the Contract required compressive strength and the underlying forms and falsework are still in place.

Unless the Engineer approves the use in writing, prohibit the following construction loads:

- Heavy stationary loads over 10 ton [9.0 metric ton]; and
- Vehicles greater than legal loads.

For post-tensioned structures, complete the span tensioning before applying loads more than 4,500 lb [2,000 kg].

Obtain the Engineer's approval before operating a mixer on the bridge decks. The Department will only allow rubber tire construction vehicles on bridge decks or approach slabs unless approved by the Engineer.

(3) Traffic Loads

The Department will not allow traffic loads on concrete decks or approach slabs until 14 days after the completion of concrete placement and after the concrete attains 100% of the Contract required compressive strength.

I. Rails, Parapets, and Curbs

Construct concrete rails, parapets, and curbs in accordance with Section 509, "Structural Concrete," and Section 511, "Reinforcing Steel for Structures." Do not place railings, parapets, and curbs until the span falsework is released and the dead load deflections have occurred for cast-in-place slab span, box girder, or post-tensioned superstructures.

(1) Forming

Provide forms in accordance with Section 502, "Forms, Falsework and Temporary Works." The Department will allow the slip form method of parapet construction if the results and curing, finishing, and protection of the concrete meet Contract requirements.

(2) Curing

Cure rail and parapet concrete in accordance with Subsection 509.04.F(2), "Forms-in-Place Method," or Subsection 509.04.F(3), "Water Method." Use either the forms-in-place or the water curing method. Use the water method on exposed surfaces. If removing forms and applying finish before the end of the specified curing period, resume curing for the remainder of the curing period.

(3) Finish

Provide a Class 2 finish for rail and parapet concrete surfaces, and curb sides in accordance with Subsection 509.04.G(2), "Class 2, Rubbed Finish." Use a wooden float to finish the tops of curbs.

(4) Line and Grade

Build the line and grade of the parapet or rail as required by the Contract. Unless otherwise required by the Contract, make parapets vertical. Construct handrails parallel to curbs.

504.05 METHOD OF MEASUREMENT

The Engineer will measure the following:

- Area of *Approach Slabs* by the top surface dimensions required by the Contract or approved by the Engineer.
- Area of *Saw-Cut Grooving* bounded by the ends of the approach slabs and the edges of the clear roadway.
- *Expansion Joints* from end to end along the joint centerline.
- *Rapid Cure Joint Sealant* along the joint centerline at the roadway surface.
- *Concrete Rail, Concrete Parapet,* or *Handrailing* with concrete posts from the outside of the end posts with no deduction for expansion joint gaps.
- *Handrailings* with metal posts from end to end.

The Engineer will not measure grinding for surface correction.

504.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) APPROACH SLAB	Square Yard [Square Meter]
(B) SAW-CUT GROOVING	Square Yard [Square Meter]
(C) EXPANSION JOINTS	Linear Foot [Meter
(D) CONCRETE RAIL	Linear Foot [Meter
(E) CONCRETE PARAPET	Linear Foot [Meter
(F) HANDRAILING	Linear Foot [Meter
(G) RAPID CURE JOINT SEALANT	Linear Foot [Meter
(H) ELASTOMERIC MORTAR	Cubic Foot [Cubic Meter]

The Department will pay for the quantities of Class AA concrete and reinforcing steel for concrete bridge decks shown on the Plans in accordance with Section 509, “Structural Concrete,” and Section 511, “Reinforcing Steel for Structures.”

The Department will consider the cost of lighting to be included in the contract unit price for the relevant pay item.

The Department will consider the cost of other joint fillers and joint sealers to be included in the contract unit price for other bid items.

Unless otherwise required by the Contract, the Department will pay for incidental steel items (metal drains) in accordance with Section 506, “Structural Steel,” and Section 511, “Reinforcing Steel for Structures.”

SECTION 505
OVERLAYS FOR CONCRETE BRIDGE DECKS

505.01 DESCRIPTION

This work consists of preparing deck surfaces and placing overlays on bridge decks, and the approach pavement to provide a smooth transition to the main line pavement. Concrete overlays and asphalt membrane overlays are covered.

505.02 MATERIALS

Provide materials in accordance with the following section and subsections:

Material:	Section or Subsection:
Portland Cement Concrete	701.01
High Density Concrete for Bridge Deck Repair and Overlay	701.10
Latex Modified Concrete for Bridge Deck Overlays	701.11
Early Strength Concrete for Bridge Deck Patching and Overlays	701.20
Multiple Layer Polymer Concrete Overlay Special Provisions	701.13.B.(13)
Waterproof Membrane for Asphalt Overlay	712.09
Reinforcing Steel for Structures	511

Provide the following overlay types as required by the Contract:

- High density concrete (HDC),
- Latex modified concrete (LMC),
- Early Strength concrete (ESC), or
- Other materials as required by the Contract.

505.03 EQUIPMENT

Provide equipment with traps, filters, drip-pans, or other devices to keep oil and deleterious material off the deck. Use the following types of surface preparation equipment as required by the Contract:

A. Hydrodemolition Equipment

Provide hydrodemolition equipment with a filtering and pumping unit that operates with self-propelled, computerized equipment. Ensure the hydrodemolition equipment uses a high pressure water jet that can remove unsound concrete in a single pass. Provide equipment with water usage rate of at least 55 gpm [210 L/min] and a pressure of at least 13,000 psi [90 Mpa].

B. Mechanical Scarifying Equipment

Use self-propelled equipment to maintain accurate depth of cut and slope. Use equipment that automatically establishes profile grades along both edges of the machine by referencing the bridge deck with a ski or matching shoe, or by an independent grade control. Equip with an integral loading device that removes the materials cut from the bridge deck and discharges them into a truck in a single operation.

C. Vacuum Cleanup Equipment

Provide vacuum cleanup equipment that cleans hydrodemolition and milling debris. Use a vacuum system equipped with dust control devices that remove wet debris and

water in the same pass. Provide equipment that washes the deck with pressurized water before vacuuming to dislodge debris and slurry from the deck surface.

D. Shot Blast Cleaning Equipment

Provide shot blasting equipment with oil traps.

E. Hand-Held Blast Cleaning Equipment

Provide hand-held blast equipment for sand blasting or water blasting to expose fine and coarse aggregates. Provide water blasting equipment that delivers at least 25 gpm [95 L/min] at 4,000 psi [28 Mpa].

F. Sawing Equipment

Provide saws that cut concrete to the depth required by the Contract.

G. Power-Driven Hand Tools

Provide power-driven hand tools, jack hammers, and chipping hammers no heavier than the 15 lb [7 kg] class.

H. Proportioning and Mixing Equipment

(1) HDC

Use proportioning and mixing equipment in accordance with Subsection 414.03, "Equipment," for high density concrete. Provide volumetric proportioning on a mobile mixer with continuous mixing or a stationary concrete mixer with rotating-paddles.

(2) LMC and ESC

Provide proportioning and mixing equipment of a self-contained, mobile, continuous-mixing type (volumetric based units) in accordance with the following:

- Provide a self-propelled mixer that can carry enough dry and unmixed cement, sand, coarse aggregate, and latex modifier to produce and place at least 5 yd^3 [5 m^3] of concrete mix uninterrupted.
- Equip mixers with a visible recording meter and ticket printout to indicate the quantity of cement going into the mix.
- Provide mixers with a positive control for the water flow and latex emulsion into the mixing chamber. Use a flow meter to indicate flow rate.
- Provide calibrated mixers to proportion and blend the composition continuously or intermittently as required by the Contract.

I. Placing and Finishing Equipment

(1) Placing Equipment

For placing and pre-screeding, use hand tools to place stiff plastic concrete to the strike off level of the screed.

(2) Finishing Machines

Use a finishing machine that can screed concrete within 12 in [300 mm] of the face of the curb or parapet wall. Extend the screed at least 6 in [150 mm] beyond the sides of the placement section, overlapping placed courses, overlay forms, and existing and planned saw-cut edges. Ensure each screed has positive controls for the vertical position, the tilt angle, and the crown shape. Power and gear the machine to maintain smooth operations in forward and reverse. Raise the screed to

clear the screeded surface for traveling in reverse. Use a machine capable of final screeding within 10 min of depositing the concrete on the deck. See Table 505:3, "Concrete Overlay Placement Rates," for other production rate specifications. Support the machine on adjustable rails (not shimmed) to obtain the profile shown on the Plans. If placing concrete in a lane that abuts a completed lane, equip the machine to travel on the completed lane without damaging its surface.

Provide deck foggers and misters on the deck finisher and work bridges in accordance with Subsection 504.03.B, "Fogging Equipment."

(3)Special Notes for High Density Concrete

For high density concrete overlays, use a mechanical strike-off to provide a uniform thickness of concrete in front of the oscillating screed. Equip the oscillating screed to consolidate the concrete to 98 percent of the unit weight in accordance with AASHTO T 121. Install identical vibrators along the screed length on 5 ft [1.5 m] maximum centers. Make the bottom face of this screed at least 5 in [125 mm] wide with a turned-up or rounded leading edge to prevent surface tearing.

(4)Special Notes for Latex Modified Overlays

For latex modified overlays, use a finishing machine equipped with at least two finishing devices:

- A vibrating screed that consolidates the modified composition to 98 percent of the rodded unit weight, and either
- A vibrating oscillating screed, or
- A finishing device with at least one rotating cylindrical drum no longer than 4 ft [1.2 m].

Equip the vibrating screed for latex modified concrete with positive control of vibration so that vibration frequency can be varied between 3,000 vibrations per minute and 6,000 vibrations per minute. Make the bottom face of the screed at least 4 in [100 mm] wide.

J. Special Notes for Polymer Concrete Overlays

(1)Mechanical Equipment

Provide a polymer distribution system, a mechanical aggregate spreader, and a self-propelled sweeper broom or vacuum truck. Provide compressed air that is free from oil and water.

(2)Hand Applications

Use calibrated containers, a paddle-type mixer, squeegees, rollers, and a broom to mix the resin and apply resin and aggregate in accordance with the manufacturer's recommendations.

(3)Night Construction

For night work, provide lighting in accordance with Subsection 509.04.C(3)(c), "Lighting."

505.04 CONSTRUCTION METHODS

A. General

Provide controls to limit dust. Perform concrete work in accordance with Section 509, "Structural Concrete." Protect traffic under the bridge and adjacent to the work zone while removing bridge deck concrete.

B. Work Plan

Before work begins, submit a work plan to the Engineer. Allow 14 days for the Engineer's review. Include the following in the work plan:

- Forming details;
- A list of project specific equipment to remove concrete, including hand tools;
- If using hydrodemolition, a plan for treating water used to remove concrete;
- A list of project specific equipment and back-up equipment for the following concrete procedures:
  - Mixing,
  - Placing,
  - Consolidating,
  - Finishing, and
  - Curing;
- A list of on-site equipment and material quantities for protection from rainy, cold, and hot weather;
- Concrete mix designs, and the expected travel time for delivery and placement;
- A planned work schedule including the following:
  - Traffic control,
  - Project phasing,
  - Surface preparation,
  - Production rate,
  - Patching cure times, and
  - Estimated time for overlay placement;
- An outline of the process used for concrete, including the following rework areas:
  - Removal,
  - Surface preparation,
  - Delivery,
  - Placement,
  - Consolidation,
  - Finishing, and
  - Curing; and
- A list of checks that will ensure the overlay meets the dimensions shown on the Plans and the quality required by the Contract.

For polymer concrete overlays, include the following additional items in the work plan:

- The compatibility of patching materials with the polymer concrete overlay material,
- The minimum air and deck surface temperatures,

- The manufacturer approval of the work plan and the number of courses and minimum cure times for each course,
- The manufacturer's written support of approval for any deviations from these specifications, and
- Necessary test reports, documentation, explanations, and justification to support the proposal.

For asphalt membrane overlays, include the following additional items in the work plan:

- Type of membrane and tack that will be used,
- Limitations of pavement/deck temperature and moisture content,
- How the pavement/deck temperature and moisture content will be measured,
- Length of time the membrane can be exposed before placing the asphalt overlay,
- Maximum temperature for the asphalt concrete overlay material, and
- How the curb line and deck drains will be sealed.

Obtain authorization from the Engineer to proceed before starting work.

C. Surface Preparation

(1) Surface Preparation for Polymer Concrete or Asphalt Membrane Overlays

Remove and dispose of existing overlays, asphalt, unsound concrete, and foreign material from the surface. Clean the deck surface by shot-blasting or water-blasting in accordance with Subsection 505.03.D, "Shot Blast Cleaning Equipment." Shot-blast after sand-blasting. Before placing the overlay, ensure the deck has no visible moisture. Test for moisture by taping a plastic sheet to the deck for at least 2 hr in accordance with ASTM D 4263 or other Engineer approved methods. Place overlay on hydraulic cement concrete of the Contract required strength.

(2) Surface Preparation for Concrete Overlays

For new decks, use a shot-blast or water-blast to prepare the surface. For existing decks, prepare deck surfaces using hydrodemolition, vacuuming, shielding, and water control. Scarify (mill) in conjunction with hydrodemolition. Provide controls to limit dust. Use jack hammering and other Engineer-approved methods to place the new concrete overlay where hydrodemolition cannot be used. Remove and dispose of existing overlays, asphalt, unsound concrete, and foreign material from the surface in accordance with Subsection 104.09 "Removal and Disposal of Salvaged Materials Structures and Obstructions," and Subsection 107.01 "Laws Rules and Regulations To Be Observed." Provide a rough, bondable surface at the depth shown on the Plans. Use the Contract required overlay material for deck patching. Monolithically place this material for the partial depth repairs. Make full depth repairs before placing the overlay in accordance with Section 513, "Repair of Concrete Bridge Decks." Place expansion joints as required by the Contract.

(a) *Scarification for Concrete Overlays*

For decks with overlays, remove the overlay with scarification. Scarify the top surface of the bridge deck before hydrodemolition. Remove approximately ¼ in [6 mm] of original deck surface. In cases where a new deck is being overlayed, the Engineer may omit the scarification and hydrodemolition.

(b)*Damage of Reinforcing Steel*

If the mechanical scarifying equipment snags the top mat of deck reinforcing steel, immediately stop and adjust the removal depth. Repair or replace damaged and dislodged reinforcing at no additional cost to the Department. Remove additional concrete to position the new reinforcing steel at the height shown on the Plans and Contract required lap splice lengths using a 15 lb [7 kg] chipping hammer at an angle of no more than 45° from horizontal.

(c)*Hydrodemolition*

If using hydrodemolition for surface preparation, perform the following:

- Shield traveling public from debris.
- Block drains, expansion joints, and areas where water can drain from the deck.
- Provide sediment basins to strain water before releasing it. Adjust drainage treatment until the released water runs clear.
- Provide a technical field representative on the project site during calibration and hydrodemolition surface preparation operations.
- Calibrate the hydrodemolition equipment on an area of sound concrete, and verify that it has a water pressure of at least 13,000 psi [90 Mpa]and a water usage rate of at least 55 gpm [210 L/min]. Establish the rate of travel.
- After calibration, move the equipment to an unsound area to verify that recorded settings remove the unsound concrete.
- Modify these settings to remove concrete to the minimum depth shown on the Plans.
- Hydrodemolish the top surface of the reinforced concrete bridge deck to make a rough and bondable surface.
- Wash the deck surface with pressurized water to dislodge debris and slurry. Before the debris and slurry dry, use a high powered vacuum cleaner to clean the deck in one pass. Remove dried material at no additional cost to the Department.
- Sound the dry deck and mark unsound areas.
- Repeat the process if the hydrodemolition surface preparation does not leave a bondable surface, remove unsound concrete, rust, oil, asphalt, or other foreign matter, and leave a clean etched concrete surface free of laitance.
- Splice exposed reinforcing steel if more than 20 percent of the reinforcing steel section bar area is lost.
- Where more than one half the reinforcing steel is exposed, handwork areas with 15 lb [7 kg] chipping hammers at 45° angles from horizontal to provide at least ¾ in of clearance around the bar. Minimize the amount of reinforcing steel exposed during hydrodemolition.
- Use hand-held blast cleaning equipment or 15 lb [7 kg]chipping hammers to clean and provide a bondable surface of the portion of the curb, the parapet wall, or both at the edge of the new overlay.

(d)*Surface Wetting for Concrete Overlays*

Before placing latex modified concrete, clean the repair areas with air blast, then flush them with water. Keep the surfaces wet for at least 1 hr, and remove puddles before placing latex modified concrete.

D. Mixing

(1) High Density Concrete

Mix high density concrete at the project site in accordance with Subsection 414.04.C, "Mixing Concrete."

(2) Latex Modified Concrete

Mix and proportion latex modified material in accordance with the following:

(a)*Measurement of Material*

Use a mobile continuous mixer to proportion latex modified concrete material for the Contract required mix. Calibrate the mixer for each material in the Engineer's presence. Operate the mixer at the manufacturer's recommended speed. Make yield checks.

(b)*Mixing of Material*

Mix material uniformly and in accordance with the equipment manufacturer's recommended procedure. Finish at the rate specified in Table 505:3, "Concrete Overlay Placement Rates."

E. Placing and Finishing Overlays

(1) Pre-Placement Check

At least 24 hr before placing the deck, inspect and ensure the following with the Engineer:

- The forms are mortar tight, cleaned, and oiled,
- Delaminations were removed by sounding the deck,
- The concrete surface is clean and bondable,
- Reinforcing steel is clean,
- Spliced-in new reinforcing steel replaces damaged reinforcing steel,
- Reinforcing steel coating damage is repaired,
- Ties are tight,
- Support provides a stable reinforcing steel mat,
- Clearances and spacing meet dimensions and tolerances as required by the Contract,
- Finishing machine rails are stable,
- Equipment is operational,
- Back-up equipment is on site and does not leak oil or fuel,

- The dry run produces acceptable results for cover and clearance,
- The calibration of the mixing equipment produces the specified mix design and rate,
- Equipment and materials specified on the Work Plan for weather protection are in-place, and
- Identify locations for temperature readings during cure period.

(2) Polymer Concrete Overlays

Ensure a technical representative from the manufacturer is present during polymer concrete overlay operations. The representative will recommend the acceptability of all phases to the Engineer, including the surface preparations, component mixing, and type and method of applications. Sufficiently blend the polymer components, and uniformly cover the work area at the Contract required rate. Provide a finished overlay thickness that measures at least ¼ in [6 mm]from the highest point on the deck surface to the top surface of the polymer (not the peaks of the aggregate). Apply layers of polymer overlay separately, as the manufacturer recommends, and at the minimum rate specified in Table 505:1, "Polymer and Aggregate Coverage Rates." Ensure that the total coverage rate is at least 7.5 gal per 100 ft² [30 L per 10 m²]. Maintain polymer and aggregate compounds at a temperature of at least 60 °F [16 °C]during application. Unless the manufacturer recommends otherwise in writing, place the concrete overlay when the air temperature is no greater than 85 °F [29 °C], and is not expected to drop below 55 °F [13 °C] within 8 hr after application.

Table 505:1
Polymer and Aggregate Coverage Rates

Course	Polymer, *gal/100 ft² [1/10 m²]*	Aggregate, *lb/yd² [kg/m²]*
1	≥2.5 [≥10]	≥10 [≥5.5]
Additional	≥5.0 [≥20]	≥14 [≥7.7]

Allow the overlay to cure before placing traffic on it to prevent wheel load damage. Cure in accordance with Table 505:2.

Table 505:2
Minimum Curing Times for Overlay Courses Based on Ambient Temperature

Course	60 °F – 64 °F	65 °F – 69 °F	70 °F – 74 °F	75 °F – 79 °F	80 °F – 84 °F	≥ 85 °F
1	4 hr	3 hr	2.5 hr	2 hr	1.5 hr	1 hr
Additional	6.5 hr	5 hr	4 hr	3 hr	3 hr	3 hr

[a] Cure course 2 for 8 hr if the ambient temperature falls below 60 °F during curing.

If work damages the overlay surface, repair the damaged area by saw-cutting rectangular sections to the top of the concrete deck surface and replacing the courses at no additional cost to the Department.

(3) Concrete Overlay

(a) *Dimensions*

Make HDC overlays at least 2 in [50 mm] thick. Make LMC and ESC overlays from 1½ in to 3 in [38 mm to 75 mm] thick. Make Class AA reinforced concrete overlays a minimum of 5 in [125 mm] thick. Limit the width of overlay passes to a maximum of 26 ft [8 m].

(b)*Joints*

1) *High Density Concrete*

Before placing the adjacent overlay course, saw the previously placed high density concrete overlay course to have straight and vertical edges at transverse and longitudinal joints. Before placing new concrete, remove slurry from prepared areas.

2) *LMC, ESC and Class AA Reinforced Concrete Overlays*

Before placing concrete, install transverse bulkheads to the thickness of the concrete layer, and equal to the grade and profile shown on the Plans.

(c) Finishing Machine Setup

Adjust the finishing machine to the overlay profile shown on the Plans. Place finishing machine rails outside the concrete area. Positively anchor the rails to give them horizontal and vertical stability. Anchor a hold-down device only into concrete that will be resurfaced. Submit working drawings for anchoring support rails for Engineer approval. Before placing concrete, make a dry run with the finishing machine to check the anticipated overlay thickness. Attach a filler block with a thickness ⅛ in [3 mm] less than the overlay thickness to the bottom of the screed. With screed guides in place, pass the screed over the area to be concreted. Correct screed elevations to provide the Contract required clearance.

(d) Placement

In general, place concrete overlay continuously in accordance with Table 505:3. Place Class AA reinforced concrete in accordance with 504.04E(2). In case of an interruption in LMC or ESC placement, install a transverse bulkhead. During delays less than 1 hr, use several layers of wet burlap to protect the end of the placement from drying. Vibrate the surface screed and the internal fresh concrete that is at least 3 in [75 mm] thick.

Table 505:3
Concrete Overlay Placement Rates

Total Overlay Area per Bridge, *yd² [m²]*	**Minimum Placement Rate, *yd³/hr [m³/hr]***
0 – 298 [0 – 249]	1.0 [0.75]
299 – 477 [250 – 399]	1.5 [1.15]
478 – 658 [400 – 550]	2.0 [1.50]
>658 [>550]	2.5 [1.90]

(e) Work Bridges

Always use at least two movable work bridges during concrete placement. Use one work bridge for fogging the surface and finishing. Use the other to apply curing material.

(f) Evaporation Control and Curing

Control evaporation and cure overlay in accordance with Subsection 504.04.E(5). Curing periods may be reduced for ESC overlays.

(g) Temperature Limitations

Keep the concrete temperature for the overlay material from 55 °F to 85 °F [13 °C to 30 °C].

Implement the following cold weather practices if the air temperature falls below 55 °F [30 °C] from 24 hr before to 6 hr after placement or the substrate temperature falls below 55 °F at the time of placement:

- Ensure the concrete mix temperature at least 75 °F [24 °C] during placement.
- Schedule the placement during rising temperatures and at the warmest part of the day.
- Place ESC when air and deck temperatures rise above 45 °F [7 °C].

(4) Asphalt Membrane Overlays

Ensure a technical representative from the manufacturer is present during asphalt membrane operations. The representative will recommend the acceptability of all phases to the Engineer, including the surface preparations, placement of the membrane including flashing for the curbs, appropriate use of tack coats, primers and type and method of applications. Place the waterproof membrane, primers and tack coats in accordance with the manufacturer's specifications, instructions, and provisions. When placing membrane, ensure that the membrane temperature is at least 50 °F [10 °C]. Extend the membrane 10 ft [3 m] beyond each end of the bridge onto the approaches. Seal the curb lines of the waterproofing membrane using a method of treatment recommended by the manufacturer. Unless otherwise directed by the manufacturer, roll the waterproofing membrane with a pneumatic roller. Vibratory rollers are not to be used during pavement application. When applying asphalt concrete overlay, use asphalt temperatures in accordance with the mix design. Ensure the asphalt temperatures do not exceed the limits for the membrane in use.

F. Acceptance Testing for Overlays

(1) Tensile Strength Test

The Engineer will choose test sites. Notify the Engineer 24 hr before performing the tensile strength test. Provide at least one tensile test site for each span or at least one test site for each 300 yd² [250 m²] of deck surface. Test in accordance with ASTM C 1583. Ensure the tensile test has a strength of at least 250 psi [2 Mpa] with 100 percent of the failure in the existing concrete deck. Submit result documentation to the Engineer.

(2) Straightedge Test

Before saw-cut grooving, test the overlay surface with a straightedge 10 ft [3 m] long. Lay it parallel and then transverse to the centerline. Grind high areas greater than ⅛ in [3 mm] from the lower edge of the straightedge.

G. Transverse Groove Final Finish for Overlays

For concrete overlays, saw-cut transverse grooves in accordance with Subsection 504.04.G, "Transverse Grooving."

H. Limitation of Operations

During the curing period required by the Contract, keep traffic off the finished surface, and do not prepare work on areas adjoining the new concrete.

505.05 METHOD OF MEASUREMENT

The Engineer will not measure Class A and Class B repairs necessitated by hydrodemolition for payment.

The Engineer will measure *Saw-Cut Grooving* in accordance with Subsection 504.05, "Method of Measurement."

505.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) BRIDGE DECK CONCRETE OVERLAY	Square Yard [Square Meter]
(B) REMOVING EXISTING OVERLAY	Square Yard [Square Meter]
(C) MULTIPLE LAYER POLYMER CONCRETE OVERLAY	Square Yard [Square Meter]
(D) ASPHALT MEMBRANE OVERLAY	Square Yard [Square Meter]
(E) HYDRODEMOLITION	Square Yard [Square Meter]

The Department will pay for bridge deck repairs in accordance with Section 513, "Repair of Concrete Bridge Decks."

The Department will consider the cost of reinforcing steel, sawing, removals, lighting, and incidental items to be included in the contract unit price for the relevant overlay pay item.

The Department defines hydrodemolition as variable depth overlay. The Department will consider the costs of variable depth to be included in the contract unit price for *Bridge Deck Overlay*. In the case of variable depth, the Department will not measure Class A or Class B patching for payment.

Asphalt Membrane Overlay includes asphalt, tack coat, membrane, primer, and flashing.

SECTION 506
STRUCTURAL STEEL

506.01 DESCRIPTION

This work consists of providing, fabricating, and erecting steel structures and structural steel portions.

506.02 MATERIALS

Use materials in accordance with the following section and subsections:

Material:	Section or Subsection:
Structural Steel	724.01
High-Strength Fasteners	724.02
Welding	724.03
Welded Stud Shear Connectors	724.04
Galvanizing	724.06
Shafting for Pins and Rollers	725.01
Steel Castings	725.02
Iron Castings	725.03
Bronze Castings	725.05
Paint-Inorganic Zinc/Epoxy/Urethane System	730.02.A
Elastomeric Bearing Pads	733.06

506.03 EQUIPMENT — VACANT

506.04 CONSTRUCTION METHODS

A. General

For main load carrying members, use a structural steel fabricating plant with an unrestricted certification under the AISC Quality Certification Programs in the Major Steel Bridges Category with endorsement "F," for the fabrication of "fracture critical" members. Provide "fracture critical" elements in accordance with ANSI/AASHTO/AWS/ D1.5, Bridge Welding Code.

Select design details in accordance with the AASHTO *Standard Specification for Highway Bridges*.

Paint structural steel in accordance with Section 512, "Painting." Paint exposed surfaces of non-weathering grades of steel unless galvanized or otherwise required by the Contract. Apply inorganic zinc primer to the top flange of girders. The Department will not allow painting of weathering steel unless required by the Contract. Blast-clean superstructures made of weathering steel in accordance with SSPC-SP6, "Commercial Blast Cleaning."

Before cutting or welding painted steel, remove paint within 9 in [225 mm] of the work, and repaint steel in accordance with Section 512, "Painting." Use falsework to erect structural steel and temporary bracing in accordance with Section 502, "Forms, Falsework, and Temporary Works."

B. Notice of Beginning of Work

Provide a written notice to the Engineer 21 calendar days before beginning work at the shop. Begin work after the Department provides inspectors.

C. Acceptance

For each heat of steel provide copies of the following before fabrication:

- Mill orders and certified mill test reports,
- Type A certifications, including chemical analysis and physical test results,
- Charpy V-notch impact tests, and
- Buy America certification in accordance with Subsection 106.01(b), "Source of Supply and Quality Requirements."

Provide Type D certifications from the fabricator for small quantity items that do not have mill test reports. For Contract required fine-grain practice, confirm material production to the requirements on the test report. Allow full access for inspection of fabrication in accordance with Subsection 106.05, "Plant Inspection". Immediately replace or correct rejected materials and work. Ship fabricated material only after the inspector approves and stamps accepted pieces. Inspect pieces at point of delivery and report damages caused by shipment to the Engineer.

Acceptance does not prevent subsequent rejection. The Engineer may reject materials or work not meeting Contract specifications. Immediately replace or correct rejected materials and work. The Engineer will make the final decision on appeals.

D. Working Drawings

Prepare and submit drawings in accordance with Subsection 105.02, "Plans and Working Drawings." The Engineer's approval of the drawings covers the requirements for "strength and detail" only. The Department is not responsible for errors in dimensions.

(1)Shop Drawings

Show component part dimensions of the structure and details of miscellaneous parts for steel structures.

Adjust girder dimensions shown on the Shop Drawings to account for vertical curve, camber, dead load deflection, and grade. These dimensions are not detailed in the Contract Plans.

Where orientation of plates is required by the Contract, show the rolling direction. Cut flanges and webs of plate girders from plates so the long dimension of the girder parallels the rolling direction.

Identify, on the Shop Drawings, the type and grade of each piece that will be made of steel with assembly marks that are cross-referenced to the original pieces of mill steel, and their certified mill test reports.

The Engineer must approve the locations of shop welded splices. Locate shop-welded splices to avoid points of maximum tensile or fatigue stress. Place splices in webs at least 12 in [300 mm] from shop splices, butt joints in flanges, or stiffeners. The Engineer may specify additional nondestructive tests on shop-welded splices.

Place a complete set of the "Bill of Materials," with pay weights, on all Shop Drawings.

(2)Erection Drawings

For structural steel bridge members, provide erection drawings showing member locations.

For steel superstructures that require falsework support during erection in accordance with Section 502, "Forms, Falsework, and Temporary Works," submit drawings of the proposed erection method. Include details of falsework bents, bridge member attachments, erection sequence, and lifting point locations. The Engineer may require calculations to demonstrate the accuracy of factored resistances, member capacities, and final geometry.

(3)Camber Diagram

Provide a camber diagram showing the camber locations shown on the Plans, at each panel point of trusses or arch ribs, field splices, and fractions of span length at least at every tenth point of continuous beams and girders or rigid frames. Show calculated cambers for structure preassembly in accordance with Subsection 506.04.F(3), "Preassembly of Field Connections."

(4)Transportation Drawings

If required by the Contract, provide transportation drawings for the Engineer's approval. Show support points, tie-downs, temporary stiffening trusses or beams, and other details to support and brace the member. Provide calculation sheets showing the dead load and impact stresses from loading and transportation. Use impact stresses at least 200 percent of the dead load stress. Use a total load at least 300 percent of the dead load. Ship and store members upright.

E. Fabrication

(1)Identification of Steels

Assembly-mark individual pieces and provide cutting instructions to the shop to maintain the identity of the original piece.

Alternatively, use material provided from stock identifiable by heat number and mill test report.

During fabrication, but before assembling members, write the material specification on the piece, or use the identification color code in accordance with AASHTO M 160, with the exception of Grade 50 W (345 W) steel.

For steel not specified in AASHTO M 160, provide information on the color code in accordance with AASHTO M 160.

Steel-die stamp or firmly attach tags to mark the grade of steel pieces that will be fabricated and may lose paint color code markings. The Department does not require steel-die stamping and tags for Grade 50W (345W) steel. If steel-stamping, place the impressions on the thicker tension-joint member in transition joints.

(2)Storage of Material

Store structural material on supports above the ground. Keep material free of foreign material. Protect material from corrosion. Store high-strength fasteners in accordance with Subsection 506.04.F.6.d, "Installation."

(3) Plates

(a) *Direction of Rolling*

Unless otherwise required by the Contract, ensure the primary rolling direction runs parallel to the principle tensile direction, the compressive stresses, or both. Provide and cut steel plates for main members, and splice plates for flanges and main tension members.

(b) *Plate Cut Edges*

1) *Edge-Planing*

Remove sheared edges on plates thicker than ⅝ in [16 mm] to a depth of ¼ in [6 mm] beyond the original sheared edge, or beyond re-entrant cuts. Fillet re-entrant cuts before cutting to a radius of at least ¾ in [20 mm].

2) *Oxygen-Cutting*

Oxygen-cut structural steel in accordance with ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

3) *Visual Inspection and Repair of Plate Cut Edges*

Visually inspect and repair plate cut edges. Cut the edges in accordance with ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

(c) Bent Plates

1) *General*

Bend unwelded, load-carrying, rolled-steel plates. If taking material from the stock plates, ensure that the bend line runs 90° to the rolling direction. Alternatively, bend cold-bent ribs for orthotropic-deck bridges with bend lines in the rolling direction. Before bending, round the corners of the plates to a radius of $^{1}/_{16}$ in [2 mm].

2) *Cold-Bending*

Cold-bend so the plate does not crack. Use the minimum bend radii in accordance with Table 506:1, "Minimum Bending Radii." Measure the minimum bend to the metal concave face.

Table 506:1
Minimum Bending Radii

Plate Thickness (t), *in [mm]*	**Bending Radius, *multiple of t***
≤½ [≤12]	2
>½ – 1 [>12 – 25]	2½
>1 – 1½ [>25 – 38]	3
>1½ – 2½ [>38 – 60]	3½
>2½ – 4 [>60 – 100]	4

For steels with Grade 100 (690) and Grade 100W (690W), allow for springback three times the springback for Grade 36 (250) steel. Use a lower die span at least 16 times the plate thickness for break-press-forming. Make multiple hits.

3) *Hot-Bending*

If using a radius shorter than the minimum radius for cold bending, hot-bend the plates at a maximum of 1,200 °F [650 °C], except for

Grade 70W (485W), Grade 100 (690), and Grade 100W (690W). If Grade 100 (690) and Grade 100W (690W) steel plates are heated to at least 1,100 °F [595 °C] or if Grade 70W (485W) steel plates are heated to at least 1,050 °F [565 °C], requench and temper in accordance with the producing mill standard practice. If directed by the Engineer, test to verify restoration of Contract required properties.

(4) Stiffeners

Provide pairs of bearing stiffeners on each side of the web. Mill to bear at the bottom flange and tight fit at the top flange. Provide fillet welds $^{5}/_{16}$ in [8 mm] on both sides of the bearing stiffener at the web. Give a full penetration weld to the top and bottom flanges of the bearing stiffener. Ensure the Engineer inspects the fit of the bearing stiffener to the flanges before covering with weld. Vertically install bearing stiffeners in the finished structure.

Fabricate intermediate stiffeners not intended to support concentrated loads to provide a tight fit against flanges. Provide fillet welds ¼ in [6 mm] in size at the web and compression flange of the stiffener. On exterior girders, place intermediate stiffeners on the outside of the web. On interior girders, place intermediate stiffeners on alternating sides of the web.

Provide pairs of diaphragm stiffeners on each side of the web. Make diaphragm stiffeners to fit tightly against both flanges. Provide fillet welds ¼ in [6mm] in size at the web and top and bottom flanges of the stiffener.

Clip the corners of stiffeners at flange-web intersections. If clip dimensions are not shown on the Plans, use the following dimensions:

- Along the flange: 1½ in [38 mm], and
- Along the web: four to six times the web thickness, and from1½ in to 3 in [38 mm to 75 mm].

(5) Abutting Joints

Mill or saw-cut abutting joints in compression members of trusses and columns to produce a square joint and uniform bearing. The Department will allow a maximum ⅜ in [10 mm] opening at other joints not required by the Contract to be faced.

(6) Facing of Bearing Surfaces

Finish bearing plates, base plates, and other bearing surfaces that will come in contact with each other or with concrete in accordance with Table 506:2.

Table 506:2
ANSI Surface Roughness Values

Bearing Surface	Surface Roughness Value, *µin [µm]*
Steel slabs	2,000 [50]
Heavy plates in shoes to be welded	1,000 [25]
Milled ends of compression members, milled or ground ends of stiffeners and fillers	500 [13]
Bridge rollers and rockets	250 [6]
Pins and pin holes	125 [3]
Sliding bearings	125 [3]

Machine sliding-bearings with a surface roughness greater than ANSI 60 [2 µm] so the cut runs parallel to the direction of movement.

Fabricate parts in bearing to provide a uniform, even contact with the adjacent bearing surface. Ensure that the gap between bearing surfaces is no greater than 0.04 in [1 mm]. The Department does not require machining of base and sole plates that are plane, true, and within the values of Table 506:2, "ANSI Surface Roughness Values," except machine sliding surfaces of base plates.

Avoid machine surfaces of fabricated members until completion of fabrication. Machine metal components after heat treatment.

(7) Straightening Material

When heat straightening steels not shown on Table 506:3, "Heat Straightening Temperatures," do not allow the heated area to exceed 1,200 °F [650 °C]. Control the heat application with temperature- indicating crayons, liquids, or bimetal thermometers.

If approved by the Engineer, straighten plates, angles, and built-up members without damaging the metal. Straighten distorted members mechanically or, if approved by the Engineer, with localized heat. Ensure the temperatures remain within the values of Table 506:3.

Table 506:3
Heat Straightening Temperatures

Material	Distance from Weld, *in [mm]*	Maximum Temperature, *°F [°C]*
Grade 70W (485W)	≥6 [≥150]	1,050 [565]
	<6 [<150]	900 [480]
Grade 100 (690) or Grade 100W (690W)	≥6 [≥150]	1,100 [595]
	<6 [<150]	950 [510]

Keep parts to be heat-straightened free of external forces and stresses.

(8) Bolt Holes

(a) *Holes for High-Strength Bolts and Unfinished Bolts*

1) *General*

Make bolt holes in accordance with Table 506:4, "Bolt Hole Sizes per Bolt Size (English)," and Table 506:5, "Bolt Hole Sizes per Bolt Size (Metric)," for standard, oversize, short slotted, and long slotted holes. Provide holes if required by the Contract.

Table 506:4
Bolt Hole Sizes per Bolt Size (English)

Bolt Size [a] (Diameter), *in*	Bolt Hole Size, *in*			
	Circular (Diameter)		Slotted (Width × Length)	
	Standard	Oversize	Short	Long
⅝	$^{11}/_{16}$	$^{13}/_{16}$	$^{11}/_{16}$ × ⅞	$^{11}/_{16}$ × $1^{9}/_{16}$
¾	$^{13}/_{16}$	$^{15}/_{16}$	$^{13}/_{16}$ × 1	$^{13}/_{16}$ × 1⅞
⅞	$^{15}/_{16}$	$1^{1}/_{16}$	$^{15}/_{16}$ × 1⅛	$^{15}/_{16}$ × $2^{3}/_{16}$
1	$1^{1}/_{16}$	1¼	$1^{1}/_{16}$ × $1^{5}/_{16}$	$1^{1}/_{16}$ × 2½

Table 506:4
Bolt Hole Sizes per Bolt Size (English)

Bolt Size [a] (Diameter), *in*	Bolt Hole Size, *in*			
	Circular (Diameter)		Slotted (Width × Length)	
	Standard	Oversize	Short	Long
1⅛	d + $^{1}/_{16}$	d + $^{5}/_{16}$	d + $^{1}/_{16}$ × d + ⅜	d + $^{1}/_{16}$ × 2½d

[a] Bolt size is represented by "d" for calculating bolt hole sizes.

Table 506:5
Bolt Hole Sizes per Bolt Size (Metric)

Bolt Size (Diameter), *mm*	Bolt Hole Size, *mm*			
	Circular (Diameter)		Slotted (Width × Length)	
	Standard	Oversize	Short	Long
16	18.0	20.0	18.0 × 22.0	18.0 × 40.0
20	22.0	24.0	22.0 × 26.0	22.0 × 50.0
22	24.0	28.0	24.0 × 30.0	24.0 × 55.0
24	27.0	30.0	27.0 × 32.0	27.0 × 60.0
27	30.0	35.0	30.0 × 37.0	30.0 × 67.0
30	33.0	38.0	33.0 × 40.0	33.0 × 75.0

Punch or drill bolt holes except as modified in accordance with Subsection 506.04.E(8)(a), "Holes for High-Strength Bolts and Unfinished Bolts." Full-size punch material that forms the member parts that are no greater than five thicknesses of metal if the thickness of the material is less than ¾ in [20 mm] for structural steel, ⅝ in [16 mm] for high-strength steel, or ½ in [12 mm] for quenched and tempered alloy steel, unless subpunching and reaming in accordance with Subsection 506.04.E(8)(e), "Preparation of Field Connections."

Subdrill and ream or drill full-size holes for material thicker than ¾ in [20 mm] for structural steel, ⅝ in [16 mm] for high-strength steel, or ½ in [12 mm] for quenched and tempered alloy steel. If required by the Contract, subdrill with thickness limitation, or subpunch ¼ in [6 mm] smaller. After assembling, ream $^{1}/_{16}$ in [2 mm] larger, or drill full-size.

2) *Punched Holes*

Use a die diameter no greater than $^{1}/_{16}$ in [2 mm] of the punch diameter. Ream the holes to accommodate the bolt sizes. Clean cut the holes without torn or ragged edges. The Department will allow slightly a conical hole from punching.

3) *Reamed or Drilled Holes*

Ream or drill holes so they are cylindrical and perpendicular to the member. Direct the reamer by mechanical means. If mechanical direction is not possible, the Department will allow other methods approved by the Engineer. Remove burrs on the surface. Ream and drill with twist drills, twist reamers, or roto-broach cutters. Assemble and secure connecting parts that are being reamed or drilled and match-marked before disassembling.

4) *Accuracy of Holes*

The Engineer will accept holes with diameters that do not deviate more than $^{1}/_{32}$ in [1 mm] from the drill or reamer nominal diameter. Ensure the width of slotted holes produced by flame cutting or a combination of drilling or punching and flame cutting does not exceed the nominal width by greater than $^{1}/_{32}$ in [1 mm]. Grind flame-cut surfaces until smooth.

(b)*Accuracy of Hole Group*

1) *Accuracy Before Reaming*

Punch full-size, subpunched, or subdrilled holes after assembling, but before reaming, so a cylindrical pin ⅛ in [3 mm] smaller in diameter than the nominal size of the punched hole may be placed perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. The Engineer will reject holes, if a pin $^{3}/_{16}$ in [5 mm] smaller in diameter than the nominal size of the punched hole cannot be inserted.

2) *Accuracy After Reaming*

The Engineer considers the maximum allowed offset of 85 percent of adjacent holes through adjacent thicknesses of metal as $^{1}/_{32}$ in [3 mm] after reaming.

Use steel templates with hardened steel bushings in holes measured from the connection centerlines as inscribed on the template. Use connection centerlines if locating templates from the milled or scribed ends of members.

(c)*Numerically-Controlled Drilled Field Connections*

Instead of drilling and reaming holes, drill or punch full-size bolt holes in unassembled pieces, connections, or both.

(d)*Holes for Ribbed Bolts, Turned Bolts, or Other Approved Bearing-Type Bolts*

Subpunch or subdrill holes for ribbed bolts or turned bolts $^{3}/_{16}$ in [5 mm] smaller than the bolt nominal diameter of the bolt. When assembled, ream or drill from the solid plate assembly. Provide finished holes with a driving fit.

(e)*Preparation of Field Connections*

Subpunch or subdrill and ream when assembled, or drill full-size holes to a steel template in field connections and splices of main members of trusses, arches, continuous beam spans, bents, tower faces, plate girders, and rigid frames.

For holes for field splices of rolled beam stringers continuous over floor beams or cross frames, drill full-size unassembled to a steel template. Alternatively, drill full-size holes, unassembled to a steel plate for floor beams or cross frames. For floor beams and stringer field end connections, subpunch and ream while assembled, or drill full-size to a steel template.

Before reaming or drilling full-size field connection holes through a steel template, bolt the template in place. Use template duplicates of the reaming matching members or the opposite faces of a single member. Locate templates for connections on similar parts or members to duplicate the parts or members without match-marking.

For connections, instead of subpunching and reaming or subdrilling and reaming, use holes drilled full-size through thicknesses or material assembled in position.

(9) Pins and Rollers

(a) *General*

Fabricate straight, smooth pins and rollers in accordance with Subsection 725.02, "Steel Castings".

(b) *Boring Pin Holes*

Bore smooth, straight pin holes to the diameter required by the Contract at 90 angles to the axis of the member and parallel with each other. Use a finishing cut to produce the final surface.

For pins 5 in [125 mm] or smaller in diameter, produce a pin hole diameter no greater than 0.02 in [0.5 mm] larger than the pin. For larger pins, produce a pin hole diameter no greater than $^{1}/_{32}$ in [1 mm].

Ensure the outside-to-outside distance of end holes in tension members and the inside-to-inside distance of end holes in compression members varies from the specifications no greater than $^{1}/_{32}$ in [1 mm]. Bore pin holes in built-up members after assembly.

(c) *Threads for Bolts and Pins*

Provide threads on bolts and pins for structural steel construction in accordance with screw threads Profile ANSI B1.13 (B1.13 M), with a tolerance Class 6G for external threads and Class 6H for internal threads.

(10) Annealing and Stress Relieving

Machine, finish bore, and straighten annealed or normalized members before heat treatment in accordance with to ASTM A 919. Ensure points on the member do not differ by more than 100 °F [38 °C].

The Department will not allow annealing or normalizing of members of Grade 100/100W (690/690W) or Grade 70W (485W) steels. Stress-relieve as required by the Contract.

Record each furnace charge, identify pieces in the charge, and record the temperatures and schedule used. Provide recording pyrometers to determine the temperatures of materials in the furnace. Make records available for the Engineer's approval. The maximum holding temperature for stress relieving Grade 100/100W (690/690W) and Grade 70W (485W) steels is 1,100 °F [595 °C] and 1,050 °F [565 °C], respectively.

Stress parts built up by welding sections of plate together in accordance with Subsection 4.4 of ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

(11) Curved Girders

(a) *General*

Cut flanges of curved, welded girders to the radii required by the Contract. Alternatively, curve flanges of curved, welded girders with heat if the radii is in accordance with AASHTO *Standard Specifications for Highway Bridges*.

(b)*Heat Curved Rolled Beams and Girders*

1) *Materials*

Do not heat curved steels manufactured to a Contract required minimum yield point greater than 50 ksi [345 MPa].

2) *Type of Heating*

Curve beams and girders using continuous or V-type heating as approved by the Engineer.

Using the continuous method, simultaneously heat a strip along the edge of the top and bottom flange. Ensure the strip obtains the Contract required curvature.

Using the V-type method, heat the top and bottom flanges in truncated triangular or wedge-shaped areas with their base along the flange edge and spaced at regular intervals. Obtain the Contract required curvature. At the same rate, heat along the top and bottom flange. Terminate the apex of the truncated triangular area before reaching the web juncture and the flange. The Department will not allow applying heat to the web. If the curvature radius is at least 1,000 ft [300 m], extend the apex of the truncated triangular heating pattern to the flange and web juncture. If the curvature radius is less than 1,000 ft [300 m], extend the apex of the truncated triangular heating pattern ⅛ of the flange width or 3 in [75 mm], whichever is less. Construct the truncated triangular pattern with an angle from 15° to 30°, with a base no greater than 10 in [250 mm]. The Engineer may approve pattern variations.

After cooling, locate the flange edges to be heated on the inside of the horizontal curve. If the flanges have a thickness of at least 1¼ in [32 mm], concurrently heat both flange surfaces.

3) *Temperature*

Ensure the steel temperature does not exceed 1,150 °F [620 °C]. Artificially cool the girder after it has naturally cooled to 600 °F [315 °C]. Obtain the Engineer's approval of the artificial cooling method.

4) *Position for Heating*

Heat-curve girders with webs in vertical or horizontal positions. If webs vertically curved, support the girder to prevent overturning.

If webs horizontally curved, support the girder at the ends and intermediate points to obtain a uniform curve. Ensure that the flange bending stress does not exceed the Contract required design stress. If horizontally heating the girder, position intermediate safety catch blocks at the girder midlength within 2 in [50 mm] of the flanges.

5) *Sequence of Operations*

Heat-curve the girder in the fabrication shop before painting. Heat-curve before or after welding the transverse intermediate stiffeners. Unless providing for girder shrinking, attach connection plates and bearing stiffeners after heat curving. If longitudinal stiffeners are required by the Contract, separately heat-curve or oxygen-cut the stiffeners, and then weld them to the curved girder. Attach cover plates to rolled beams before curving if the total

thickness of one flange and cover plate is less than 2½ in [65 mm] and the curvature radius is at least 1,000 ft [300 m]. For other rolled beams with cover plates, heat-curve the beams before attaching the cover plates. Before welding to the curved bottom, separately heat-curve or oxygen-cut these cover plates.

6) *Camber*

Camber girders before heat-curving. Use heat-cambering methods to camber rolled beams as approved by the Engineer. For plate girders, cut the web to the Contract required camber, and allow for shrinkage. Apply heat to correct deviations as directed by the Engineer.

7) *Measurement of Camber Curves*

The Engineer will measure horizontal curves and vertical camber after the completion of welding and heating and the flanges have cooled to a uniform temperature. Check horizontal curves with the girder in the vertical position.

(12)Full-Size Tests

Provide facilities, material, supervision, and labor to make and record the full-size tests of fabricated structural members required by the Contract.

(13)Marking and Shipping

Paint and mark members with an erection mark shown on the Working Drawings.

At the Engineer's request, provide copies of material orders, shipping statements, and erection drawings, showing the weight of the individual members. Mark the weight of members over 6,000 lb [3,000 kg] on the material orders, shipping statements, and erection drawings.

Ship fastener components from each rotational-capacity lot in the same container. If each nut and washer size has one production lot number, ship them in separate containers. Ship pins, small parts, and packages of bolts, nuts, and washers in boxes, crates, kegs, or barrels, with a gross weight per package no greater than 300 lb [140 kg]. Mark a list and description of the contained materials on the outside of each shipping container.

F. Assembly

(1)Bolting

Clean surfaces of metal before assembling. Pin and draw together assembled member parts before drilling, reaming, or bolting. Disassemble pieces to remove burrs and shavings. Ensure members do not contain deformaties.

During assembly, drift position the parts without enlarging the holes or distorting the metal. Place a washer that turns under the bolted assembly element during installation.

(2)Welded Connection

Make surfaces and edges uniform, clean, and smooth. Prepare edges in accordance with ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

(3) Preassembly of Field Connections

(a) ***General***

Preassemble main member field connections of trusses, arches, continuous beams, plate girders, bents, towers, and rigid frames before erecting to verify the geometry of the completed structure or unit and to verify or prepare field splices. Submit preassembly details for the Engineer's approval. Use preassembly methods and details as shown on the erection drawings and camber diagrams.

Preassemble at least three contiguous panels or sections adjusted for line and camber. For successive assemblies include at least one panel or section of the previous assembly. If necessary, reposition and pin assemblies for alignment. Add at least two sections or panels to the advancing end. For structures longer than 150 ft [50 m], make each assembly at least 150 ft [50 m] long, regardless of the length of individual continuous panels or sections. Begin assembly from a structure location in one or both directions as required by the Contract.

(b) ***Bolted connections***

Prepare bolted connection holes in accordance with Subsection 506.04.E(8), "Bolt Holes." If applicable, assemble major components with milled ends of compression members in full bearing, then ream subsized holes to the size required by the Contract.

(c) ***Check Assembly/Numerically Controlled Drilling***

If using numerically controlled drilling or punching, make a check assembly for each major structural type on the Project. Fabricate the check assembly at least three contiguous shop sections. For a truss, fabricate the check assembly of members associated with at least three contiguous chord lengths. Base check assemblies on considerations such as the order of erection, joints in bearings, and special complex points. With the exception of check assemblies, the Department does not require shop assemblies. Recheck inaccurate check assemblies at no additional cost to the Department.

Obtain Engineer approval for each assembly before reaming or dismantling numerically controlled drilled check assembly.

(d) ***Field Welded Connections***

The Department will not allow the use of field welded connections unless required by the Contract. Verify the fit of members with the segment preassembled in accordance with Subsection 506.04.F(3)(a), "General."

(4) Match-Marking

Provide a diagram of match-marked connecting parts preassembled in the shop to ensure they fit in the field.

(5) Connections Using Unfinished or Turned Bolts

(a) ***General***

Use unfinished, turned, or ribbed bolts as required by the Contract in accordance with ASTM A 568, Property Class 4.6, 60 ksi [400 MPa] tensile strength. Use bolts with single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope of at least 1:20 with respect to a plane

normal to the bolt axis. Refer to Subsection 506.04.F.6, "Connections Using High-Strength Bolts," for high-strength bolted connections.

(b)*Turned Bolts*

Provide turned bolts with a body surface ANSI roughness no greater than 125 in [3.2 mm]. Provide hex-headed bolts and nuts of the Contract required nominal size. Ream holes for turned bolts. Provide bolts for a light driving fit. Keep bolt threads outside of the holes. Provide a washer under the nut.

(6)Connections Using High-Strength Bolts

(a)*General*

Use Direct Tension Indicators (DTI) on connections using high-strength bolts.

Install bolts in holes in accordance with Subsection 506.04.E(8), "Bolt Holes."

(b)*Bolted Parts*

Use steel material within the grip of the bolt with no compressible material. Fabricate bolted steel parts to fit together after tightening the bolts. Limit the maximum slope of the surfaces of parts in contact with the bolt head or nut to 1:20 with respect to a plane normal to the bolt axis.

(c)*Surface Conditions*

In painted joints, paint the faying surfaces with inorganic zinc primer of the Inorganic Zinc/Epoxy/Urethane (IZ-E-U) paint system in accordance with Subsection 730.02, "Requirements for Paint Systems." Before blast-cleaning and painting, remove burrs that prevent seating in the snug-tight condition. During assembly, clean joint surfaces. Repair damage that would prevent solid seating of the connected parts in the snug-tight condition.

If the Contract requires a paint system other than IZ-E-U, paint the faying surfaces using a Class B primer with a minimum slip coefficient of 0.5, tested in accordance with the Research Council on Structural Connections "Test Method to Determine the Slip Coefficient for Coatings Used in Bolted Joints." Otherwise treat the joint as a non-painted joint. Assemble the painted joints after the primer cured for the minimum time used in the qualifying test.

In non-painted joints, do not paint areas closer than one bolt diameter, but at least 1 in [25 mm], from the edge of holes and bolt pattern areas. During assembly, clean joint surfaces of foreign material and scale, except tight mill scale. Remove burrs that prevent connected parts from seating in the snug-tight condition.

Hot-dip-galvanize faying surfaces in accordance with AASHTO M 111, and rough with a hand wire brush.

(d)Installation

1) *General*

Install fasteners of the same lot number together. Protect fasteners from dirt and moisture. From protected storage, remove the number of fasteners that will be installed and tightened during a work shift. Return unused

fasteners to protected storage. Do not clean lubricant from fasteners. Before installation, clean, re-lubricate, and test slip-critical connection fasteners for rotational capacity. Lubricate galvanized nuts with a lubricant containing a visible dye. Provide plain bolts oily to the touch when delivered and installed. Remove lubricant before painting.

Provide a Skidmore-Wilhelm calibrator, or an approved bolt—tension measuring device, at job sites that require the installation and tightening of high-tension strength fasteners. Use the tension-measuring device for the rotational—capacity test and to confirm the requirements of Table 506:6, “Minimum Required Bolt Tension (English),” Table 506:7, "Minimum Required Bolt Tension (Metric)," and the wrench calibration. Ensure the bolting crew understands the tightening method.

For short grip bolts, use DTI with solid plates to test as follows:

- Check the DTI with a longer grip bolt in the Skidmore-Wilhelm calibrator.
- Ensure the frequency of confirmation testing, number of tests to be performed, and test procedure are in accordance with Subsection 506.04.F(6)(d)4), “Turn of Nut Tightening,” and Subsection 506.04.F(6)(d)6), “Direct Tension Indicator Tightening.”
- At least annually, confirm the accuracy of the tension measuring device by a Department approved testing agency.

Install and tighten fasteners together with Contract required washers at specified locations in accordance with Subsection 506:04.F(6)(d)3), "Washers," and in aligned holes. Tighten to at least the minimum tension specified in Table 506:6 and Table 506:7. Use the direct tension indicator method where required by the Contract.

Table 506:6
Minimum Required Bolt Tension (English) [a]

Bolt Size, *in*	**AASHTO M 164 and ASTM A 325M, *lbf***	**AASHTO M 253 and ASTM A 490M, *lbf***
⅝	19,000	24,000
¾	28,000	35,000
⅞	39,000	49,000
1	51,000	64,000
1⅛	56,000	80,000
1¼	71,000	102,000

[a] Equal to 70 percent of the Contract required minimum tesile strength of bolts, rounded to the nearest 1,000 lb.

Table 506:7 Minimum Required Bolt Tension (Metric) [a]		
Bolt Size, *mm*	**AASHTO M 164 and ASTM A 325M, *kN***	**AASHTO M 253 and ASTM A 490M, *kN***
16	91.2	114
20	142	179
22	176	221
24	205	257
27	267	334
30	326	408
36	476	595

[a] Equal to 70 percent of the Contract required minimum tesile strength of bolts, rounded to the nearest 0.1 kN.

If using impact wrenches, provide capacity and air to tighten each bolt in 10 seconds. The Department will not allow reusuing AASHTO M 253 and AASHTO M 164 fasteners. The Engineer will not consider touching-up or re-tightening previously tightened bolts that were loosened by the tightening of adjacent bolts as re-use, provided the snugging-up continues from the initial position and does not require greater rotation than specified by Table 506:8.

Table 506:8 [a] Nut Rotation for Snug-Tight Condition Geometry of Outer Faces of Bolted Parts [b]			
Bolt Length (Measured from Head Underside to Bolt End)	**Both Faces Normal to Bolt Axis**	**One Face Normal to Bolt Axis, Other Face Sloped No More than 1:20 (Bevel Washers Not Used)**	**Both Faces Normal to Bolt Axis, Other Face Sloped No More than 1:20 (Bevel Washers Not Used)**
≤4 diameters	⅓ turn	½ turn	⅔ turn
<4 – 8 diameter	½ turn	⅔ turn	$^5/_6$ turn
<8 – 12 diameters [c]	⅔ turn	$^5/_6$ turn	1 turn

[a] Applicable to connections where material within the grip of the bolt is steel.
[b] Nut rotation is relative to bolt, regardless of the element being turned. The tolerance is a 30° range for bolts installed by ½ turn or less. The tolerance is a 45° range for bolts installed by ⅔ turn or more.
[c] For bolt lengths greater than 12 diameters, determine the required rotation by tests in a tension device simulating the actual conditions.

Snug-tightness exists if the plies of the joint are in firm contact. Use a few impacts of an impact wrench or a full effect of a worker using an ordinary spud wrench to attain snug tightness. Install the bolts in the connection holes and snug-tighten them from the most rigid part of the connection to the free edges. Snug-tighten the bolts and ensure the connection fully compacts.

2) *Rotational-Capacity Tests*

Subject black and galvanized, high-strength fasteners to job-site rotational-capacity tests in accordance with AASHTO M 164 and the following:

- Include washers as part of the test.
- Test each combination of bolt production lot, nut lot, and washer lot as an assembly.
- If washers are required by the Contract, include them in the lot identification.
- Assign a rotational-capacity lot number to each combination of lots tested.
- Test at least two assemblies per rotational-capacity lot.
- Assemble and test bolt, nut, and washer assemblies in a Skidmore-Wilhelm Calibrator or approved device.
- For bolts too short to test in a Skidmore-Wilhelm Calibrator, test the assembly in a steel joint. Calculate the maximum torque requirement using a P-value equal to the turn test tension.
- After snug-tightening, tighten the fastener twice the number of turns specified in Table 506:8, "Nut Rotation for Snug-Tight Conditions," in a Skidmore-Wilhelm Calibrator or other Department approved device.
- During this test, ensure that the maximum recorded tension is equal to or greater than the turn test tension.
- After exceeding the turn test tension of 1.15 times the fastener tension, record one reading of tension and torque. Ensure the measured torque at a tension “P” follows the equation:

$$£ = \frac{P \times D}{4}$$

where

$£$ = Measured torque, foot·pounds [Newton meter],
P = Measured bolt tension, pounds [kilonewtons], and
D = Bolt diameter, feet [millimeters].

3) *Washers*

Where the outer face of the bolted parts has a slope greater than 1:20, use a hardened beveled washer to compensate for the lack of parallelism.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels in accordance with AASHTO M 293.

Where necessary, clip washers at least ⅞ of the bolt diameter from the center of the washer on one side.

For hardened washers not Contract required for connections, use AASHTO M 164 and AASHTO M 253 bolts, except as follows:

- Use hardened washers under the head and the nut if installing AASHTO M 253 bolts in material with a Contract required yield point less than 40 ksi [275 MPa],
- Use a hardened washer in accordance with AASHTO M 293 if installing AASHTO M 164 bolts or AASHTO M 253 bolts 1 in [24 mm] or smaller in diameter in oversize or short-slotted holes in an outer ply,

- Use hardened washers in accordance with AASHTO M 293 under the head and the nut. Ensure the combined thickness of hardened washers does not exceed $^{5}/_{16}$ in [8 mm],
- If installing AASHTO M 164 bolts or AASHTO M 253 bolts with a diameter of 1 in [24 mm] or smaller in a long-slotted hole in an outer ply and is structural grade material needing hardening, provide a plate washer or continuous bar at least $^{5}/_{16}$ in [8 mm] thick to cover the slot. Ensure the combined thickness of hardened washers does not exceed $^{5}/_{16}$ in [8 mm],
- If using AASHTO M 253 bolts greater than 1 in [24 mm] in diameter in long-slotted holes in external plies, use a single hardened washer in accordance with AASHTO M 293 at least $^{5}/_{16}$ in [8 mm] thick, and
- Use alternative design fasteners in accordance with Subection 724.02, “High-Strength Fasteners,” with a bearing circle on the head or nut with a diameter at least that of hardened washers in accordance with AASHTO M 293 without washers.

4) *Turn-of-Nut Tightening*

If turn-of-nut tightening is specified, use hardened washers in accordance with Subsection 506.04.F(6)(d)3), “Washers.”

At the start of the work, test nut tightening with a device that indicates bolt tension. Provide samples of at least three bolt-and-nut assemblies of each diameter, length, and grade. Demonstrate that the method for estimating the snug-tightness and controlling the turns develops a tension at least 5 percent greater than the tension specified in Table 506:6, “Minimum Required Bolt Tension (English),” and Table 506:7, "Minimum Required Bolt Tension (Metric)." Retest if directed by the Engineer.

After snug-tightening, tighten bolts in accordance with Table 506:6 and Table 506:7. Ensure the fastener part not turned by the wrench does not rotate. Tighten from the most rigid part to the free edges of the joint.

5) *Installation of Alternative Design Bolts*

If fasteners designed to indicate the bolt tension or to automatically provide the tension specified in Table 506:6, “Minimum Required Bolt Tension (English),” Table 506:7, "Minimum Required Bolt Tension (Metric)," and Subsection 724.02, “High-Strength Fasteners,” are to be installed, test a sample at least three bolt-and-nut assemblies of each diameter, length, and grade. If flat-hardened washers are required by the Contract, include them in the test assembly. Arrange the washers in the connections to be tensioned. Test calibration to demonstrate that each bolt tenses at least 5 percent greater than the tension specified in Table 506:6 and Table 506:7. Follow the manufacturer’s installation procedure. Re-test if directed by the Engineer.

If using alternative design fasteners to control or indicate bolt tension of the fasteners, install bolts in connection holes and tighten to bring plies of the joint into firm contact without yielding. Do not fracture the control or indicator. To minimize relaxation of previously tightened fasteners, continue to tighten from the most rigid part of the connection to the free edges.

Tensioning may require more than one cycle of partial tightening before final twist-off of the control or indicator of individual fasteners.

6) *Direct Tension Indicator Tightening*

If using DTIs in accordance with Subsection 724.02, "High-Strength Fasteners," with high-strength bolts to indicate bolt tension, test assemblies in accordance with Subsection 506.04.F(6)(d)6)6.1), "Verification," and install them in accordance with Subsection 506.04.F(6)(d)6)6.2), "Installation."

Install DTIs with the protrusions against the head of the bolt, and turn the nut to tighten the fastener. Prevent the element against the DTI from turning during installation and final tensioning.

During verification, do not exceed the maximum number of refusals after snugging allowed by the Contract.

6.1) Verification

Perform verification testing in a calibrated bolt tension-measuring device. Use a flat insert instead of the bolt head holding the insert.

Perform three verification tests for each combination of fastener rotational-capacity lot, DTI lot, and DTI position relative to the turned element. Do not turn the element against the DTI. Test in two stages. Install the bolt, nut, and DTI assembly so from three threads to five threads are between the bearing face of the nut and the bolt head. Tighten the fastener first in accordance with the load specified in Table 506:9, "Direct Tension Indicator Requirements," under verification tension for the grade and diameter of the fastener.

If using an impact wrench, tighten to slightly below the DTI-specified load and then use a manual wrench to tighten to the Contract required tension. Record the number of refusals of a 0.005 in [0.125 mm] tapered feeler gauge in the spaces between the protrusions. Ensure the maximum number of refusals for coated DTIs does not exceed one less than the spaces on the DTI. The Engineer will reject the DTI if the number of refusals exceeds the values in Table 506:9, or if spaces refuse the gauge.

Table 506:9
Direct Tension Indicator Requirements (English) [a]

Bolt Size (Diameter), *in*	Verification Testing, *kip*		Maximum Verification Refusals		DTI Spaces		Minimum Installation Refusals	
	M 164 A 325	M 253 A 490	M 164 A 325	M 253 A 490	M 164 A 325	M 253 A 490	M 164 A 325	M 253 A 490
⅝	20	25	1	2	4	5	2	3
¾	29	37	2	2	5	6	3	3
⅞	41	51	2	2	5	6	3	3
1	54	67	2	3	6	7	3	4
1⅛	59	84	2	3	6	7	3	4
1¼	75	107	3	3	7	8	4	4

[a] The test methods refer to AASHTO M 164, ASTM A 324, AASHTO M 253, and ASTM A 490.

Table 506:10
Direct Tension Indicator Requirements (Metric) [a]

Bolt Size (Diameter), *mm*	Verification Testing, *kN*		Maximum Verification Refusals		DTI Spaces		Minimum Installation Refusals	
	M 164 A 325	M 253 A 490	M 164 A 325	M 253 A 490	M 164 A 325	M 253 A 490	M 164 A 325	M 253 A 490
16	88.96	111.2	1	2	4	5	2	3
20	129.0	164.6	2	2	5	6	3	3
22	182.4	226.9	2	2	5	6	3	3
24	240.2	298.0	2	3	6	7	3	4
27	262.4	373.6	2	3	6	7	3	4
30	333.6	475.9	3	3	7	8	4	4
36	395.9	564.9	3	3	7	8	4	4

[a] The test methods refer to AASHTO M 164, ASTM A 324, AASHTO M 253, and ASTM A 490.

After recording the number of refusals, tighten the fastener until the 0.005 in [0.125 mm] feeler gauge does not fit in spaces and at least one gap remains. Record the load at this condition and remove the fastener from the tension-measurer. Reject the DTI lot if the nut cannot be hand-reassembled for the thread length of the bolt (excluding thread runout), unless the recorded load is less than 95 percent of the average load measured in the rotational-capacity test of the fastener lot, as specified in Subsection 506.04.F(6)(d)2), “Rotational-Capacity Tests.”

If the bolt is too short to test in the calibration device, test the DTI on a long bolt in a calibrator in accordance with Subsection 506:04.F(6)(d)6), "Direct Tension Indicator Tightening." Determine the number of refusals at the verification tension listed in Table 506:9, “Direct Tension Indicator Requirements (English),” and Table 506:10, “Direct Tension Indicator Requirements (Metric).”

Test another DTI from the same lot with a short bolt in a work hole. Tighten the fastener assembly until the 0.005 in [0.125 mm] feeler gauge does not fit in spaces and at least one gap remains. Disassemble the fastener, remove it from the hole, and reassemble it by hand for the thread length of the bolt, excluding thread runout. Reject the DTI lot if the nut cannot be run down this thread length.

6.2) Installation

Install the fastener using DTIs in two stages. Ensure the fastener element does not rotate against the DTI. Snug the connection with bolts installed in the connection holes, and tighten them to bring the plies of the connection into firm contact. If the number of spaces in which a 0.005 in [0.125 mm] feeler gauge is refused exceeds those listed under “Maximum Verification Refusals” in Table 506:9, “Direct Tension Indicator Requirements (English),” and Table 506:10, “Direct Tension Indicator Requirements (Metric),” replace the assembly, and resnug.

Tighten the connection until the number of refusals of the 0.005 in [0.125 mm] feeler gauge is equal to or greater than the number listed under "Minimum Installation Refusals" in Table 506:9 and Table 506:10. To minimize relaxation of previously tightened fasteners, tighten fasteners from the most rigid part of the connection to the free edges. If no gap remains, replace the assembly.

7) *Inspection*

Within 24 hr of bolt tightening, inspect the tightened bolts in the presence of the Engineer. Use an inspection torque wrench, or alternative fasteners or DTIs.

Individually place three bolts of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Calibrate them at least once per inspection day.

If using washers on the structure, use one washer under the part turned in tightening each bolt. If not using washers, use the same specification material that abuts the part turned in the tension-measurer. In the calibrated device, tighten bolts to the Contract required tension. Apply the inspecting wrench to the tightened bolt to determine the torque required to turn the nut or head 5°, 1 in [25 mm] at a 12 in [300 mm] radius, in the tightening direction. Use the average of the torque required for three bolts as the job-inspection torque.

In each connection, randomly select at least two tightened bolts. Apply the job-inspection torque to selected bolts. Hold the bolts with the inspecting wrench in the tightening direction. If this torque does not turn bolt heads or nuts, the bolts are properly tightened. If the torque turns at least one bolt head or nut, apply the job-inspection torque to bolts. Tighten and re-inspect bolts with heads or nuts that turn, or re-tighten bolts and re-submit for inspection.

(7) Welding

Ensure that welding, welder qualifications, prequalification of weld details, and inspection of welds are in accordance with ANSI/AASHTO/AWS D1.5, Bridge Welding Code.

The Department will not allow welding or tacking of brackets, clips, shipping devices, and other material to members unless otherwise shown by the Shop Drawings.

G. Erection

(1) General

Provide tools, machinery, and equipment to erect the structure. Ensure falsework and forms are in accordance with Section 502, "Forms, Falsework, and Temporary Works."

(2) Handling and Storing Material

Place material stored at the job site above the ground on skids. Keep material clean and drained. Place and shore girders and beams upright. Support long

members, such as columns and chords, on skids placed close enough together to prevent deflection.

If the Contract requires erection only, check the material received against shipping lists and promptly report shortages or injuries to the Engineer in writing. After receiving material, assume responsibility for damaged or lost material.

(3) Bearings and Anchorages

Provide and install bridge bearings and anchors in accordance with Section 507, "Bearing Assemblies." If placing the steel superstructure on a substructure, verify the construction of concrete pedestals as shown on the Plans before ordering material.

If actual centerline bearing of the assembly does not line up horizontally within 2 in [50 mm] of the vertical bearing stiffener plates, weld additional vertical bearing stiffeners to the beam or girder.

(4) Erection Procedures

(a) ***Conformance to Drawings***

Erect as the Contract requires and in accordance with erection drawings. Revise drawings and verify stresses and geometry for deviations from the erection procedure.

(b) ***Erection Stresses***

Allow for erection stresses due to unapproved methods of erection or equipment that will remain in the finished structure as locked-in stresses. Provide material to keep stresses within specified limits.

During erection, provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure.

(c) ***Maintaining Alignment and Camber***

During erection, support segments of the structure to align and camber in the completed structure. Install cross frames and diagonal bracing for stability and correct geometry. Provide temporary bracing to ensure structure alignment and camber.

(5) Field Assembly

Before assembling in accordance with erection drawings, clean bearing surfaces and permanent contact surfaces. Do not hammer or damage the members.

Assemble splices and field connections with at least two cylindrical erection pins per part. Ensure there are at least eight cylindrical erection driftpins per splice or connection. Install at least four driftpins in the web, two driftpins in the top flange and two driftpins in the bottom flange. Place the pins in the corner holes of the splice plates. Where field bolted diaphragms are required by the Contract, erect at least every other diaphragm at the time the beams are set in place with bolts or driftpins placed in half of the connection holes. Where field welded diaphragms are required by the Contract, erect diaphragms as the beams are set in place by a ¾ inch [20 mm] make-up bolt at each connection point.

Install additional cylindrical driftpins to align the parts. Fill the remaining holes with bolts, and tighten them from the most rigid part of the connection to the free edges. Replace cylindrical driftpins with tightened bolts.

After tightening the bolts, release temporary erection supports at a splice or connection. Indicate special assembly and support situations on the erection and falsework drawings.

Fitting-up bolts may be the same high-strength bolts used in the installation. If other fitting-up bolts are required by the Contract, use the same nominal diameter as the high-strength bolts. Use cylindrical driftpins $^{1}/_{32}$ in [0.75 mm] larger than the bolts.

(6) Pin Connection

Use pilot and driving nuts to drive pins at no additional cost to the Department. Drive the pins to fully bear members. Screw pin nuts tight, and burr the threads at the face of the nut with a pointed tool.

(7) Misfit

Correct minor misfits if approved by the Engineer. Correct errors, reaming, cutting, chipping, or other misfits at no additional cost to the Department. The Engineer will reject errors in the shop fabrication or deformation from handling and transport.

H. Expansion Joints

Install expansion joints in accordance with Section 504, "Bridge Decks, Approaches, Rails, and Parapets."

Submit complete working drawings for fabrication and installation of expansion joints. Include the joint manufacturer's instructions for installation.

Show the joint opening dimension for an ambient temperature of 60 °F [15 °C] and adjustments to that dimension due to temperature variations.

Conform expansion joints to concrete floor sections, matching cross slopes, and break points. Assemble expansion joints in the shop, check for fit, and match mark for shipment.

For sealed expansion joints, fabricate the steel receptors to be continuous for the length of the joint. Minimize the number of splices in the steel receptor. To splice, use a partial penetration weld, ground smooth. The Department will not allow welding in the areas in contact with the neoprene.

Continuously provide and install a neoprene gland the length of the joint. Where the Contract requires joints to be mitered for skew of at least 35°, splice the neoprene by vulcanizing or other Engineer approved method. Ensure spliced neoprene has equal strength and durability to unspliced neoprene. Make splices watertight.

506.05 METHOD OF MEASUREMENT

The Engineer will calculate weight on the basis of the net finished dimensions of the parts required by the Contract. The Engineer will measure approved substituted sections larger than those required by the Contract by the weight of the original sections.

The Engineer will not deduct for cuts, clips, copes, bolt holes, pin holes, or weld joint preparation in the measurement calculations.

The Department will not consider and pay for changes in quantities resulting from alternative details proposed by the Contractor in the drawings as approved by the Engineer.

Table 506:11
Steel and Iron Density Unit Weights

Unit	Density, *lb/ft³ [kg/m³]*
Steel, rolled or cast	490 [7,850]
Cast iron	445 [7,130]
Malleable iron	470 [7,530]
Wrought iron	487 [7,800]

The Engineer will measure the weight of rolled shapes on the basis of their nominal weight per foot as required by the Contract. For unspecified weight, refer to AASHTO M 160. The Engineer will measure the weight of plates on the basis of the nominal weight for their width and thickness as required by the Contract, with no allowance for overruns.

The Engineer will measure the weight of castings from the dimensions shown on the Shop Drawings, deducting for open holes, and adding 5 percent allowance for fillets and overruns. The Engineer will include steel and iron castings, steel or cast iron pipe for drains and minor items in the weight. For castings or small, complex parts, the Engineer will subsitute scale weight for calculated weight. The Engineer will include the weight of heads, nuts, single washers, DTIs, and threaded stick-through of high tensile strength bolts in accordance with Table 506:12 and Table 506:13.

Table 506:12
Bolt Sizes and Weights (English)

Bolt Size, *in*	Weight per 100 bolts, *lb*
⅝	31.7
¾	52.4
⅞	80.4
1	116.7
1⅛	165.1
1¼	212.0

Table 506:13
Bolt Sizes and Weights (Metric)

Bolt Size, *mm*	Weight per 100 bolts, *kg*
16	14.4
20	23.8
22	36.5
24	53.0
27	75.0
30	96.4
36	127.3

The Engineer will measure the weight of the following as structural steel:

- Anchor bolt assemblies,
- Anchor plates not embedded in concrete, and
- Diaphragm bolt assemblies for diaphragms between prestressed concrete girders.

The Engineer will calculate the weight of threaded bars on the basis of smooth bar of the diameter required by the Contract.

The Engineer will determine the weight of nuts and washers from the AISC Reference Manual.

The Engineer will not include the weight of additional material required under Subsection 506.04.G(4)(b), “Erection Stresses,” to accommodate erection stresses or the weight of additional bearing stiffeners required under Subsection 506.04.G(3), “Bearings and Anchorages.”

The Engineer will measure metal expansion joints in accordance with Section 504, “Bridge Decks, Approaches, Rails and Parapets.”

506.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) STRUCTURAL STEEL	Pound [Kilogram]
(B) STRUCTURAL STEEL A 709 GRADE HPS 70W (485W)	Pound [Kilogram]

SECTION 507
BEARING ASSEMBLIES

507.01 DESCRIPTION

This work consists of providing and installing bearing assemblies and elastomeric bearing pads.

507.02 MATERIALS

A. General

Provide materials in accordance with the following section and subsections:

Material:	Section or Subsection:
Welding	724.03
Stainless Steel for Bridge Bearing Assemblies	724.05
Elastomeric Bearing Pad	733.06

B. Steel Laminates

Provide steel laminates in accordance with AASHTO M 270 Grade 50 or ASTM A 1011 Grade 40.

C. Stainless Steel

Provide stainless steel in accordance with Subsection 724.05, “Stainless Steel for Bridge Bearing Assemblies,” for bearing plates and bearing assemblies, including anchor bolts, nuts, washers, contact plates, and contact angles.

507.03 EQUIPMENT — VACANT

507.04 CONSTRUCTION METHODS

A. Shop Drawings

Submit drawings for the bearing assemblies and pads in accordance with Subsection 105.02, "Plans and Working Drawings," and Subsection 733.06, "Elastomeric Bearing Pads."

B. Fabrication

Assemble and check the geometry of bearing assemblies in the shop.

C. Packaging, Handling, and Storage

Before shipping, mark the top of the bearing components and their orientation in the structure.

Protectively package bearings. Dismantle bearing assemblies for inspection and installation. During storage, protect bearing devices and components at the work site from damage.

D. Installation

Provide bearing surfaces on members and bridge seats with a smooth, uniform surface. Construct cast-in-place bearing surfaces in accordance with Subsection 509.04.K, "Girder Bearing Surfaces." Set anchor bolts before placing concrete, or install them in accordance with Subsection 509.04.D(3), "Doweling into Existing Concrete." Leave a ⅛ in [3 mm] gap between the top of the washers and the bottom of the nut on fixed and expansion bearing assemblies. If the plan requires two nuts on each anchor bolt, tighten the top nut sufficiently against the lower nut to lock them together as a unit.

Clean the bearing assemblies of deleterious materials. Install the bearings at the positions and dimensions shown on Plans. Center anchor bolts in the slotted holes on expansion bearing plates.

Set elastomeric bearing pads for bearing assemblies on level concrete without bedding material.

Field weld bearing plates to bottom flanges or embedded sole plates as the Contract requires. Weld in accordance with Subsection 724.03, "Welding." Weld the bearings after inspection. Do not expose the elastomer or bond to temperatures greater than 350 °F [175 °C]. If bearing plates are less than 1½ in [38 mm] thick, provide temperature measurements of the steel adjacent to the elastomer to ensure the steel does not exceed the temperature limitations. Replace the elastomeric bearing pads if the temperature exceeds 350 °F [175 °C].

If the centerline of the bearing does not horizontally line up within 2 in [50 mm]of the vertical bearing stiffener, weld additional bearing stiffeners to the steel beam or girder.

E. Elastomeric Bearing Pads

If the Contract requires, install elastomeric bearing pads between the top of the beam and the bottom of the bridge deck.

507.05 METHOD OF MEASUREMENT

The Department will measure the number of completed and accepted *Fixed Bearing Assemblies, Expansion Bearing Assemblies*, and *Elastomeric Bearing Pads* listed in the Bid Schedule that are completed and accepted for payment.

507.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) FIXED BEARING ASSEMBLIES	Each
(B) EXPANSION BEARING ASSEMBLIES	Each
(C) ELASTOMERIC BEARING PADS	Each

The Department considers the cost of anchor bolts, bearing plates, contact plates, nuts, contact angles, nuts, plain or laminated elastomeric bearing pads, and welding to be included in the contract unit price for *Fixed Bearing Assemblies* and *Expansion Bearing Assemblies*.

SECTION 508
CONCRETE CULVERTS

508.01 DESCRIPTION

This work consists of constructing concrete culverts.

508.02 MATERIALS

Provide materials in accordance with the following section and subsections:

Material:	Section or Subsection:
Structural Concrete (Class AA)	701.01
Reinforcing Steel for Structures	723
Joint Materials	726.01.B

Provide precast concrete box sections for culverts in accordance with AASHTO M 259 or AASHTO M 273.

508.03 EQUIPMENT — VACANT

508.04 CONSTRUCTION METHODS

A. General

Complete construction in accordance with Section 501, “Excavation and Backfill for Structures,” Section 502, “Forms, Falsework, and Temporary Works,” Section 509, “Structural Concrete,” and Section 511, “Reinforcing Steel for Structures.”

The Department will allow precast concrete box culverts instead of cast-in-place concrete box culverts if approved by the Engineer or allowed by the Contract.

The Department will not allow precast structures for bridge class structures, unless otherwise shown on the Plans.

Construct curtain walls as shown on the Plans to prevent undermining.

If the barrel length of cast-in-place culverts is longer than 100 ft [30 m], install a construction joint in the culvert. The Department will allow construction joints installed in culverts from 60 ft to 100 ft [18 m to 30 m], unless otherwise required by the Contract. Construct the joint in accordance with

Subsection 509.04.D, "Construction Joints." Extend longitudinal reinforcing steel through the joint at least 18 in [0.5 m], and lap it 18 in [0.5 m] with the longitudinal reinforcing steel in the adjoining section.

B. Finish

Apply a Class 2-Rubbed Finish to the exposed wings, curbs, rails, and retaining walls in accordance with Subsection 509.04.G(2), "Class 2, Rubbed Finish."

C. Bedding

Provide bedding for precast concrete box culverts at least 4 in [100 mm] thick below the precast box sections. Provide bedding material that meets the requirements for Class B bedding in accordance with Subsection 613.04.C, "Bedding." The Department will include bedding and necessary excavation for the bedding in the price bid for the structure.

D. Laying Precast Sections

Place precast concrete box sections after the Engineer approves the bedding material condition. Slowly lower and place the precast section into final position. Use hoisting equipment that will not damage the section or the bedding material. Clean the inside before lowering the sections into place.

Replace damaged sections at no additional cost to the Department.

Begin placing the precast sections at the downstream end of the culvert. Join precast sections in accordance with Subsection 613.04.H, "Joining Pipe Conduit." Place the sections to the line and grade shown on the Plans. After the Engineer's approval of the placement of the precast culvert, prevent displacement or damage to the sections when backfilling.

E. Box Culvert End Sections

For concrete box culverts, cast end sections in place. End sections include wingwalls, curbs, end of barrels, curtain walls, and aprons. If using precast sections in skewed structures, build wings in the same skewed relationship to the culvert walls as shown on the Plans for the cast-in-place culvert. Build curbs and curtain walls perpendicular to the barrels of precast sections for skews between 90° and 60°.

F. Working Drawings for Precast Box Sections

Before constructing precast concrete box culverts, provide the Engineer with complete, sealed working drawings of the proposed construction in accordance with Subsection 105.02, "Plans and Working Drawings." Show details of reinforcing steel and concrete dimensions.

G. Extension of Existing Cast-in-Place Culvert

If the Contract requires extension of an existing cast-in-place culvert, perform work as follows:

- Remove the existing wing walls, curbs, handrails, aprons, and other structures, as shown on the Plans.
- Repair culvert areas damaged during removal.
- Provide dowel bars of the same diameter and grade as the longitudinal reinforcing steel in the new adjoining section of culvert.
- Lap dowel bars 18 in [460 mm] with each longitudinal bar in the new section in accordance with Subsection 509.04.D(3), "Doweling into Existing Concrete."

508.05 METHOD OF MEASUREMENT — VACANT

508.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
REMOVAL OF CULVERT END	Each

The Department will pay for precast concrete box culverts using the contract unit prices for the relevant pay items and quantities as determined by field measurements for cast-in-place concrete box culverts.

The Department will pay for quantities of excavation and backfill, reinforcing steel and dowel bars, and concrete used in the construction of concrete culverts in accordance with Section 501, "Excavation and Backfill for Structures," Section 511, "Reinforcing Steel for Structures," and Section 509, "Structural Concrete," respectively.

SECTION 509
STRUCTURAL CONCRETE

509.01 DESCRIPTION

This work consists of providing, placing, finishing, and curing concrete in bridges, culverts, and other structures.

509.02 MATERIALS

Provide materials in accordance with the following sections and subsection:

Material:	Section or Subsection:
Portland Cement Concrete	701
Supplementary Cementitious Materials	702
Waterstops	733.08
Concrete Surface Finish for Structures	737

509.03 EQUIPMENT — VACANT

509.04 CONSTRUCTION METHODS

A. General

Handle and measure materials, batching, and mixing in accordance with Subsection 414.04.C, "Mixing Concrete," Subsection 414.04.D, "Light and Weather Limitations," and Subsection 414.04.E, "Setting Forms," unless otherwise required by the Contract.

Use falsework and forms in accordance with Section 502, "Forms, Falsework, and Temporary Works." Support concrete until it reaches the Contract required strength. If approved by the Engineer, use maturity meters for form removal or for opening roadways. Submit a plan for using maturity meters at no additional cost to the Department.

Perform related work for concrete structures in accordance with Section 502, "Forms, Falsework, and Temporary Works," Section 503, "Prestressed Concrete Bridge Members," Section 504, "Bridge Decks, Approaches, Rails, and Parapets," Section 511, "Reinforcing Steel for Structures," and Section 517, "Post-Tensioning."

B. Protection of Concrete from Environmental Conditions

(1)General

Protect the concrete from environmental damage during placement and curing. Replace or repair frozen or damaged concrete.

Place concrete with a temperature from 50 °F to 90 °F [10 °C to 32 °C]. Measure the concrete temperature immediately before placement. Place the concrete against forms, the ground, or reinforcement with a temperature from 35 °F to 100 °F [2 °C to 38 °C].

Keep at least two thermometers on the Project that can record the maximum and minimum temperatures within 5 °F [3 °C]. Install the thermometers and submit the temperature data as directed by the Engineer. Report readings and reset thermometers daily.

(2) Rain Protection

The Department will not allow the placement of concrete during rain. If rain occurs, protect the surface of the concrete.

(3) Hot Weather Protection

Use a water spray to cool surfaces hotter than 100 °F [38 °C] that come in contact with poured concrete.

Maintain the Contract required concrete temperature using a combination of the following methods:

- Shade the material storage areas and the production equipment,
- Cool the aggregates by sprinkling them with water in accordance with Subsection 701.04, "Water,"
- Cool the aggregates or water by refrigeration or replace the mix water with ice, ensuring it melts during mixing, and
- Inject liquid nitrogen.

(4) Cold Weather Protection

The Department defines cold weather as the time during the concrete placement or curing period that the ambient temperature drops below 35 °F [2 °C]. To determine ambient temperature, measure the air temperature in the shade 5 ft [1.5 m] above the ground. Before placing concrete in cold weather, ensure the availability of protection material and equipment.

Remove snow, ice, and frost from the surfaces coming in contact with the concrete. Ensure the temperatures of the surfaces that come into contact with fresh concrete are at least 35 °F [2 °C].

If using heaters, place the heaters and direct ducts in a manner that prevents fire hazards and excessive localized drying. Vent exhaust flue gases from combustion heating units to the outside of enclosures. Apply and withdraw the heat gradually and uniformly so the concrete surface does not heat to more than 90 °F [32 °C] before setting. When removing protection, prevent the temperature from varying by more than 20 °F [11 °C] in 8 hr.

During concrete mixing, prevent the cement from coming into contact with aggregates hotter than 100 °F [38 °C]. The Department will not allow heating aggregates with a direct flame or on sheet metal over a fire. Do not use direct steam to heat fine aggregate. The Department will not allow salts to prevent freezing.

Place concrete with a uniform temperature and free of frost lumps.

During cold weather, protect the concrete for at least 7 calendar days so the surface temperature does not drop below 50 °F [10 °C]. Provide and install recording thermometers, maturity meters, or other recording temperature measuring devices to verify that the concrete is protected. Extend the protection period to 10 days if fly ash, slag, and silica fume are used in the concrete.

C. Handling and Placing Concrete

(1) General

Place and consolidate concrete, preventing mix segregation and producing a dense homogeneous concrete, free of voids and rock pockets. Prevent displacement of reinforcing steel and other embedded materials in the concrete.

Place and consolidate concrete before initial set. Place the concrete in accordance with the time limits in Table 509:1. Begin measuring time when adding the cement to the mix. Do not re-temper concrete or add air-entraining admixtures after initial batching. If submitted as part of the mix design, add high range water-reducing admixtures at the Project site in accordance with Section 701, "Portland Cement Concrete."

Table 509:1
Time Limits for Completion of Concrete Placement/Consolidation

Cement Type	Time Limit, *hr*
Type I or II	1.00
Type I or II with retarding admixture	1.50
Type III	0.75
Type III with retarding admixture	1.25

Place the concrete after the Engineer approves the forms, materials, and footing foundation material. Remove mortar, debris, and foreign material from the forms and reinforcing steel. Moisten the forms and subgrade before placing the concrete against them. Remove temporary form spreaders when the concrete placement precludes their need.

Place concrete uninterrupted between construction or expansion joints. Place and consolidate fresh concrete against previously placed concrete before initial set. Place successive batches within 20 min of the preceding batch. Increase this period to 30 min if the ambient temperature falls below 60 °F [15 °C]. If placement is delayed and the initial set occurs, make an emergency construction joint in accordance with Subsection 509.04.D, "Construction Joints."

During and after concrete placement, do not break the bond with reinforcing steel or damage the concrete. Keep foot traffic off the fresh concrete. The Department will not allow placing support platforms on reinforcing steel. After the concrete sets, do not apply force to reinforcing steel and forms projecting from the concrete until the concrete is strong enough to resist damage.

(2) Sequence of Placement

Release the forms and falsework in accordance with Subsection 502.04.(C), "Removal of Forms and Falsework."

(a) *Substructures*

To determine if bents, piers, or abutments meet strength requirements to support loads, test a concrete sample of the same type and cured under the same conditions. Use the cylinder test to ensure the concrete reaches at least 80 percent of its 28-day compressive strength or ages at least 7 days. If the ambient temperature falls below 50 ºF [10 ºC], allow the concrete to age at least 7 days before loading the concrete.

(b)*Vertical Members*

For vertical members at least 16 ft [5 m] high, allow the concrete to set for 12 hr before placing concrete for integral horizontal members. For vertical members less than 16 ft [5 m] high, allow the concrete to consolidate for at least 30 min. If mounting friction collars or falsework brackets, place concrete for horizontal members after the vertical member is in place at least 7 days or attains the 28-day strength.

(c)*Superstructures*

Remove substructure forms before placing concrete in the superstructure to ensure the substructure can support the superstructure. Place concrete in the superstructure when the substructure attains the Contract required strength.

Place concrete for cast-in-place T-beams or pan girders in one to two operations. If the section exceeds 4 ft [1.2 m] deep, place in two operations. Wait at least 5 calendar days after stem placement before placing the top deck slab concrete.

Place concrete for box girders in two to three operations consisting of the bottom slab, girder webs, the top slab, or as required by the Contract. Place the bottom slab first. Place the top slab at least 5 calendar days after placement of the girder webs.

(d)*Arches*

Place concrete in arch rings to uniformly load the centering.

(e)*Box Culverts*

Allow the box culvert base slab to set 24 hr before placing the culvert walls. For walls shorter than 5 ft [1.5 m], place the walls and top slab in one operation. For walls higher than 5 ft [1.5 m], place the walls and top slab in accordance with Subsection 509.04.C(2)(b), "Vertical Members."

(f) *Precast Elements*

Place and consolidate concrete to prevent shrinkage cracks.

(3)Placing Methods

(a)*General*

Place concrete close to its final position. The Department will not allow the use of vibrators to move a mass of fresh concrete.

Place concrete in horizontal layers less than 18 in [0.5 m] thick. Ensure the vibrators consolidate and merge new layers with the previous layer. When placing concrete, do not exceed the design loading for forms.

Drop unconfined concrete from a height of less than 6 ft [2 m]. Confine concrete using a tube fitted with a hopper head or other device that prevents mix segregation and mortar spattering.

(b)*Equipment*

Provide equipment that will not damage the concrete from vibration or cause mix segregation or mortar loss. Provide equipment with no aluminum parts that come in contact with the concrete. Remove mortar from inside surfaces of placing equipment.

Use chutes lined with smooth, watertight material. Equip the chutes with baffles or reverses if working around steep slopes. Operate concrete pumps to discharge a continuous concrete stream without air pockets.

Use conveyor belt systems less than 550 ft [170 m] measured from end to end of the belt assembly. Arrange the belt assembly so sections discharge into a vertical hopper without mortar adhering to the belt. Use a hopper, chute, and deflectors at the discharge end of the conveyor belt so that the concrete drops vertically.

(c) ***Lighting***

If placing concrete at night, provide lighting required by the Contract and avoid interruptions to concrete placement. Repair damage to the lighting system and replace burned out lamps.

(4) Consolidation

Consolidate concrete using internal mechanical vibrators, unless placing concrete in drilled shafts. Use external form vibrators on thin sections if the forms are designed for external vibration.

Ensure vibrators transmit at frequencies of at least 75 Hz.

Use vibrators to consolidate the concrete batches immediately after placing them. Provide at least one spare vibrator in case of breakdown.

Use vibrators to work the concrete around reinforcement, embedded fixtures, corners, and angles in the forms. Beginning at the deposit point, vibrate the concrete at uniformly spaced locations. Ensure the distance between the locations is no greater than one and one-half times the visible effective radius of the vibration. Vertically insert vibrators so the affected vibrated areas overlap, then slowly withdraw them from the concrete. Ensure the vibration consolidates the concrete without causing segregation. Do not cause grout formation. The Department will not allow vibrating reinforcement or through reinforcement to layers of concrete that has become non-plastic.

Alternatively, spade to make smooth surfaces and dense concrete along forms, in corners, and areas inaccessible to vibrators.

(5) Underwater Placement

(a) ***General***

The Engineer will allow underwater placement for seal concrete and drilled shafts. Use seal concrete to seal structures from water. For concrete placed underwater, increase the cement content in the concrete mix by 10 percent to compensate for loss. Place drilled shafts in accordance with Section 516, “Drilled Shaft Foundations.”

Place concrete underwater in a compact mass and prevent seal concrete segregation. Maintain still water at the deposit point. Make underwater forms watertight. During placement and curing, vent cofferdams to equalize the hydrostatic pressure and prevent water from flowing through the seal concrete.

If placing seal concrete underwater, maintain a continuous concrete flow. Keep the concrete surface level. To ensure bonding, place layers of seal

concrete before the preceding layer sets. For large pours, use more than one tremie or pump.

(b)*Equipment*

1) *Tremies*

Use watertight tremies with a diameter of at least 10 in [250 mm]. Fit the top with a hopper. Use multiple tremies required by the Contract. Ensure tremies can lower rapidly to retard or stop the concrete flow.

At the start of concrete placement, seal the discharge end and fill the tremie tube with concrete. Keep the tremie tube full of concrete during placement. If water enters the tube, withdraw the tremie and reseal the discharge end. Maintain a continuous concrete flow until completing the placement.

2) *Concrete Pumps*

Use pumps that seal out water while concrete fills the tube. When the concrete begins to flow, keep the end of the discharge tube full of concrete and below the surface of the deposited concrete until completing the placement.

(c)*Cleanup*

Dewater after test specimens, cured under similar conditions, indicate that the seal concrete has sufficient strength to resist the expected loads. Remove all laitance or other unsatisfactory materials from the exposed surface by scraping, chipping, or other means which will not injure the surface of the seal concrete before placing the foundational concrete.

D. Construction Joints

(1)General

Make construction joints where required by the Contract. Extend reinforcing steel through joints. Place emergency construction joints as approved by the Engineer, and add steel dowels across the joint at no additional cost to the Department.

(2)Bonding

Unless otherwise required by the Contract, construct horizontal joints without shear keys and vertical joints with shear keys. Rough float the fresh concrete at a horizontal joint to consolidate the surface. Leave the joint roughened. The Department defines shear keys as depressions in the surface that cover one-third of the contact surface. Bevel the key forms so that removal does not damage the concrete.

Clean debris from construction joints before placing fresh concrete against the joint surface. Use an abrasive blast with an amplitude of ¼ in [6 mm], or other methods to clean joints without shear keys to expose clean aggregate. Clean joints with shear keys. Flush construction joints with water and allow them to dry before placing new concrete.

(3) Doweling into Existing Concrete

Do not use dowels in an overhead position or permanent sustained tension. Before bonding new concrete to existing concrete structures, clean and flush the existing concrete in accordance with Subsection 509.04.D(2), "Bonding." Drill holes for grouted reinforcing dowels at construction joints to the depth required by the Contract without damaging adjacent concrete. Extend the holes to the greater of 15 bar diameters or the epoxy manufacturer's recommended depth for the dowel bar hole depth. Ensure the hole diameter does not exceed the dowel diameter by more than ¼ in [6 mm].

Use Type H epoxy in accordance with Subsection 701.13, "Epoxy Resin Adhesives for General Use with Concrete." Submit information on the proposed epoxy including the brand name, specification, type, class, and grade for Engineer approval before use. Use equipment and techniques to proportion, mix, and place the epoxy in accordance with the manufacturer's recommendations.

Inject epoxy into the hole through a tube or hose long enough to reach the closed end of the hole. Start filling the hole from the closed end. Except in horizontal applications, fill the hole to a level that after dowel insertion, excess epoxy runs out. Twist the dowel to ensure a uniform epoxy coating. Clean excess epoxy around the hole while the epoxy remains fluid. If the epoxy is inconsistent using this procedure, use the manufacturer's recommended procedure.

(4) Forms at Construction Joints

If forms overlap previously placed concrete at construction joints, retighten the forms before depositing new concrete. Neatly form the visible joint faces with straight bulkheads or grade strips, or otherwise finish joints.

E. Installing Expansion and Contraction Joints

Construct expansion and contraction joints as required by the Contract. Expansion and contraction joints include the following joint types:

- Open,
- Filled,
- Reinforced with steel armor,
- Waterstops,
- Compression seals,
- Elastomeric expansion joint seals, and
- Joints with combinations of these features.

(1) Open Joints

Form open joints with wooden strip, metal plate, or other Engineer approved material. Remove the joint forming material without breaking the corners of the concrete. Do not extend reinforcement across open joints. Use an edging tool with a radius of ½ in [12 mm] to finish the edges of non-armored joints.

(2) Filled Joints

Cut premolded expansion joint filler to the joint surface dimensions. Secure the joint filler on one surface of the joint with galvanized nails, waterproof adhesive, or other Engineer approved methods. Minimize the use of splices in the filler material. Splice in accordance with the manufacturer's recommendations. After

removing the forms, remove and cut concrete or mortar sealed across the joint. Fill joint gaps at least ⅛ in [3 mm] wide with hot asphalt or other Engineer approved filler. Place devices as shown on the Plans.

(3) Steel Joints

Construct metal expansion joints in bridge decks in accordance with Section 504, "Bridge Decks, Approaches, Rails, and Parapets."

(4) Water Stops

Place rubber or plastic waterstops as required by the Contract. Where joint movement is required by the Contract, use waterstops that allow the movement.

(a) *Rubber Waterstops*

Before installation, submit the following for approval:

- Performance test data,
- A 1 yd [1 m] sample of Contract required types of waterstop, and
- If using splices, at least one preliminary field splice.

Form waterstops with a cross-section, uniform in width and web thickness. The Department will not allow splicing straight strips. Full-mold junctions in the special connection pieces. Provide cured, dense, nonporous, homogeneous special connection pieces. Fabricate dense, homogenous splices made watertight by vulcanizing or machine throughout the cross-section. Make splices with a minimum tensile strength of 50 percent of the unspliced rubber waterstop.

(b) *Plastic Waterstops*

Before installation, submit at least one preliminary field splice sample. Heat splices in accordance with the manufacturer's instructions to make watertight. Fabricate splices with a minimum tensile strength of 80 percent of the unspliced plastic waterstop.

(c) *Placing Waterstops*

Protect waterstops from displacement or damage. Keep waterstop surfaces free of deleterious material until embedded in the concrete. Enclose embedded waterstops in dense concrete.

(5) Compression Joint Seals

Use one-piece compression joint seals for transverse joints and the longest lengths for longitudinal joints. Clean and dry joints and remove spalls and irregularities. Apply a lubricant-adhesive to both sides of the seal immediately before installation. Compress the seal and place it in the joint as recommended by the manufacturer. Ensure the seal contacts both joint walls along seal length.

Discard twisted, curled, nicked or improperly formed seals. Reinstall joint seals that stretch more than 5 percent of their original length if compressed. Remove excess lubricant-adhesive before it dries.

(6) Elastomeric Expansion Joint Seal

Install the joint in accordance with the manufacturer's recommendations.

F. Concrete Curing

(1) General

Cure all new concrete using one or more method in accordance with Subsection 509.04.F(2) through Subsection 509.04.F(6). Unless otherwise required by the Contract, begin curing immediately after the surface water evaporates and finishing is complete. Do not damage the concrete surface during curing operations. If the concrete begins to dry before curing begins, use a fog spray to moisten the surface.

Keep surfaces moist after removing forms. Cure immediately after the first rub.

Unless using steam or radiant heat curing methods, continuously cure the concrete for at least 7 calendar days. If more than 10 percent of the portland cement weight consists of pozzolans, cure continuously for at least 10 calendar days. Except for concrete in bridge floors and pavements, reduce the curing period if cylinders cured under the same conditions indicate that the concrete reaches at least 70 percent of its Contract required strength.

Use curing agents in accordance with Subsection 701.07, "Curing Agents."

(2) Forms-in-Place Method

For formed surfaces, leave the forms in place without loosening them. If removing forms during the curing period for rubbing, strip forms from areas that can be rubbed in one shift. Keep the surface of the exposed concrete moist during rubbing. After rubbing, continue the curing process by applying the water method or a Type 1-D curing compound.

(3) Water Method

Keep the concrete surface wet using ponding, spraying, or covering material. Ensure covering material does not discolor or damage the concrete.

(4) Liquid Membrane Curing Compound Method

Use Type 2, white pigmented, liquid membrane on visible bridge deck and approach slab surfaces. Use either Type 1-D, clear curing compounds or Type 2, hite pigmented liquid membrane on other surfaces.

Mix membrane-curing solutions that contain pigments before use. Continue to agitate during the application. Use equipment that produces a fine spray. Apply the curing compound at a coverage rate of at least 1 gal per 160 ft^2 [1 L per 4 m^2] in one to two applications. If using two applications, apply the second within 30 min at right angles to the first application. Continue curing applications until gray is not visible.

Apply a new coat of curing compound if rain damages the membrane during the curing period.

The Department will not allow the use of the liquid membrane method on surfaces that receive a Class 2 rub-finish. The Engineer will allow curing compound on construction joints if sandblasting removes the compound before the next concrete placement against the joint. Protect reinforcing steel from the liquid membrane-curing compound.

(5) Waterproof Cover Method

Cover the wet concrete surface with wide sheets of waterproof material that prevents moisture loss. Lap adjacent sheets at least 6 in [150 mm] and tightly seal the seams with pressure sensitive tape, mastic, glue, or other methods approved by the Engineer. Secure the material so wind does not displace it. Repair damaged sheets.

(6) Steam or Radiant Heat Method

Use the steam or radiant heat method for precast concrete members manufactured in established plants.

Conduct steam or radiant heat curing in an enclosure to contain the heat and steam. Ensure a uniform temperature inside the enclosure. Place the temperature recorder inside the enclosure.

Apply steam or radiant heat after the concrete initial set, or from 2 hr to 4 hr after final placement for normal set concrete. Allow retarded set concrete to sit from 4 hr to 6 hr. Measure the time of initial set in accordance with AASHTO T 197 (ASTM C 403). After placement, and before using this curing method, use steam or radiant heat to maintain the curing chamber temperature from 50 °F to 90 °F [10 °C to 32 °C].

Prevent localized high temperatures on the members caused by directly applying steam or radiant heat. Limit the rate of ambient temperature change in the curing enclosure to 40 °F/hr [22 °C/hr]. Ensure the temperature inside the enclosure does not exceed 160 °F [70 °C]. Maintain the curing temperature until it reaches the Contract required concrete detensioning strength. When discontinuing steam or radiant heat, allow the ambient air temperature in the enclosure to cool to 20 °F [10 °C] above the outside temperature. Do not reapply steam or radiant heat after cooling.

For the steam method, use low pressure, saturated steam with 100 percent relative humidity. Apply the radiant heat using pipes that circulate steam, hot oil, hot water, or electric heating elements. If using the radiant heat method, cover exposed concrete with plastic sheeting or a liquid membrane-curing compound. After the curing, remove compound residue from areas requiring surface bonding.

Unless maintaining the ambient temperature above 60 °F [16 °C], transfer the stressing force on prestressed members immediately after discontinuing the curing.

G. Finishing Formed Concrete Surfaces

Replace or repair rock pockets or honeycombed concrete. Provide a durable, uniformly textured and colored, tightly bonded surface finish. Except for Class 7 finish, apply a penetrating water repellent treatment in accordance with Section 515, "Penetrating Water Repellent Treatment." Apply coatings, grout, and mortar when the surface temperature is 40 °F [10 °C] or higher, except for Class 6 Mortar Finish (see below). Comply with the Manufacturer's temperature requirements when they are more restrictive.

(1) Class 1, Ordinary Surface Finish

Finish formed concrete surfaces with a Class 1, ordinary surface finish. If another class of surface finish is required by the Contract, apply it after the Class 1 finish.

Begin finishing upon form removal. Remove irregularities from exposed surfaces or those specified for waterproofing. Remove bulges and offsets with carborundum stones or discs. Remove poorly bonded rock pockets or honeycombed concrete, and replace them with concrete or packed mortar in accordance with Subsection 509.04.H, "Mortar and Grout." The Engineer may identify rock pockets or honeycombed concrete areas that may materially affect structural strength or steel reinforcement effectiveness, determine that the areas are defective, and require their replacement.

Clean and point defects, and saturate the area with water. Finish the area with less than 1 hr old mortar in accordance with Subsection 509.04.H, "Mortar and Grout." After the mortar sets, rub and continue curing if required by the Contract. Match exposed surfaces to surrounding concrete.

Tool and remove free mortar and concrete from construction and expansion joints. Leave joint filler exposed along its length with clean edges. Rub or grind bearing surfaces on piers and abutments to the elevation and slope shown on the Plans. If the final finished surface is not uniform, provide a Class 2, rubbed finish.

(2)Class 2, Rubbed Finish

Except for superstructure soffits, concrete girder bottoms, concrete girder interior faces, and the interior faces of reinforced concrete boxes, finish concrete surfaces with a Class 2, rubbed finish.

Saturate the concrete surfaces with water immediately before rubbing with a medium coarse carborundum stone with a small amount of mortar on the face. Mix mortar from cement and fine sand in the same proportions as the finished concrete. Continue rubbing to remove form marks, projections, and irregularities, and to obtain a uniform surface. Leave the paste in place.

After completing other surface work, rub with a fine carborundum stone and water until smooth and uniform in color. After the surface dries, rub with burlap to remove loose powder. Ensure the surface is free from unsound patches, paste, powder, and marks.

For slip formed surfaces, achieve a rubbed finish.

(3)Class 3, Tooled Finish

Provide a Class 3 surface finish if required by the Contract. Let the concrete set for at least 14 calendar days. Use air tools. Chip away the surface mortar and break the aggregate particles to expose a group of broken aggregate particles in a matrix of mortar.

(4)Class 4 Sandblasted Finish

Provide a Class 4 surface finish required by the Contract. Let the concrete set for at least 14 calendar days. Protect adjacent surfaces that are not sandblasted. Sandblast the surface to produce a fine-grained surface exposing the aggregate.

(5)Class 5 Wire Brushed or Scrubbed Finish

Provide a Class 5 surface finish if required by the Contract. Begin after form removal. Scrub the surface with stiff wire or fiber brushes and a solution of 1 part muriatic acid to 4 parts water. Scrub away the cement film to expose the aggregate

particles. Leave an even pebbled texture. Wash the surface with water and ACI recommended amount of ammonia.

(6)Class 6 Mortar Finish

Except for bearing surfaces, or unless otherwise required by the Contract, provide a Class 6 surface finish. Use cement mortar in accordance with Section 737, "Concrete Surface Finish for Structures." Unless otherwise specified by the Contract, use a lighter color than the concrete.

Build 18 in × 36 in [0.5 m × 1 m] concrete finish sample panels. Obtain the Engineer's approval of the color. Protect the approved sample panel during the work. Finish designated surfaces to match the color of the approved sample.

Complete other adjacent work before applying the mortar finish. After completing the Class 1 surface finish, remove deleterious material by lightly abrasive-cleaning the surface. Wash the surface with a jet spray of water.

Protect the untreated surfaces. Apply the finish to a dry surface when the surface temperature reaches at least 50 °F [10 °C] with a forecast of at least 50 °F [10 °C] during the 24 hr following application:

- Apply the finish as the manufacturer specifies.
- Apply the coating using a plaster-type spray gun or the brush and float method.
- Cure cement-based mortar coatings as specified for curing concrete.

Clean concrete areas that will not be finished. Clean and recoat defective areas at no additional cost to the Department.

(7)Class 7 Paint Finish

Paint concrete if the Contract requires. Before painting, apply water repellent in accordance with Section 515, "Penetrating Water Repellant Treatment." Paint concrete in accordance with Section 737, "Concrete Surface Finish for Structures." Before painting, clean surfaces with a power washer with a pressure of at least 3,000 psi [21 Mpa]. Submit the manufacturer's specifications to the Engineer 14 days before application. Apply the paint in accordance with the manufacturer recommendations.

H. Mortar and Grout

(1)General

This work consists of making and placing of mortar and grout for use in concrete structures, other than in prestressed ducts. The use of mortar includes filling voids and repairing surface defects. The use of grout includes filling sleeves for anchor bolts.

(2)Materials and Mixing

Provide materials for mortar and grout to fill voids, repair surface defects, and fill sleeves for anchor bolts in accordance with Section 701, "Portland Cement Concrete." If the width or depth of the void is less than ¾ in [20 mm], modify the sand grading for use in grout or mortar so material passes through a No. 8 sieve. Use Type I Portland Cement and air entraining admixture. Unless otherwise required by the Contract, use 1 part cement to 2 parts sand for mortar and 1 part cement to 1 part sand for grout.

If using non-shrink mortar or grout as required by the Contract, use a non-shrink admixture or expansive hydraulic cement in accordance with ASTM C 845. Use enough water to allow placing and packing. For mortar, limit the amount of water so the mortar forms a ball if squeezed.

Use hand methods or rotating paddle-type machines to mix. Mix to thoroughly blend ingredients. Do not re-temper mortar or grout and place it within 1 hr of mixing.

(3)Placing and Curing

Clean foreign material from areas that contact the mortar or grout. Flush the areas with water and allow them to dry before placement.

Fill and tightly pack holes and locations identified by the Engineer with mortar or grout. For structural repairs, use the water method to cure mortar and grout surfaces for at least 3 days. Apply loads on mortar or grout after completion of curing.

Replace defective mortar and grout.

I. Application of Loads

(1)General

Do not apply loads to concrete structures until the concrete has attained sufficient strength and, when applicable, sufficient prestressing has been completed. Determine strengths from test cylinders cured at the work site under similar environmental conditions in accordance with Section 701, "Portland Cement Concrete."

(2)Earth Loads

Place backfill around structures to minimize overturning or sliding forces. If backfill placement causes flexural stress in the concrete, and unless otherwise approved by the Engineer, allow concrete to reach at least 80 percent of its Contract required strength and age at least 7 days before placing backfill.

For a rigid frame bridge or a bridge where the abutments are integral with the superstructure, place the superstructure and remove the forms that support the girders and deck before backfilling the abutments. The Department will not allow placement of embankments around supporting forms.

(3)Construction Loads

Allow the concrete in substructure elements to reach at least 80 percent of its Contract required strength and age at least 7 days before loading these elements with girders, precast concrete or steel. Additionally, the girders may be erected earlier than the 7 days, once the pier caps and abutments reach at least 100 percent of its Contract-required strength and the underlying forms and falsework remain in place on the pier caps.

Place construction loads on bridge decks in accordance with Section 504, "Bridge Decks, Approaches, Rails, and Parapets." Limit construction loads on structures to the load carrying capacity in accordance with AASHTO *Standard Specifications for Highway Bridges*. Calculate capacities using the lowest measured, actual strength of the structure.

J. Concrete Anchorage Devices

Use chemical, grouted, or cast-in-place concrete anchorage devices to attach equipment or fixtures to concrete. Provide the following:

- Concrete anchorage device sample,
- Manufacturer's installation instructions, and
- Material data and certifications.

Fabricate metal parts of the anchorage devices from stainless steel or steel protected with a corrosion-resistant metallic coating that does not react to concrete. Supply anchorage devices with hardware. For chemical or grouted anchors, conduct a system approval test at the job site on one anchor, unincorporated in the work. Conduct a static load test in accordance with ASTM E 488.

Demonstrate that the anchorage device can withstand a direct tension test load for at least 48 hr. Ensure the device can withstand at least the values shown in Table 509:2 and Table 509:3, and moves no more than 0.035 in [1 mm]. Demonstrate that, if loaded to failure, the steel of the anchor device fails and not the chemical, grout, or concrete.

Table 509:2
Sustained Load Test Values (English)

Anchorage Device Stud Size, *in*	Tension Test Load, *lbf*
¼	1,000
⅜	2,100
½	3,200
⅝	4,100
¾	5,100

Table 509:3
Sustained Load Test Values (Metric)

Anchorage Device Stud Size	Tension Test Load, *kN*
M8	7.1
M12	12.7
M16	18.3
M20	24.0

Install concrete anchorage devices in accordance with the manufacturer recommendations. Ensure the attached equipment or fixtures bear firmly against the concrete. Torque nuts in accordance with Table 509:4 and Table 509:5, unless otherwise recommended by the manufacturer.

Table 509:4
Torque for Anchorage Devices (English)

Anchorage Device Stud Size, *in*	Torque, *lb ft*
¼	10
⅜	35
½	60
⅝	90
¾	125

Table 509:5 Torque for Anchorage Devices (Metric)	
Anchorage Device Stud Size	**Torque, *N m***
M8	30
M12	80
M16	130
M20	180

In the Engineer's presence, test a random sample of at least 10 percent of the anchors. Proof-load the anchors to 90 percent of the steel yield stress. If an anchor fails, reset and proof-torque it and the remaining anchors. To apply the proof load, torque the anchors against load indicator washers, and apply direct tension load to the anchor, or another method approved by the Engineer. After proof-loading, release the load on the anchor and retighten to the load specified in Table 509:4 and Table 509:5, or to the manufacturer recommended load.

K. Girder Bearings Surfaces

Finish concrete bearing surfaces in accordance with Subsection 509.04.G(2), "Class 2, Rubbed Finish."

Before erecting girders, check concrete bearing surfaces for smoothness, levelness, and elevation in the Engineer's presence. Build the concrete bearing surfaces within ¼ in [6 mm] of the elevations shown on the Plans. Ensure the bearing surfaces do not slope more than 0.5 percent from horizontal. If bearing surfaces do not meet the Contract required tolerances, notify the Engineer, and submit a written proposal to modify the installation.

L. Testing

Evaluate the compressive strength in accordance with Subsection 701.01, "Mix Design and Proportioning."

Perform other tests as required by the Contract.

509.05 METHOD OF MEASUREMENT

The Engineer will measure structural concrete along the neat lines of the structure as shown on the Plans, unless otherwise modified to fit field conditions. The Engineer will not deduct the volume occupied by reinforcing steel, anchors, weep holes, piling, or pipes and ducts less than 8 in [200 mm] in diameter.

The Engineer will measure concrete volumes less than 20 yd^3 [15 m^3] per structure as *Class A Concrete, Small Structures*, if included as a pay item.

Do not measure floodlighting for payment.

509.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) CLASS AA CONCRETE	Cubic Yard [Cubic Meter]
(B) CLASS A CONCRETE	Cubic Yard [Cubic Meter]
(C) CLASS A CONCRETE, SMALL STRUCTURES	Cubic Yard [Cubic Meter]
(D) CLASS C CONCRETE	Cubic Yard [Cubic Meter]
(E) CLASS P CONCRETE	Cubic Yard [Cubic Meter]

The Department may accept concrete with strengths, air content, or both lower than required in accordance with Subsection 105.03, "Conformity with Plans and Specifications." The Department will use the following equation to calculate the strength pay factor for concrete volumes with strengths less than the specified requirements:

$$\text{Low Strength Pay Factor} = (\text{Actual Strength}/\text{Specified Strength})^2$$

Multiply the Contract price by the Low Strength Pay Factor for the represented concrete volume. Check any outlying concrete cylinder breaks in accordance with ASTM E 178 Table 1, "Upper 10% Significance Level."

Use the following table to compute the air content pay factor for volumes of concrete with entrained air less than the specified requirements, except for drill shafts, in accordance with Subsection 105.03, "Conformity with Plans and Specifications."

Table 509:6
Air Content Pay Factor

Below Target, *% Air*	**Pay Factor**
>0.0 – ≤ 1.5	1.00
>1.6 – ≤ 3.0	(1.33 x Actual Air %) / (Target Air %)
> 3.0	Unacceptable

Multiply the Contract price by the air content pay factor for the represented volume of concrete. If testing of subsequent loads of concrete are within 1.5 percent of the entrained air target, the pay factor will only apply to the volume of concrete outside the 1.5 percent of the entrained air target. If any concrete entrained air test results are believed to be an outlier, then the Engineer will check each test result in accordance with the ASTM E 178 using Table 1, Upper 10% Significance Level.

If the Pay Factors are determined by the Engineer to be less than 100 percent, the Contractor may elect to core the represented concrete at no additional cost to the Department. The proposed method and location of the coring must be approved in advance by the Engineer. Coring must be performed in the presence of a Department representative. Testing of the cores will be conducted by the Materials Division and the cores must comply with the sample requirements of the applicable test methods.

Do not use volumes of concrete with entrained air 10 percent or greater. Replace concrete with entrained air of 10 percent or greater at no additional cost to the Department.

SECTION 510
EARTH RETAINING SYSTEMS AND SOUND BARRIER WALLS

510.01 DESCRIPTION

This work consists of constructing earth retaining systems, cast-in-place concrete sound barrier walls, and slopewalls.

510.02 MATERIALS

A. General

Provide materials in accordance with the following sections and subsections:

Material:	Section or Subsection:
Structural Concrete	509
Reinforcing Steel for Structures	511
Portland Cement Concrete	701
Cover Material for Pipe Underdrains	703.06
Granular Backfill	703.07
Drainage Conduits	726

For slopewalls, use Class A concrete with coarse aggregate for thin section concrete.

B. Precast Elements

Provide precast walls (retaining walls and sound walls) from manufacturers certified by the National Precast Concrete Association (NPCA). Use Class AA concrete in accordance with Section 509, "Structural Concrete" for manufacturing precast wall elements.

C. Filter Fabric

Provide filter fabric in accordance with Subsection 712.03, "Geotextiles for Subsurface Drainage Purposes."

D. Granular Backfill for Mechanically Stabilized Earth (MSE) Walls

Provide granular backfill for MSE walls in accordance with Subsection 703.07, "Granular Backfill."

Provide backfill material with an internal friction angle of at least 34°. Determine the internal friction angle using the Standard Direct Shear Test in accordance with AASHTO T 236. Test portions of material that pass through a No. 10 [2 mm] sieve. At the optimum moisture content, compact a material sample to 95 percent in accordance with AASHTO T 99, Method C or Method D (with oversized correction). If at least 80 percent of sizes are greater than ¾ in [20 mm] sieve size, the Department does not require testing for backfills.

If using backfill material with steel soil reinforcement, provide backfill material that meets the following electrochemical requirements:

- pH of 5 to 10,
- Resistivity of ≤30 ohm meter,
- Chlorides: ≤100 ppm, and

- Sulfates: ≤200 ppm.

510.03 EQUIPMENT — VACANT

510.04 CONSTRUCTION METHODS

A. General

For earth retaining systems and noise barrier walls, use construction methods in accordance with Section 501, "Excavation and Backfill for Structures," Section 502, "Forms, Falsework, and Temporary Works," Section 509, "Structural Concrete," Section 511, "Reinforcing Steel for Structures," and Section 613, "Drainage Conduits."

The Department may allow alternative designs for earth retaining systems and sound barrier walls. Obtain the Engineer's approval of the working drawings before using an alternative design. The Department may allow the use of design methods for structure types or elements not covered by these specifications if documented in published literature, proven adequate through use by expert personnel performing the design for these walls, and if approved by the Engineer.

B. Working Drawings

Provide working drawings and design calculations for alternative earth retaining systems and noise barrier walls, or as required by the Contract. Submit drawings in accordance with Subsection 105.02, "Plans and Working Drawings," and include the following:

- Verification of existing ground elevations for structures involving construction in original ground;
- The layout of an effective retaining wall or noise barrier wall that maintains or surpasses the height and length required by the Contract;
- Design calculations proving that the design satisfies AASHTO *LRFD Specification* design parameters including internal, external, overall, and compound stability;
- Details of elements required for the construction of the system, including complete material specifications;
- Earthwork requirements for retaining walls, including specifications for material and backfill compaction;
- Details of revisions or additions to drainage systems or other facilities;
- Other information required by the Contract or requested by the Engineer;
- For concrete walls that require an architectural finish, show the layout and identify each piece of form liners; and
- Show the sequence of construction.

C. Backfill

Place backfill material within the lines shown on the Plans. Use the type of granular backfill for retaining walls required in the Contract.

D. Drainage

(1) Concrete Gutters

Construct concrete gutters to the profile required by the Contract or shown on the Plans. Provide drainage outlets at sags in the profile, the low points of the gutter, and other Contract required locations.

(2) Weep Holes

Construct weep holes at locations required by the Contract or shown on the Plans. Place at least 2 ft^3 [0.06 m^3] of coarse cover material for pipe underdrains encapsulated with filter fabric at the weep holes.

Cover joints with filter fabric between precast concrete retaining wall face panels that function as weep holes. Bond the filter fabric to the face panels in accordance with the manufacturer's recommendations. Dry the face panels, and clean off dust and loose materials before applying the filter.

(3) Drainage Blankets

Construct drainage blankets from the following materials:

- Coarse cover material for pipe underdrains encapsulated in filter fabric or filter sand,
- Collector pipes,
- Outlet pipes, and
- Cleanout pipes.

Before installing filter fabric, compact the subgrade to the Contract required density, and grade it to the elevation shown on the Plans. Remove material and sharp objects that could damage the fabric. Stretch and align the fabric. Smooth-out wrinkles. Overlap adjacent borders from 12 in to 18 in [300 mm to 450 mm]. Repair damaged fabric by covering the area with a piece of fabric that meets the overlap specifications.

Place coarse cover material in horizontal layers, and compact it. The Department will not allow ponding or jetting of the coarse cover material or adjacent backfill. When spreading and compacting, maintain at least 6 in [150 mm] of cover material between the construction equipment and the fabric.

Place perforated collector pipes in the cover material to the elevations shown on the Plans.

Place outlet pipes at sags in the flow line, the low ends of the collector pipes, and other Contract required locations.

Place cleanout pipes at the high ends of collector pipes and locations shown on the Plans.

(4) Geocomposite Drainage Systems

Install geocomposite drainage systems at the locations required by the Contract or shown on the Plans. Place and secure geocomposite drainage material against the excavated face, lagging, or back of wall as required by the Contract. Before placing concrete against geocomposite drainage material, protect the drainage material from damage and grout leakage.

E. Wall Systems

(1) Cast-in-place Concrete Walls

(a) *Architectural Finish*

If an architectural finish on the exposed wall surfaces is shown on the Plans, complete the following:

- Submit a sample of the form liner for Engineer approval, with working drawings.
- Use the least possible number of joints in the form liner.
- Discard and replace damaged form liner.

(b) *Retaining Wall Placement*

Unless otherwise required by the Contract, cast retaining walls with a 1 percent batter toward the backfill to compensate for wall deflection. Postpone backfilling until after casting and curing each section within a continuous section of wall in accordance with Section 509, "Structural Concrete."

(c) *Vertical Precast Concrete Wall Elements with Cast-in-Place Concrete Footings*

Support precast concrete wall elements to prevent vertical or horizontal displacement. Continue to support precast concrete wall elements until footing concrete has been placed, completely cured, and has sufficient strength to support precast concrete wall elements in accordance with Section 509.

(2) MSE Walls

Ensure the Engineer approves MSE retaining wall systems used on ODOT projects before use.

For MSE retaining walls, build a facing system. Connect steel or polymeric soil reinforcement to the facing system. Place structure backfill material around the reinforcement.

Design the MSE retaining walls in accordance with the current edition of the AASHTO LRFD *Standard Specifications for Highway Bridges*, the Contract, and Subsection 105.02, "Plans and Working Drawings." Use MSE retaining walls designed by a Registered Engineer in the State of Oklahoma.

Design MSE retaining walls for internal, external, overall, and compound stability. The design and analysis of MSE retaining walls with parapet walls or concrete railing must include the effects of rail load applied at the top of the rail parapet in accordance with the design specification.

Unless otherwise shown on the Plans, ensure the following for backfill design parameters for MSE retaining walls:

- A maximum friction angle of 34º when computing horizontal stress in the MSE mass,
- A cohesion of 0, and
- Unit weight of at least 120 lb/ft³ [2,000 kg/ m³].

If constructing an MSE precast retaining wall system in cut areas or hill sides with established piezometric levels, create a drainage blanket behind and beneath the stabilized zone if required by the Contract. For MSE structures, provide drainage to prevent saturation of the stabilized backfill, and intercept surface flows

with aggressive elements such as deicing chemicals. Ensure the shop drawings provided by the proprietary wall company show the drainage system, the intercept system, or both.

Allowable longitudinal differential settlements for mechanically stabilized earth structures are largely a function of panel size and joint design. The Department will allow differential settlements in the longitudinal direction of 1 percent for discrete modular panels less than 30 ft² [3 m²] in area with a design joint of at least ¾ in [19 mm]. Proportionally reduce the allowance for larger panels or for panels with smaller design joints. Allowable transverse differential settlements are a function of reinforcement length, size and ability of the panel connection to rotate. Control or limit the vertical movements between panel connection and the reinforcement to maintain allowable reinforcement yield strains.

Provide additional soil testing if required by the MSE retaining wall design and analysis. Submit a copy of these calculations, including shop drawings of the retaining wall, to the Engineer for review and approval.

The Department requires MSE walls to have a service life of at least 100 years. Design reinforcing elements with a metal area that correlates with the corrosion area expected over 100 years. Base the design section on the area defined by the following equation:

$$Ac = An - As$$

where

Ac = Area of design section,
An = Area of the original reinforcement, and
As = Area of the sacrificial section lost to corrosion.

Provide data for resistivity, pH, chlorides, and sulfates using Contract required test procedures for the sites.

Complete service life calculations in accordance with the Federal Highway Administration "Geotechnical Engineering Notebook," Chapter 5, Section 3, Section 4 for structures exposed to deicing salts. The increased chloride concentration will affect the upper 7.5 ft [2.3 m] of backfill measured from the roadway surface. Submit a copy of these service life calculations to the Engineer for review and approval.

(a)*Facing*

Provide facing made of precast concrete panels required by the Contract and shown on the Plans.

Provide a Class 2-Rubbed finish or the architectural treatment required by the Contract. Ensure the face not exposed to view has a uniform surface finish, no open aggregate pockets, and surface distortion of ¼ in [6 mm] or less. Locate and secure soil reinforcement connection hardware during concrete placement. Prevent contact between hardware and the facing reinforcing steel.

(b)*Soil Reinforcement*

Unless otherwise required by the Contract, galvanize steel reinforcement and steel connection hardware in accordance with AASHTO M 111.

Form facing mesh by bending the soil reinforcement mesh to 90º. Connect it to the soil reinforcing mesh above with a pre-bent tie.

Provide a backing mat made of 2 in × 6 in [50 mm × 150 mm], W1.7 × W1.7 welded wire fabric meeting ASTM A-185 and in accordance with Subsection 723.02, "Welded Steel Wire Fabric." Welded wire fabric to be shop fabricated from cold-drawn wire. Wire must conform with AASHTO M 32. Provide backing mat with a height 2 in [50 mm] smaller than the facing mesh height.

Retain soil by placing hardware cloth, with openings no greater than ¼ in, [6 mm] between the backfill and backing mat. Galvanize in accordance with AASHTO M 111. To avoid the loss of backfill fines, ensure the hardware cloth extends 3 in [75 mm] beyond the facing mesh height.

Inspect reinforcing and attachment devices to ensure they meet Contract size requirements with no defects.

Provide shop-fabricated reinforcing wire mesh made of cold drawn steel wire in accordance with Subsection 723.07, "Cold Drawn Steel Wire." Weld it into the finished mesh fabric in accordance with ANSI/AASHTO/AWS D 1.1, Structural Welding Code-Steel. Galvanize the fabricated mesh. Repair damage to mesh galvanization before installation. Provide a galvanized coating in accordance with AASHTO M 111.

Provide a High Density Polyethylene (HDPE) integrally formed grid structure as a soil reinforcement geogrid. Provide a geogrid with a high tensile modulus relative to the reinforced material, large apertures, thick ribs, and junctions to allow mechanical interlock with the reinforced material. Ensure the geogrid has a high continuity of tensile strength through the ribs and junctions of the structure. The geogrid must resist deformation under sustained long term load, ultraviolet degradation, and biological or chemical degradation in the reinforced material. The geogrid must at least meet the physical property requirements of Type 2 Subsection 712.07, "Geogrid Subgrade Reinforcement of Pavement Structures." Use ½ in [13 mm] diameter Schedule 80 polyvinyl chloride plastic pipe, ASTM D 1785, or a ½ in × ¼ in [13 mm × 6 mm] HDPE bar as connector pins at each geogrid splice.

Make tie strips of hot rolled steel Grade 50 [Grade 345] or equivalent in accordance with AASHTO M 270. Make 1-inch [25 mm] coil embed of cold drawn steel wire in accordance with AISI C1035. Galvanize in accordance with ASTM B 633. Fill the cavity of the coil embed with no-oxid grease, or an equivalent approved by the Engineer.

Provide a 1 in [25 mm] diameter coil bolt with 2 in [50 mm] of thread, cast of 80-55-06 ductile iron in accordance with ASTM A 536. Galvanize in accordance with ASTM B 633.

Ensure fasteners consist of hexagonal cap screw bolts and nuts, with a ½ in [13 mm] diameter, galvanized in accordance with AASHTO M 164.

Make connector pins and mat bars for the Reinforced Soil Embankment system from ASTM A 709 Grade 36 (AASHTO M 270). Weld to the soil reinforcement mats as shown on the Plans.

Cold form panel anchors of cold drawn wire in accordance with ASTM A 82 (AASHTO M 32). Galvanize anchors after forming.

Provide polymeric reinforcement of the type and size required by the Contract or shown on the working drawings. Provide connection hardware as required by the Contract or shown on the working drawings.

(c) ***Construction***

Install joint filler to the dimensions and thicknesses shown on the Plans.

Install 18 in [450 mm] wide strips of filter cloth on the back face of the panel, over the panel joints. To secure the cloth, apply an adhesive compound to the back face of the panel.

Provide and install one of the following:

- Preformed cork in accordance with AASHTO M 153 Type II,
- Preformed EPDM rubber pads in accordance with ASTM D 2000 for 4AA, 812 rubbers, or
- Neoprene (polychloroprene) elastomeric pads with a Durometer Hardness from 50 to 60 in horizontal joints between panels.

Grade the structure foundation level for a width at least the length of reinforcement elements, plus 1 ft [300 mm], or as shown on the Plans. Before constructing the wall, compact the foundation using two passes of a vibratory drum compactor except where the wall is constructed on rock. Replace unacceptable foundation soils below the footing elevation with concrete or Controlled Low-Strength Material (CLSM) at no additional cost to the Department. Provide the type of a cast-in-place unreinforced concrete leveling pad at each panel foundation shown on the Plans. Cure the leveling pad for at least 12 hr before placing wall panels. Provide the pad with at least 2 ft [600 mm]of backfill cover.

Ensure a field representative from the chosen proprietary wall system is available during wall erection. Provide the representative's services at no additional cost to the Department.

During erection, handle panels with lifting devices connected to the upper edge of the panels. During backfill placement, place panels in successive horizontal lifts in the sequence shown on the Plans. When placing backfill material behind the panels, hold the panels in a vertical position with temporary wedges or bracing in accordance with the recommendations of the wall supplier. For structures with precast facing panels, ensure that concrete vertical tolerances and horizontal alignment tolerances do not exceed ¾ in [18 mm] when measured with a 10 ft [3 m] straight edge. During construction, prevent panel offset from surpassing ¾ in [18 mm].

Maintain an overall vertical wall tolerance of no more than ½ in [12.5 mm] per 10 ft [3 m] in height. Check the plumb and tolerances of the panel row at the face before erecting the next panel row. For panels that do not meet the Contract required tolerances, remove the backfill and reset the panels. Ensure uniform horizontal, vertical, and slope joints with openings between panels from½ in to 1¼ in [13 mm to 30 mm] wide. Place reinforcement elements

normal to the wall face, unless otherwise shown on the Plans. Before placing the reinforcing elements, compact backfill as specified by the backfill placement procedures shown on the Plans.

Place backfill immediately after erecting each course of panels. Do not damage or disturb the wall materials, or misalign the facing panels. Replace damaged wall materials at no additional cost to the Department. Correct misalignment or distortion from placing backfill outside the Contract required limits at no additional cost to the Department. Compact backfill to 95 percent of the maximum density in accordance with AASHTO T 99, Method C or Method D (with oversize correction as specified in Note 7), or as shown on the Plans. Before and during compaction, uniformly distribute the moisture of the backfill material throughout each layer. Remove and rework backfill material with a placement moisture content greater than optimum.

Place backfill layer in 6 in [150 mm] or less lifts. Use a lightweight mechanical tamper, roller, or vibratory system for compaction within 3 ft [1 m] of the backface of the wall using at least three passes.

At the end of each work day, slope the last level of backfill away from the wall to direct runoff. Prevent surface runoff from entering the wall construction site.

F. Slopewalls

Construct slopewalls in accordance with Section 610, "Concrete or Bituminous Sidewalks, Driveways, Dividing Strip, and Tactile Warning Devices." The Department will not allow the placement of horizontal construction joints in the slopewalls. Space vertical construction joints less than 10 ft [3 m], measured along the top of slopewall. The Engineer will determine the final number and location of construction joints in the field.

G. Sound Barrier Walls

(1) Cast-in-Place Sound Barrier Wall

Construct cast-in-place sound Barrier walls in accordance with Section 509, "Structural Concrete," Section 511, "Reinforcing Steel for Structures," and Section 516, "Drilled Shaft Foundations."

If an architectural finish on the exposed wall surfaces is shown on the Plans, complete the following:

- Submit a sample of the form liner for Engineer approval, with working drawings.
- Use the least possible number of joints in the form liner.
- Discard and replace damaged form liner.

(2) Pre-cast Sound Barrier Walls

Design the Pre-cast Sound Barrier Walls in accordance with the current edition of the AASHTO Guide Specification for Structural Design of Sound Barriers, the Contract, and Subsection 105.02, "Plans and Working Drawings." Use pre-cast sound barrier walls designed by a Professional Engineer registered in the State of Oklahoma.

Ensure the Engineer designed the pre-cast sound barrier walls for external and internal stability.

Construct pre-cast sound barrier wall in accordance with Section 509, “Structural Concrete,” Section 511, “Reinforcing Steel for Structures,” and Section 516, “Drilled Shaft Foundations.”

The Department will allow a final tolerance of ⅛ in per 12 in for level and plumbness.

510.05 METHOD OF MEASUREMENT

The Engineer will measure the area of *Retaining Wall*, *Sound Barrier Wall*, and *MSE Retaining Wall* from the top of footing to the wall top.

The Engineer will measure the area of *Slopewall* in accordance with the dimensions shown on the Plans.

510.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) RETAINING WALL	Square Yard [Square Meter]
(B) SOUND BARRIER WALL	Square Yard [Square Meter]
(C) SLOPEWALL	Square Yard [Square Meter]
(D) MSE RETAINING WALL	Square Yard [Square Meter]
(E) GEOCOMPOSITE WALL DRAIN	Square Yard [Square Meter]

The Department will consider the cost of the following to be included in the contract unit price for relevant wall pay item:

- Engineering and associated costs,
- Excavation,
- Backfill,
- Backfill material,
- Concrete,
- Reinforcing steel,
- Form liners,
- Perforated pipe underdrain,
- Geocomposites,
- Filter fabric,
- Pipe underdrain cover material,
- Concrete surface finish, and
- Sheeting and shoring.

The Department will pay for drilled shafts and piling required by the Contract in accordance with Section 516, "Drilled Shaft Foundations," and Section 514, "Driven Foundation Piles," respectively.

SECTION 511
REINFORCING STEEL FOR STRUCTURES

511.01 DESCRIPTION

This work consists of providing and placing reinforcing steel.

511.02 MATERIALS

A. General

Provide reinforcing steel consisting of deformed bars, epoxy-coated deformed bars, and cold-drawn wire mesh. Provide reinforcing steel in accordance with Section 723, “Reinforcing Steel.” Ensure the strength requirements are in accordance with Grade 60 (420), unless otherwise required by the Contract. Provide cold-drawn wire for spiral ties and other reinforcing designated in W (wire) sizes.

B. Bar Lists and Bending Diagrams

Use the bar list and bending diagrams in the Contract to estimate quantities. Ensure bent bars are dimensioned out-to-out. Before ordering, verify and correct the quantity, size, and shape of the bar reinforcement.

If the bar list and bending diagram are not included in the Plans, create and submit them for the Engineer’s approval in accordance with Subsection 105.02, “Plans and Working Drawings.” Obtain the Engineer’s approval before constructing vertical reinforcement in columns, walls, and piers.

C. Fabrication

(1) Bending

Fabricate reinforcing bars in accordance with ACI 318 (318M). Cold-bend reinforcing bars unless otherwise required by the Contract. If the Engineer allows heating for field bending reinforcing bars, ensure the physical properties of the steel remain unaltered. Do not bend bars partially embedded in concrete unless otherwise required by the Contract.

(2) Hook and Bend Dimensions

If the hook dimensions or the bend diameters are not shown on the Plans, provide hooks in accordance with ACI 318 (318M).

(3) Identification

Ship bar reinforcement in standard bundles, tagged and marked in accordance with CRSI *Manual of Standard Practice*.

511.03 EQUIPMENT — VACANT

511.04 CONSTRUCTION METHODS

A. Protection of Material

(1) General

Store reinforcing steel on platforms or skids. Protect steel from damage.

Use clean reinforcing steel meeting the minimum dimensions, cross-sectional area, and tensile properties in accordance with the Contract required steel size and grade. Use reinforcing steel that is not cracked, laminated, or contaminated with deleterious material. Leave thin, powdery rust and tight rust that does not affect the cross section.

(2) Epoxy Coated Reinforcing

Support coated bars on pads. Pad bundled bands. Lift bars using a strong back, multiple supports, or a platform bridge. Prevent bar-to-bar abrasion. Avoid dropping or dragging bundles.

Before placement, inspect the bars for coating damage. Clean damaged areas by removing contaminants and damaged coating. Remove rust by blast-cleaning or power-tool-cleaning. Roughen the areas, then patch the defects with prequalified patching, or repair in accordance with AASHTO M 284. After placement, clean and patch new damage.

Treat the damaged bars as specified by the resin manufacturer, before oxidation occurs. Overlap the original coating with the patching material by 2 in [50 mm], or as recommended by the manufacturer. Provide a dry film thickness at least 8 mil [200 mm] thick on the patched areas.

Replace bars with severely damaged coatings. The Department considers severely damaged coating as a coating with damage to at least 18 in [450 mm] of the bar length and 5 percent of the surface area. Coat mechanical splices after splice installation in accordance with AASHTO M 284 for patching damaged epoxy coatings.

B. Placing and Fastening

(1) General

Place reinforcing steel in the positions required by the Contract. While placing concrete, use supports to firmly hold the reinforcing steel in place. The Department will not allow spot-welding of reinforcing steel.

Measure the spacing of parallel bars from center to center. For circular cages, measure along the curve. For concrete clearance, measure the distance from the concrete face to reinforcing steel.

Space parallel bars, center to center, from two and one-half times the bar diameter to one and one-half times the maximum nominal size of the concrete coarse aggregate plus one bar diameter.

For bridge decks, place reinforcing steel within ¼ in [6 mm] of the location shown on the Plans. For slabs and walls less than 12 in [300 mm] thick, place reinforcing steel within ½ in [12 mm] of the location shown on the Plans. Provide 2 in [50 mm] of clear cover, measured perpendicular to the nearest concrete

surface, for reinforcement unless otherwise specified in the Contract. For structure elements in direct contact with the ground, such as footings, abutments, retaining walls, and piers, provide 3 in [75 mm] of clear cover.

Space parallel bars within 1½ in [40 mm] of the Contract required spacing. The Engineer will not accept cumulated spacing variations. Ensure the average of the spaces between two adjacent spaces does not exceed the Contract required spacing.

For mats and cages, tie reinforcing bars at intersections. If spacing is less than 12 in [300 mm] in both directions, tie alternate intersections. Tie intersections around the perimeter of a mat. Tie intersections of the last stirrup, hoop, or complete turn of a spiral at both ends of a cage.

Tie bundle bars together at intervals no greater than 6 ft [2 m]. Bundle bars only if the location and splice details are required in the Contract. Use plastic-coated ties to tie epoxy-coated bars.

Obtain Engineer approval before placing concrete reinforcement.

(2) Support System

Support reinforcing steel with mortar blocks, wire bar supports, supplementary bars, or other approved devices. Use enough supports to maintain the bar position within tolerances. Space slab bar supports no more than 4 ft [1.2 m] apart, transversely or longitudinally. The Department will not allow the use of reinforcing steel or bar supports to carry equipment and platforms for workers.

(3) Mortar Blocks

Use mortar blocks with the same color and texture as the poured concrete encasing the mortar block. Provide mortar blocks with a compressive strength equal to or greater than that of the poured concrete encasing the mortar block. For blocks in contact with the forms, make the face of the blocks no bigger than 2 in × 2 in [50 mm × 50 mm]. Attach concrete block supports to the bar with 14 gauge [2 mm] wire cast in the center of each block. If supporting epoxy-coated reinforcing, use plastic or epoxy-coated wire.

(4) Wire Supports

If using wire supports, use ferrous metal chairs and bolsters in accordance with the CRSI *Manual of Standard Practice*. Use Class 1 plastic-protected, Class 1 Type A epoxy-coated, or Class 2 Type B stainless-steel-protected metal supports in contact with exposed concrete surfaces and metal deck forms. Use stainless steel supports in accordance with ASTM A 493, Type 430. Use a dielectric material to coat chairs, tie-wires, and other devices that support, position, or fasten epoxy-coated reinforcement. Use plastic supports only for prestressed concrete bridge members.

C. Splices

(1) General

Provide reinforcing steel in lengths required by the Contract. Unless otherwise required by the Contract, obtain written approval by the Engineer before splicing, except for splices of No. 4 [No. 13] or smaller bars.

(2) Lapped Splices

Provide lap lengths as shown on the Plans. Splice reinforcing bars at locations shown on the Plans. Stagger splices if possible. Do not place slab bar mechanical splices next to each other. Make lapped splices by wiring the reinforcing bars together to maintain their position. The Department will not allow lap splicing of bars larger than No. 11 [No. 36] bars; use welded or mechanical splices approved by the Engineer.

(3) Mechanical Splices

If shown on the Plans, use mechanical couplers with at least 125 percent of the Contract required yield strength of the reinforcing steel.

When directed by the Engineer, remove and test two of every one hundred coupler splices installed to verify the capacity. The Engineer will randomly select the splices for testing.

(4) Splicing of Mesh

For welded wire fabric shipped in rolls, flatten the fabric before placement. Splice sheets of mesh or bar mat reinforcement by overlapping at least one mesh width plus 2 in [50 mm]. Securely fasten at the ends and edges.

511.05 METHOD OF MEASUREMENT

The Engineer will measure reinforcing steel in the concrete based on the total calculated weight [mass] for the sizes and lengths of bars, wire, or welded wire fabric required by the Contract.

The Engineer will calculate the weight [mass] of plain or epoxy-coated reinforcing bars in accordance with Table 511:1, “Reinforcing Bar Weights.” The Engineer will calculate the weight [mass] of reinforcing wire, welded wire fabric, and plain bar of sizes other than those listed in Table 511:1.

Table 511:1
Reinforcing Bar Weight[Mass]

Bar Designation, ***No.(English [metric])***	**Nominal Weight [Mass],** ***lb/ft [kg/m]***
3 [10]	0.376 [0.560]
4 [13]	0.668 [0.994]
5 [16]	1.043 [1.552]
6 [19]	1.502 [2.235]
7 [22]	2.044 [3.042]
8 [25]	2.670 [3.973]
9 [29]	3.400 [5.060]
10 [32]	4.303 [6.404]
11 [36]	5.313 [7.907]
14 [43]	7.650 [11.380]
18 [57]	13.600 [20.240]

The Engineer will not measure the following:

- Weight [mass] of reinforcing steel if the weight [mass] has been included in the weight [mass] of structural members using reinforcing steel,
- Weight [mass] of epoxy coating to calculate the weight [mass] of epoxy-coated reinforcing steel, and

- Weight [mass] of reinforcing steel, placed for the convenience of the Contractor, that exceeds the plan quantity for *Reinforcing Steel* and *Epoxy Coated Reinforcing Steel*.

511.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) REINFORCING STEEL	Pound [Kilogram]
(B) EPOXY COATED REINFORCING STEEL	Pound [Kilogram]

If not included in the measurement of the relevant structural steel pay item, the Department will consider the cost of threaded bars or dowels, placed after the installation of precast members to attach members to cast-in-place concrete, to be included in the contract unit price for *Reinforcing Steel*.

The Department will consider the cost of material for fastening the reinforcement to be included in the contract unit price for *Reinforcing Steel*.

The Department will consider the cost of authorized additional steel, required for splices or reinforcement not required by the Contract, to be included in the contract unit price for *Reinforcing Steel* and *Epoxy Coated Reinforcing Steel*.

SECTION 512
PAINTING

512.01 DESCRIPTION

A. General

This work consists of preparing surfaces, applying and curing paint, and protecting the work facilities, vehicles, public, and environment from damage.

B. References, Definitions, and Abbreviations

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). CERCLA is commonly referred to as "Superfund."

Code of Federal Regulations (CFR). To obtain a copy, contact:

Superintendent of Documents
General Printing Office
Washington, D.C. 20402
Telephone (202) 783-3238

Comply with the CFR, including but not limited to the following titles:

- 29 CFR 1910, "Occupational Safety and Health Standards,"
- 29 CFR 1926, "Safety and Health Regulations for Construction,"
- 29 CFR 1926.62, "Lead,"
- 40 CFR 50, App. B, "Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method),"
- 40 CFR 50, App. J, "Reference Method for Determination of Particulate Matter as PM-10, in the Atmosphere,"

- 40 CFR 50.6, “National Primary and Secondary Ambient Air Quality Standards for Particulate Matter,”
- 40 CFR 50, App. G, “Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air,”
- 40 CFR50.12, “National Primary and Secondary Ambient Air Quality Standards for Lead,”
- 40 CFR 261, “Identification and Listing of Hazardous Waste,”
- 40 CRF 262, “Standard Applicable to Generations of Hazardous Waste,”
- 40 CFR 263, “Standards Applicable to Transporters of Hazardous Waste,”
- 40 CFR 268, “Land Disposal Restrictions,”
- 40 CFR 300, “National Oil and Hazardous Substances Pollution,”
- 40 CFR 302, “Designation, Reportable Quantities, and Notification,”
- 49 CFR 172, “Hazardous Materials Tables, Hazardous Materials Communications Requirements, and Emergency Response Information Requirements,”
- 49 CFR 173, “Shippers: General Requirements for Shipments and Packaging,” and
- 49 CFR 178, “Shipping Container Specifications.”

Chain of Custody Form. A form to identify environmental, paint, and waste samples. Includes signatures and dates from the time of sampling through transportation, receipt at the laboratory, and testing.

Deleading. The removal and elimination of lead-based paint or lead-based paint contaminated materials.

Hazardous Waste. When waste samples from Toxicity Characteristics Leaching Procedure (TCLP) tests contain the listed elements with quantities meeting or exceeding the concentration limits specified in Table 512:1, the Department will consider this material as hazardous waste. Other materials, such as chemical strippers, solvents, or thinners can make a waste hazardous as defined in 40 CFR 261.

Table 512:1
Concentration of Hazardous Elements

Hazardous Elements	Maximum Concentration, *[ppm]*
Arsenic	5.0
Barium [a]	100.0
Cadmium [a]	1.0
Chromium [a]	5.0
Lead [a]	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0

[a] Elements found some paints. Some abrasives contain arsenic or other hazardous elements.

High Efficiency Particulate Air (HEPA) Filters. A filter that removes at least 99.97 percent of particles with a diameter of at least 0.3 microns.

Manifest. The shipping document U.S. EPA (Environmental Protection Agency) Form 8700-22 and, if necessary, U.S. EPA Form 8700-22A (continuation sheet).

Manifest Document Number. The U.S. EPA twelve-digit identification number assigned to the generator, and a unique five-digit document number that the generator assigns to the manifest for recording and reporting.

Oklahoma Administrative Code (OAC) 252:205-Hazardous Waste Management

Oklahoma Administrative Code (OAC) 252:515 Management of Solid Waste, specifically subchapter 31.

Occupational Safety and Health Administration (OSHA)

Oklahoma Department of Environmental Quality (DEQ)

Permissible Exposure Limit (PEL). Employee exposure, without regard to respirator use, to an airborne concentration in micrograms per cubic meter of air (μg/m³), calculated as an 8 hr Time-Weighted Average (TWA). The PEL for lead is 50 μg/m³ as an 8 hr TWA. If an employee works for longer than 8 hr in a given day, adjust the PEL in accordance with the following equation:

$$APEL = \frac{PEL \times 8}{T}$$

where

$APEL$ = Adjusted permissible exposure limit,
PEL = Permissible exposure limit, and
T = Time worked in the day (hours).

Product Data Sheet (PDS). The manufacturer's published recommendations for use, properties, and characteristics.

Resource Conservation and Recovery Act (RCRA).

Reportable Release of Lead. A discharge of at least 10 lb [4.5 kg]of lead into the atmosphere, water, or soil within a 24 hr period in accordance with 40 CFR 262, 40 CFR 265, 40 CFR 300, and 40 CFR 302, or CERCLA.

Representative Sample. A sample exhibiting average properties of the material being sampled.

The Society for Protective Coatings (SSPC). Formerly Steel Structures Painting Council. Direct inquiries to the following address:

SSPC
40 24th Street
Pittsburgh, PA 15222-4643
Telephone (412) 281-2331

Referenced SSPC Standards, Guides and Specifications:

- SSPC-SP 1, "Solvent Cleaning,"
- SSPC-SP 2, "Hand Tool Cleaning,"
- SSPC-SP 3, "Power Tool Cleaning,"
- SSPC-SP 10/NACE 2, "Near-White Blast Cleaning,"
- SSPC-SP 11, "Power Tool Cleaning to Bare Metal,"
- SSPC-SP 12/NACE 5, "Surface Preparation and Cleaning of Steel and Other Hard Materials by High and Ultrahigh Pressure Water Jetting Prior to Recoating,"
- SSPC-SP 15, "Commercial Grade Power Tool Cleaning,"

- SSPC AB1, "Mineral And Slag Abrasives,"
- SSPC AB2, "Specification for Cleanliness of Recycled Ferrous Metallic Abrasives,"
- SSPC AB3, "Newly Manufactured or Re-Manufactured Steel Abrasives,"
- SSPC-VIS 1, "Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning,"
- SSPC-VIS 2, "Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces,"
- SSPC-VIS 3, "Visual Standard For Power- and Hand-Tool Cleaned Steel,"
- SSPC-VIS 5/NACE VIS 9, "Guide and Reference Photographs for Steel Surfaces Prepared by Wet Abrasive Blast Cleaning,"
- SSPC-TU 7, "Conducting Ambient Air, Soil, and Water Sampling During Surface Preparation and Paint Disturbance Activities,"
- SSPC Guide 3 – A Guide for Safety in Paint Application,
- SSPC Guide 16, "Guide to Selecting and Specifying Dust Collectors," and
- SSPC Guide 6, "Guide for Containing Debris Generated During Paint Removal Operations," describes methods of paint removal, containment systems, and procedures for preventing emissions from escaping the work area and for assessing emissions control. Use the following class definitions from Table 512:2.

Table 512:2
SSPC Guide 6 Containment Classes

Class	Definition
2A	Abrasive blast-cleaning containment that consists of air-impenetrable walls with rigid or flexible framing, fully sealed joints, resealable or overlapping entryways, forced or natural air flow (negative pressure verified visually), and exhaust air filtration.
3A	Abrasive blast-cleaning containment that consists of walls with rigid or flexible framing, full or partially sealed joints, open seam entryway, forced or natural airflow and exhaust air filtration.
4A	Abrasive blast-cleaning containment that consists of air-penetrable walls with flexible framing, open seams and entryways, and natural airflow.
2W	Wet preparation method containment that consists of water-impermeable walls and floors with rigid or flexible framing, fully sealed joints, overlapping entryways, and natural airflow.
3W	Wet preparation method containment that consists of water-impermeable walls and floors with minimal framing, partially sealed joints, open seam entryways, and natural airflow.
2C	Chemical stripping containment that consists of water-impermeable and chemical resistant walls and floors with rigid or flexible framing, fully sealed joints, overlapping entryways, and natural airflow.
3C	Chemical stripping containment that consists of water-impermeable and chemical-resistant walls and floors with minimal framing, partially sealed joints, open seam entryways, and natural airflow.

Table 512:2 SSPC Guide 6 Containment Classes	
Class	**Definition**
2P	Hand or power tool cleaning containment that consists of air-impenetrable or air-penetrable walls, rigid or flexible framing, fully sealed joints, overlapping or open entryway, and natural airflow.
3P	Hand or power tool cleaning containment that consists of air-penetrable walls with minimal framing, partially sealed joints, open seam entryways, and natural air flow.

Subtitle C Landfill. A landfill for disposing hazardous waste, in accordance with OAC 252:205 Hazardous Waste Management Regulations, incorporating 40 CFR 260-279 and Subtitle C of the RCRA.

Subtitle D Landfill. A landfill for disposing non-hazardous waste, in accordance with OAC 252:515 Solid Waste Management Regulations.

Toxicity Characteristic Leaching Procedure (TCLP) Test. EPA Method 1311 in SW 846, "Test Methods for Evaluating Solid Wastes".

Total Suspended Particulate (TSP). Term used in the collection of airborne particles using high-volume ambient air samples. Filters are typically analyzed for lead (40 CFR 50 Appendix B and Appendix G).

Treatment. A process designed to change the physical, chemical or biological characteristics or composition of any hazardous waste to neutralize or make non-hazardous.

Waste Generator. The Contractor and the Department are waste generators or co-generators when hazardous paint is removed. Under co-generator status, both parties are permanently responsible for the waste and Resource Conservation and Recovery Act (RCRA) compliance.

Water Booms. Long, narrow tubes less than 1 ft [300 mm] in diameter that are linked together to create a floating containment wall on water.

512.02 MATERIALS

Provide paint in accordance with Section 730, "Paint for Structural Steel."

512.03 EQUIPMENT

Provide surface preparation and coating application equipment. Include mixing equipment for paint system components and pot agitation for zinc-rich coatings as the manufacturer specifies. Provide calibrated coating inspection instruments for quality control measurements. Provide compressed air for abrasive blast cleaning, conventional spray application, or blowing down surfaces. Ensure compressed air used for abrasive blast cleaning, conventional spray application or blowing down surfaces does not contain oil, moisture, black spots, and wet spots when tested in accordance with ASTM D 4285.

Provide equipment to recycle abrasives when the area to be painted is more than 5,000 ft² [465 m²].

512.04 CONSTRUCTION METHODS

A. General Requirements

(1) Contractor Qualifications

If the Contract requires SSPC-QP 2 certification, "Standard Procedure for Evaluating Qualifications of Contractors to Remove Hazardous Paint from Industrial Structures," submit a current SSPC-QP 2 certificate, Category A, for abrasive blasting, water blasting, or water jetting, and Category C for chemical stripping or power tool cleaning. Refer to Table 512:3 for definitions of the categories. Submit SSPC certificates while submitting the Proposal including a statement that removal technique will be consistent with the SSPC-QP 2 certification category. Work with personnel in accordance with SSPC QP-2 and SSPC QP-1, "Standard Procedure for Evaluation of Qualifications of Painting Contractors." The Engineer will not require SSPC certifications for projects with painting areas less than 500 ft² [50 m²]. Refer to Subsection 512.04.B(2), "Paint Systems," for definitions of paint system categories.

Table 512:3
SSPC-QP 2 Certification Categories

Category	Type of Work
A	Abrasive blasting, water-blasting and water-jetting within containments in accordance with Class 1A, Class 2A or Class 1W of SSPC Guide 6.
C	Chemical stripping and power tool-cleaning within containment in accordance with Class 1C or Class 1P of SSPC Guide 6.

(2) Submittal Requirements

The Engineer does not require a work plan if the Contract requires painting an area smaller than 500 ft² [50 m²], but regulatory agencies may require written plans and programs.

(a) *Work Plan*

At least 14 calendar days before beginning surface preparation, submit a written plan to the Engineer for review and acceptance that details the methods of conducting and inspecting the work, and of protecting the environment, public, adjacent property, and workers. Make the plan available to state and federal agencies.

1) *Material Safety Data Sheet (MSDS) and Product Data Sheet (PDS)*

Include the following in the work plan if required by the Contract:

- The MSDS for cleaning and painting products, and
- The PDS for the coatings and abrasives.

Submit the MSDS for chemical solutions of any cleaning agents to the Engineer to obtain approval before using any chemical solutions.

2) *Paint Removal and Painting Plan*

Include the following in the work plan if required by the Contract:

- Methods for removing paint and applying the new coat,

- Methods for chloride removal, stripe coats, inhibitors, and weld and edge preparation,
- Certification from the abrasive supplier that the abrasives are in accordance with SSPC-AB1, SSPC-AB2, or SSPC-AB3,
- A copy of the paint manufacturer's written statement approving the cleaning method, abrasive, and additives, and
- A description of the cleaning method.

3) *Chemical Strippers*

Obtain permission from the Engineer to use chemical stripping materials.

4) *Quality Control (QC)*

Include the following in the work plan as appropriate:

- Written QC procedures for surface preparation and paint application,
- Copies of documentation forms used for QC, and
- Qualifications of personnel responsible for QC.

5) *Containment Design*

Include the following in the work plan if required by the Contract:

- Surface preparation methods,
- Containment design for surface preparation and clean-up activities,
- Data, calculations, and assumptions for the containment and ventilation system design,
- Methods that verify air flow characteristics and negative pressure within containment,
- Plan for staging, installing, moving, and removing the containment,
- Methods of attachment,
- Provisions for moving the containment in inclement weather,
- Provisions for moving the containment out of navigation lanes if working over active waterways,
- Plans for containing debris in the event of an unintended spill,
- Plans for maintaining existing equipment and facilities, including lighting and,
- When the containment design includes suspended platforms or scaffolding for support, provide calculations showing the design is in accordance with the OSHA Scaffold Standards, 29 CFR 1926.450-453.

If the length of the span required by the Contract for containment exceeds 100 ft [30 m] or consists of a truss structure, provide an evaluation of loads and stresses to the bridge which includes additional loads from the containment system dead and wind loads, erection loads, blast waste loads, worker and equipment live loads plus normal bridge loads. Perform computations in accordance with the AASHTO *LRFD Bridge Design Specifications.*

Ensure professional engineers registered in Oklahoma stamp the drawings.

Notify agencies, including the Coast Guard, Corps of Engineers, and Railroad, of right-of-ways, containment clearances, and project restrictions.

6) *Waste Management Plan*

Include the following in the Waste Management Plan:

- Types of waste generated by cleaning and painting;
- Description of the following waste procedures:
  - Sampling and testing (including how sampling is representative),
  - Collecting,
  - Handling,
  - Treating,
  - Storing, and
  - Transporting, treating, and disposing;
- Documentation;
- Clearance-testing after project completion;
- Proposed on-site storage location;
- The following company information for the waste transporter and disposal facilities:
  - Name,
  - Address,
  - Contact name, and
  - Phone number for the waste transporter and disposal facility;
- EPA Identification Number (for large and small quantity generator projects);
- Licenses;
- Permits; and
- Certifications.

7) *Waste Disposal Documentation*

Before transporting hazardous waste, submit the following to the Engineer:

- A complete Oklahoma DEQ Land Protection Division Disposal Plan Application for large quantity generator projects,
- Laboratory test results,
- Waste classification statement, and
- Hazardous Waste Manifests.

List the Co-Generators on the Waste Manifest. Sign the Manifest at the time of transportation. Perform and document the handling, disposal, and notifications as required by the Contract. Provide Non-Hazardous Waste Manifests to document quantity and disposal.

8) *Worker Protection Plan*

Submit to the Engineer a Worker Protection Plan that proposes safety measures to protect workers from site hazards in accordance with OSHA. For sites with lead, submit a site-specific lead compliance program in accordance with 29 CFR 1926.62. Include descriptions of the following in the Worker Protection Plan:

- Hygiene facilities,
- Employee training,

- Design,
- Operation,
- Maintenance of engineering controls,
- Demarcation of regulated areas,
- Medical surveillance, and
- Measures to reduce exposure to lead and other hazardous materials.

9) *Environmental Compliance Plan*

Include the following in the Environmental Compliance Plan:

- Methods to ensure ambient air, soil, and water/sediment quality,
- A report of hazardous materials, hazardous waste, or both released,
- Calibration records,
- Monitoring methods and locations,
- Testing frequency,
- Laboratory for analysis,
- Data-recording methods, and
- Locations where soil samples will be taken in accordance with 512.04(A)(3)(a)1), "Soil Sampling."

10)*Laboratory Services*

For environmental and waste analysis, use a laboratory certified by the Oklahoma DEQ. Provide the name, address, phone number, contact person, and certifications for the laboratories.

For metals analysis, use an American Industrial Hygiene Association (AIHA) accredited laboratory for worker monitoring which participates in the AIHA Environmental Lead Laboratory Accreditation Program (ELLAP) or EPA National Lead Laboratory Accreditation Program (NLLAP).

Provide documentation of the Contract required laboratory certifications.

11)*Certification*

Provide a written certification stating that methods of waste management storage, treatment and disposal, or both are legal and conform to federal, state, and local regulations, and the Contract.

12)*Documentation*

Record samples, waste types and quantities, airborne emissions, and batch numbers of coating. Include dates and the name of the person recording the information. Make these logs available to the Engineer.

13)*Reporting*

Report ambient air monitoring within 72 hr after testing. Report other samples on the laboratory results within 10 days after test submission. Include the following:

- The laboratory report, including QA/QC verification,
- A table of results,
- Chain of custody forms,
- Distribution,

- Identification for test results that exceed specified or regulatory limits, and
- Corrective measures taken.

14)*Painting Structural Steel*

Inform the Engineer in writing at least one week before beginning field cleaning and painting.

15)*Schedule*

Submit a schedule for the Project. Include key tasks such as:

- Rigging and erecting containment,
- Surface preparation,
- Waste collection and sampling,
- Primer application,
- Intermediate and topcoat,
- Containment movement,
- Removing containment,
- Waste transportation, and
- Final inspection.

Update the schedule every 30 days, or if requested by the Engineer.

(b)*Department Acceptance*

Department acceptance of the submittals does not imply approval. Conduct the work in accordance with federal, state, or city regulations, and protect the health and safety of workers, inspectors and the public. Provide scaffolding in accordance with 29 CFR 1910.28 for inspection of surface preparation, profile, chloride content mill thickness, and other items as determined by the Engineer.

Stop work to correct procedures that do not yield Contract performance requirements.

(3)Protection of Public, Property, and Workers

(a)*General*

Maintain containment systems and ground covers to prevent the escape of debris, including paint chips. If spills or releases occur, immediately shut down the emissions-producing operations, clean up the debris, and take corrective actions to prevent similar releases from occurring.

Collect debris from the ground by hand and HEPA vacuuming. Use water booms, boats with skimmers, or other means to remove debris that falls into the water. Provide ground covers at any location where debris is stored, transferred or released.

Ensure the work site is clear of visible surface preparation or paint debris at the end of each work day.

At Project completion, clean the Project ground and water and the surrounding areas of paint chips, paint removal media, fuel, construction materials, litter, and debris, even if the material was a pre-existing condition.

(b)*Protection Requirements for Cleaning Existing Steel Bridges*

Comply with the following requirements for projects involving cleaning steel bridges:

1) Soil Sampling

Collect the pre-job and post-job soil samples in the Engineer's presence in accordance with SSPC-Guide 6, Subsection 5.5.5, Method E-Soil Analysis for Toxic Metals. Provide the Engineer with splits of the samples and a chain of custody form. Submit test results from a DEQ-certified laboratory within two weeks of collection. Clean the soils if the geometric mean of the post-job soil test results exceeds 100 ppm or two standard deviations, whichever is greater, higher than the geometric mean of the pre-job soil test results.

2) Airborne Emissions Monitoring

While removing the paint, monitor the air in accordance with Table 512:4, "Airborne Emissions Monitoring," and SSPC TU-7. The Department does not require ambient air monitoring for Category R projects with a surface area less than 300 ft² [30 m²], except in the presence of hazardous materials. When hazardous materials are present, complete Category R projects in accordance with Visible Emissions Level 2 for Project Situation 1.

Table 512:4
Airborne Emissions Monitoring

Project Situation	Methods Required
1. Project located within 300 ft [100 m] or two times the bridge height, whichever is greater, of inhabited buildings or areas frequented by the public.	Method A: Visible Emissions, Level 1 and Ambient Method B: Air Monitoring for PM-10 Method D: TSP-Lead in lieu of PM-10 in the presence of lead paint.
2. Projects involving hazardous materials located beyond 300 ft [100 m] or two times the bridge height, whichever is greater, for inhabited buildings or areas frequented by the public.	Method A: Visible Emissions, Level 2.
3. Projects involving non-hazardous materials and located beyond 300 ft [100 m] or two times the height of the bridge, which ever is greater, from inhabited buildings or areas frequented by the public.	Method A: Visible Emissions, Level 3.

For Method A monitoring, the Department defines the boundary of the emissions as the edge of the containment system and around dust collectors, abrasive recycling equipment and any areas where waste is handled. Discontinue operations and correct the problem if emissions exceed the

cumulative duration limits specified in Section 5.5, Guide 6 over each hour period. For Level 1 emissions, do not exceed 1 percent of the work day (e.g. five minutes in an eight hour work day).

For Method B, PM-10 monitoring, discontinue operations and correct the problem if emissions exceed 150 μg/m³ over a 24 hr period (40 CFR 50 Appendix B). Use an Adjusted Daily Average (ADA) if calculating in accordance with SSPC formulas in Guide 6, as directed by the Engineer.

For Method D monitoring, discontinue operations and correct the problem if emissions exceed 1.5 μg/m³ in a 24 hr period or a daily allowance of 4.5 μg/m³ TSP-Lead (40 CFR 50.12) over an 8 hr average work shift. Use an ADA if calculating in accordance with SSPC formulas in Guide 6, as directed by the Engineer.

Report PM-10 and TSP-Lead test results within 72 hr of sampling for the first week of operation and as directed by the Engineer.

3) *Containment Requirements*

During cleaning operations, contain waste all solid or liquid waste within the work area. Keep different waste streams separate. Consider the waste from cleaning existing paint to be hazardous until approved TCLP testing indicates otherwise.

Design and implement a containment system for the work area in accordance with SSPC Class 2A, Class 2W, Class 2C, Class 2P (open power tool), or Class 3P (vacuum shrouded power tool or vacuum blasting) for hazardous materials and SSPC Class 3A (non-rural), Class 4A (rural),Class 3W, Class 3C, or Class 3P for non-hazardous materials.

For vacuum blasting, maintain continuous contact between the blasting head and the blast surface. If dust is visible, discontinue vacuum blasting and correct the problem. Equip cleaning power tools with HEPA filters. For vacuum blasting and power tool cleaning, provide an equipment manufacturer representative at the start of work to ensure correct equipment use. Have the representative write a letter addressing observations about equipment use, and provide a copy to the Engineer within 10 calendar days. Maintain at least Class 3P containment for vacuum blasting to control unintentional releases related to worker fatigue.

Obtain written permission from the Engineer before using chemical strippers.

4) *Worker Safety and Health*

Refer to Subsection 107.05, “Public Convenience and Safety,” and Subsection 107.12, “Responsibility for Damage Claims.” Comply with 29 CFR 1926.62. Provide each worker on the Project site with a copy of “Working with Lead in the Construction Industry,” OSHA 3126. Ensure the workers familiarize themselves with its contents.

Arrange for a Certified Industrial Hygienist (CIH), to review blood lead level test results of each worker on the Project site before, during, and after de-leading operations, and corrective actions taken. Use a Clinical

Laboratory Improvement Amendments (CLIA) certified laboratory to test blood, and submit the lab name certification and location to the Engineer. Report blood lead levels to:

Oklahoma State Department of Health
Lead Poisoning Prevention Program
1000 N.E. 10th Street
Oklahoma City, OK 73117-12199

Monitor worker exposure using personal air monitors in accordance with 29 CFR 1926.62 for lead or 29 CFR 1926.55 for other hazardous materials. Provide respiratory protection commensurate with measured levels of airborne lead or other airborne contaminants, based on presumed exposure levels until test results verify actual worker exposure.

5) *Work Area Signs*

During surface cleaning in areas with hazardous materials, post signs in the work area with boundaries at the OSHA Action Level, 30 μg/m³ for lead, which read as follows:

WARNING
Lead Work Area
POISON
From This Point On No Smoking or Eating
Authorized Personnel Only

6) *Waste Sampling and Testing*

At the beginning of blasting operations, test one sample to characterize the waste as either hazardous or non-hazardous. Collect at least four representative samples of each waste stream containing portions from the top, middle, and bottom of the container. Collect samples large enough to split each into three equal parts from 300 g to 400 g. Supply the testing laboratory one part and the Engineer with two of the three parts. Document the transfer with chain-of-custody forms. Retain the remaining part until the test results have been obtained and it is clear that a dispute resolution will not be required. Conduct at least four TCLP tests for collected debris from all other waste streams generated. Collect at least two representative samples and perform two separate TCLP tests for debris taken from dust collectors. Test for the hazardous elements specified in Section 512.01, “Description.” Alternately, in lieu of testing the collected blast debris, the Contractor may deem the blast waste to be hazardous based on knowledge of process (KOP).

7) *Waste Storage*

Store waste in separate, leak-proof, closed containers (drums, lined roll-off boxes, or both) for each waste stream in accordance with EPA requirements and state administrative code. For waste from dust collectors, add the label “From Dust Collectors.” Apply the following label to the containers:

HAZARDOUS WASTE. FEDERAL LAW PROHIBITS IMPROPER DISPOSAL. IF FOUND, CONTACT THE NEAREST POLICE, PUBLIC SAFETY AUTHORITY, OR THE U. S. ENVIRONMENTAL PROTECTION AGENCY.	
Proper D.O.T. Shipping Name U NOR NA#_____ GENERATOR INFORMATION Name_____ Address_____ _____ City:_____	State, Zip_____
EPA ID No._____	Waste No._____
Accumulation_____ Start Date_____	Manifest_____ Document No.____
HANDLE WITH CARE! CONTAINS HAZARDOUS OR TOXIC WASTES.	

WARNING
Contents: Lead Paint Residue Tare Wt. _____ Date Collected_____ Location_____ Container No._____

To prevent vandalism, store waste containers on the project site in a storage area secured by an 8 ft [2.4 m] tall gated and locked chain link fence or an enclosed, locked storage container. Place impenetrable tarpaulins on the ground. Place drums on pallets no more than two drums deep or two drums high. Place the storage area within the right-of-way as the Engineer approves. Obtain written approval from the Engineer and Oklahoma DEQ before storing waste outside of the right-of-way or away from the project site. Place the storage area where water will not pond and away from a flood plain.

8) *Waste Treatment*

The Contractor may use proprietary additives to pre-treat abrasives. If proposing to treat the waste on-site after generation, use an approved WAP.

Incinerate combustible solid waste, including solvents and paints, at an EPA-approved, State permitted TSD, or both. Obtain written approval from the Engineer and Oklahoma DEQ before using non-hazardous blast debris as feedstock for cement kilns.

9) *Transportation and Disposal*

Transport the hazardous collected debris, including solvent paint waste, in accordance with 40 CFR 263 for hazardous waste and 49 CFR for hazardous material.

10)*Disposal*

Submit a proposed Treatment, Storage, and Disposal (TSD) facility to the Engineer for approval. Use a State of Oklahoma Treatment, Storage and Disposal (TSD) facility for waste disposal. Dispose of waste at a DEQ-permitted, Subtitle C landfill for hazardous waste stabilization, or Subtitle D for non-hazardous waste. Dispose of all waste within 80 days of generation, and before the final inspection.

(4)Protection of the Work

Provide tarps, screens, covers, and other protective devices to prevent damage to the work. Prevent dust, oil, grease, and other harmful materials from contaminating freshly-painted surfaces. Protect the work from paint splatters, splashes, and smirches. Repair damaged painted surfaces with materials and thicknesses equal to the damaged coat at no additional cost to the Department.

If traffic causes dust, sprinkle the adjacent roadbed and shoulders with water or dust palliative, as directed by the Engineer. When painting operations are complete and contaminating foreign materials are eliminated, clean the surfaces of dust, grease, and other foreign materials without damaging the surfaces.

(5)Color

Use contrasting colors for succeeding application of paint coats. The Engineer will not allow field-tinting. Provide color samples as required by the Contract, and obtain the Engineer's approval before applying paint. Unless otherwise shown on the Plans, provide a light gray topcoat color in accordance with Federal Standard No. 595A-26440. For weathering steel, unless otherwise shown on the Plans, provide a dark brown topcoat color in accordance with Federal Standard No. 595A-20075.

B. Painting Steel Structures

Clean surfaces before painting. Place protective coverings over exposed surfaces before blast-cleaning near machinery, seal bearings, journals, motors, and moving parts.

(1)Surface Preparation

(a)*New Steel or Existing Steel Stripped of Paint*

Install covers to protect surfaces from cleaning agents and coatings. Use solvents to remove any areas that contain asphalt cement, oil, grease, or diesel fuel deposits in accordance with SSPC-SP 1, Solvent Cleaning, prior to blast cleaning.

1) Abrasive blasting method

When the area of an existing bridge to be painted exceeds 5,000 ft² [465 m²], use recycled abrasives in accordance with 512.04B.(1)(c) of this specification. For paint areas less than 5,000 ft² [465 m²], the use of recycled abrasives is optional. After the initial cleaning, remove remaining dirt, mill scale, rust, paint, and other foreign material from exposed surfaces in accordance with SSPC-SP 10, "Near-White Blast Cleaning." Clean in accordance with SSPC-VIS 1. Conduct final abrasive blast-cleaning when the steel surface temperature reaches at least 5 °F [3 °C] above the dew point.

Blast-clean surfaces with clean abrasive mineral grit, or steel grit with gradation that can produce a dense, uniform anchor pattern. Use automated blasting equipment with steel abrasives that have at least 25 percent steel grit.

2) Wet abrasive blast-cleaning method

Use SSPC-VIS 5/NACE VIS 9 to determine if the surfaces are Near White (e.g. C WAB-10). Obtain written approval from the Engineer and the coating manufacturer for light flash rusting before coating.

3) Chloride testing

After blast-cleaning, provide access to the Engineer in accordance with section 105.11 for chloride testing at areas designated by the Engineer, such as beam ends. If the chloride content exceeds 7 μg/cm², continue cleaning to obtain a chloride level less than 7 μg/cm² before painting. If water-cleaning, use Low Pressure Water-Cleaning (LPWC) in accordance with SSPC-SP 12/NACE 5. Obtain the Engineer's approval before using soluble salt cleaning aids or additives. Provide at least Class 3W containment to collect water, paint chips, and solids as specified in SSPC Guide 6. Consider waste hazardous until approved TCLP testing indicates otherwise. Testing performed by cotton swab method is unacceptable for dispute resolution.

4) Anchor Profile

After blast-cleaning, provide access at locations designated by the Engineer in accordance with Section 105.11, "Inspection of Work" for checking anchor profile heights. If anchor profile heights are not in the range from 1.0 mil to 3.5 mil [25 mm to 87 mm] or at least the height that the coating manufacturer's product data sheet specifies, continue surface preparation until the Engineer determines that the profiles are the correct heights. Apply primer only after verifying the anchor profile ranges are within the Contract requirements.

On the day of cleaning, remove dirt, dust, and debris from the surface by brushing, blowing with clean dry air, or vacuuming, and apply the first coat of paint. Repeat blast-cleaning if the surfaces rust or become contaminated before painting. Use HEPA-vacuums to clean surfaces of lead paint except when inside containment with operating dust collectors. The Department will allow the use of oil-free compressed air to remove secondary dust not generated by the blasting operation.

(b)*Existing Steel With Paint to Remain*

The Engineer will determine the degree of surface corrosion present in accordance with SSPC-VIS 2. Clean and prepare surfaces in accordance with SSPC-SP 1, SSPC-SP 2, SP 3, SP 10 and SP 11, based on the percentage of visible rust. Clean 2 in [50 mm] beyond damaged areas. Feather edges of old paint to make a smooth transition. If using tools, clean in accordance with SSPC-VIS 3.

For less than 10 percent visible rust and deteriorated paint, use tool cleaning methods in accordance with SSPC-SP 2 and SP 3 to remove dirt, loose mill scale, loose rust, and loose paint. Clean small areas with pinhole corrosion, stone damage from traffic, or minor scratches.

For more than 10 percent visible rust and deteriorated paint, use the SSPC SP 10 blast-cleaning methods specified in Subsection 512.04.B(1)(a), "New Steel or Existing Steel Stripped of Paint," to remove visible mill scale, rust, paint, oxides, corrosion products, and other foreign matter. If using power tools, clean in accordance with SSPC-SP 11, "Power Tool Cleaning to Bare Metal." Prepare new structural steel used in repair applications in accordance with SSPC-SP 10.

On the day of cleaning, remove dirt, dust, and other contaminants from the surface in accordance with SSPC-SP 1 and by blowing, brushing, or, in the presence of lead, HEPA vacuuming. Spot paint areas cleaned after the first coat. If the surfaces cleaned by SP-10 or SP-11 show rust, clean them again before painting.

(c) ***Abrasives and Pretreatments***

Use abrasives free from oil, moisture, and hazardous and corrosive substances such as chlorides, sulfates, and salts in accordance with SSPC-AB 1 for expendable abrasives, SSPC-AB 3 for metallic abrasives, and SSPC-AB 2 for recycled abrasives. Obtain the Engineer's and paint manufacturer's approval before using pre-treatment additives or inhibitors. Use abrasives with no more than 1 percent "free" silica. For vacuum blasters, use aluminum oxide grit to achieve the profile in accordance with Subsection 512.04.B(1)(a), "New Steel or Existing Steel Stripped of Paint."

(2) Paint Systems

Provide paint systems in accordance with Section 730, "Paint for Structural Steel," categorized as follows:

Table 512:5
Paint System Application

Category	Application	Paint System
N	New structure. Shop-applied primer. Field-applied intermediate and topcoats.	IZ-E-U
E	Existing structure with all existing paint removed. Field-applied coats.	IZ-E-U, OZ-E-U [a] or SC-MC-U
O	Existing structure with existing sound paint (Overcoating). Field-applied coats.	SC-MC-U
R	Repair of existing structure. Field-applied coats. Application area limited to repair area as required by the Contract.	SC-MC-U or an approved Performance Class 2 paint system

[a] The Department will evaluate systems on a case-by-case basis pending acceptance.
[b] Since inorganic zinc does not readily stick to itself, the paint manufacturer should be contacted for repair procedures when the millage is too low.

If the Plans do not specify a paint system, use a Category N or Category E paint system. For Category O and Category R applications, verify the compatibility of the paint system with the existing system in accordance with the following:

- Apply the proposed system to the topcoat and primer. At least 48 hr after application, verify that the system shows no signs of lifting, bleeding, blistering, wrinkling, cracking, and flaking.
- Perform adhesion tests in accordance with ASTM D 3359, Method A, or ASTM D 4541. For ASTM D 3359, the Engineer will accept 3A ratings or better. For ASTM D 4541, the Engineer will accept adhesion strengths greater than 350 psi [2,413 kPa] unless the paint manufacturer specifies greater strengths. Immediately notify the Engineer if the adhesion tests fail at the interface of the existing system and substrate or between the existing top coat and primer.
- Test for compatibility at least 2 weeks before ordering paint. Provide a written certification and test results to the Engineer to verify compatibility.

(3) Weather Conditions

Paint when metal surfaces are cool and dry enough to prevent blisters, porous film, or separation of the vehicle from the pigment. Apply paint in the following conditions:

- Thoroughly dry paint surface,
- Ambient air temperatures and surface temperatures from 40 °F to 100 °F [5 °C to 38 °C],
- A surface temperature at least 5 °F [3 °C] above the dew point,
- A humidity of 85 percent or less,
- For moisture cure paints, a humidity of at least 50 percent or as specified by the paint manufacturer in writing, and
- No predictions of rain, fog, or ambient air temperature below 40 °F [5 °C] during the drying period.

As an alternative, provide enclosures capable of maintaining the above conditions. Ventilate the enclosures to prevent hazardous conditions.

(4) Film Thickness

Limit thickness of each application so the paint film will dry uniformly. Immediately after painting, use an Engineer approved wet film paint thickness gauge to verify the application rate of each coat adjusted for volatile content.

Ensure the dry film thickness of each coat and total thickness of the finished product is in accordance with Section 730, "Paint for Structural Steel." Measure dry coating thickness after each paint application in accordance with SSPC-PA2, "Measurement of Dry Paint Thickness with Magnetic Gauges." For quality assurance purposes, provide access to the Engineer in accordance with Section 105.11, "Inspection of Work" for testing paint film thickness at locations specified by the Engineer.

Table 512:6
Dry Film Thickness Requirements Categories N, E, & O

Coat	IZ-E-U	OZ-E-U	SC-MC-U
Thickness	mils [µm]	mils [µm]	mils [µm]
Primer	3.0 [75 µm]	4.0 [75 µm]	3.5 [89 µm]
Intermediate	4.0 [100 µm]	4.0 [100 µm]	3.5 [89 µm]

Table 512:6 Dry Film Thickness Requirements Categories N, E, & O			
Coat	**IZ-E-U**	**OZ-E-U**	**SC-MC-U**
Top	2.0 [50 µm]	2.0 [50 µm]	3.0 [75 µm]
Total	9.0 [225 µm]	10.0 [225 µm]	10.0 [253 µm]
Note: Thickness of each coat must be within -0.5/+2.0 mils [-15/+50 µm].			

(5) Application of Paints

(a) ***General***

Mix and apply the paint in accordance with the manufacturer's instruction data sheet and this specification whichever is more restrictive. Use mechanical mixers. Take precautions when mixing systems that cure by reacting with air or moisture. Before and during application, mix the paint to blend-in the pigment and vehicle. Use pot agitation for inorganic zinc and zinc-rich organic coatings as the manufacturer specifies. Continue mixing during paint application. The Department will not allow thinning of paints formulated ready for application.

Use tarpaulins, screens, covers, or shields to protect surroundings from paint. Apply paint with a brush, spray, or roller, as specified by the manufacturer. Prevent build-up, runs, sags, skips, holidays, and thin areas in the paint film. Brush-out runs and sags before drying.

Use round, oval-shaped brushes, or flat brushes no wider than 4½ in [115 mm], with enough bristle body and length to uniformly spread the paint. Brush out the paint during application. Use airless or conventional spray equipment with traps, filters, or separators to exclude oil and water from the compressed air. Verify compressed air cleanliness in accordance with ASTM D 5913. Use rollers only on flat, even surfaces. Use rollers that do not leave a stippled texture.

Use sheepskin daubers, bottle brushes, or other approved methods to paint surfaces inaccessible for painting by brush, roller, and spray. When spot-painting, scrape off old paint that lifts after the first application. Repaint the area before the next application.

Cure each application of paint. Correct skips, holidays, thin areas, and deficiencies before the next application.

Before erection, coat new structures and replacement steel with the primer. Pressure-wash after erection and before applying the field coats. Use power tools to re-clean surfaces with damaged or deteriorating coating, or exposed, unpainted surfaces. Spot-coat with the primer to the Contract required thickness.

For the Category O paint system, spot coat bare steel with primer to the Contract required thickness.

(b) ***Application of Zinc-Rich Primers***

Apply zinc-rich primers by spray methods within 12 hr of completing the surface preparation. On areas inaccessible for spray, use a brush or daubers as the manufacturer specifies.

Use mechanical mixers. Take precautions if coating systems that cure by reacting with air or moisture. Strain multi component primers through a metal 30-60 mesh screen or a double layer of cheesecloth while pouring into the spray pot. Alternatively, strain immediately before pouring.

Apply the primer with an agitating spray pot unless the manufacturer recommends otherwise. Ensure the agitator or stirring rod reaches within 2 in [50 mm] of the spray pot bottom and moves continuously during primer application. Keep the primer well mixed.

Use spray equipment with the pot, pump, and atomization pressures needed to produce a coating in accordance with the more restrictive of the coating manufacturer's published data sheet or zinc paint in accordance with Section 730, "Paint for Structural Steel."

If using conventional spray, provide a hose from the pot to the nozzle no greater than 75 ft [23 m] long. Spray no more than 15 ft [4.5 m] above or below the pot if applying inorganic zinc.

If mud-cracking occurs in areas with inorganic zinc primer, blast-clean back to soundly bonded primer, and recoat using approved methods to obtain the Contract required thickness specified for the original coat. Obtain the Engineer's approval before using SSPC-SP 11, "Power Tool Cleaning to Bare Metal," instead of blast-cleaning small areas.

Before applying additional coats, ensure primer coats and intermediate coats are cured and dry. Clean paint surfaces of dust, dirt, salt, and other deleterious materials prior to applying any paint. Cure inorganic zinc primer for 48 hr, at a humidity of at least 45 percent, or in accordance with the manufacturer's published data. Provide continuous misting during the curing process when the humidity falls below 50 percent. Start the misting operation when the inorganic zinc is dry to the touch. Before applying the intermediate coat, test the cure of the inorganic zinc primer in accordance with ASTM D 4752, "Standard Test Method for Measuring MEK Resistance of Ethyl Silicate Zinc Rich Primers by Solvent Rub." Provide a Resistance of 5 as specified in ASTM D4752 Table 1 – Scale for Resistance Rating. Test in the presence of the Engineer.

Wash the cured primer with water if using shop-primed steel, the steel contains dirt, or the primer is exposed for more than 2 weeks.

(c) ***Installation of Stripe Coats and Caulking Materials (Required for Category E and O Paint Application)***

Caulk locations shown on the plans or as required by the Engineer including seams at joints, plates, seams and field splices where water may collect. Do not apply caulking to pack rust. Use a product compatible with the coating system and as recommended by the coating manufacturer. Provide MSDS and PDS to the Engineer and Materials Divisions.

After applying the primer and before applying the intermediate coat brush, apply a stripe coat of the intermediate coat to sharp edges, corners, bolt heads and caulked seams and joints. Extend the stripe coat 1 in [25 mm] from the sharp edge or corner. Apply a penetrating stripe coat of high ratio co-polymerized calcium sulfonate, recommended by the manufacturer, between plates exhibiting pack-rust, rust stain or corrosion. Before applying calcium

sulfonate, blow dry the area with pack rust using *dry* compressed air. Wipe off any excess calcium sulfonate.

(6) Painting Galvanized Surfaces

Before painting, wash the surface with a mineral spirit solvent to remove oil, grease, and contaminants in accordance with SSPC-SP 1. Apply the intermediate and final coats of the Contract required paint system.

(7) Labeling

Stencil the bridge number, paint types of all coats, manufacturer name, contractor name, and date of completion inside the exterior girder on the southwest corner of the bridge. Provide a font height of 1 in [25 mm].

512.05 METHOD OF MEASUREMENT — VACANT

512.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) PAINTING EXISTING STRUCTURES	Lump Sum
(B) COLLECTION AND HANDLING OF WASTE	Lump Sum

For new structural steel, the Department will consider the cost of cleaning, painting, caulking, enclosures, and related work to be included in the contract unit price for the relevant structural steel pay item.

The Department will pay for the painting of existing steel structures as *Painting Existing Structures*, unless otherwise required by the Contract. The Department will consider the cost of painting, caulking, enclosures, providing access, and related work to be included in the contract unit price for *Painting Existing Structures*.

The Department requires paint material certifications for final payment.

The Department will consider the cost of cleaning, containment, stabilization, incineration, transportation and disposal of waste, sampling and testing of soil, air, and waste materials, permits, related work, and submission of required documentation to be included in the contract unit price for *Collection and Handling of Waste*.

SECTION 513
REPAIR OF CONCRETE BRIDGE DECKS

513.01 DESCRIPTION

This work consists of patching decks, repairing decks, or both.

513.02 MATERIALS

Provide materials in accordance with the following sections and subsection:

Material:	Section or Subsection:
Portland Cement Concrete	701
Reinforcing Steel	511
Early Strength Concrete for Bridge Deck Patching and Overlays	701.20

513.03 EQUIPMENT

Protect the deck from oil or other harmful material by providing equipment with traps, filters, drip-pans, or other devices. Use the following types of surface preparation equipment as required by the Contract and as directed by the Engineer:

A. Hand-Held Blast Cleaning Equipment

Provide hand-held blast equipment for sand-blasting or water-blasting to expose fine and coarse aggregates. Provide water-blasting equipment that delivers at least 25 gpm [95 L/min] at 4,000 psi [28 Mpa].

B. Sawing Equipment

Provide saws capable of cutting concrete to depth required by the Contract.

C. Power-Driven Hand Tools

Provide power-driven hand tools, jack hammers, and chipping hammers that weigh no more than a nominal 15 lb [7 kg].

D. Proportioning and Mixing Equipment

For high density concrete, provide proportioning and mixing equipment in accordance with Subsection 414.03, “Equipment.” Provide a rotating-paddle type construction or stationary concrete mixer. Alternatively, use a continuous mixer in conjunction with volumetric proportioning.

E. Finishing Equipment

Provide a vibrating screed to finish the deck surface. For small patches where a vibrating screed is impractical use hand tools to vibrate, strike-off, and leave a rough finish.

F. Lighting Equipment

Provide lighting for night work in accordance with Subsection 509.4.C(3)(c), “Lighting.”

G. Pachometer

Provide a pachometer that can determine that depth, size, and spacing of reinforcing steel.

513.04 CONSTRUCTION METHODS

A. General

Use engineering controls to limit dust in accordance with Section 509, “Structural Concrete.” Limit the maximum concrete temperature to 85 °F [30 °C]. During bridge deck concrete removal, protect traffic under the bridge and adjacent to the work zone.

B. Work Plan

Before starting work, submit a work plan to the Engineer and allow 14 days for review. Include descriptions of the following:

- Material,
- Equipment,
- Procedures for placing and removing patches,
- Forms,
- Labor requirements, and
- Anticipated work schedule, including:
  - Traffic control,
  - Project phasing,
  - Patching cure times,
  - Surface preparation, and
  - Estimated placement time.

Begin work after approval of the work plan.

C. Deck Repairs and Patching

(1) General

Remove existing overlays, asphalt, unsound concrete, and foreign materials from the surface. Use a chain drag, or other Engineer approved method, to locate delaminations in the bridge deck. Before removal, obtain the Engineer’s approval for deck removal areas. Remove unsound concrete using equipment in accordance with Subsection 513.03.A, "Hand-Held Blast Cleaning Equipment," and Subsection 513.03.C, "Power-Driven Hand Tools." Operate jack hammers at angles 45° or less from horizontal.

(2) Materials

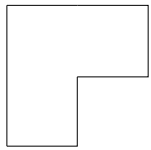
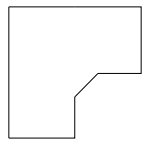
If approved as part of the mix design, add fibers.

(3) Patch Preparation

Before making saw cuts, use a pachometer or provide measurements where reinforcing steel is exposed to locate the depth of existing reinforcing steel. Provide a saw-cut vertical edge around the perimeter of the repair areas. When the depth of the reinforcing steel is less that 1 in [25 mm], extend the cut to just above the top of the existing reinforcing steel. For depths of reinforcing steel that are greater than 1 in [25 mm], make the saw cut at least 1 in [25 mm] deep, measure from the original deck surface. Do not create patches with re-entrant corners. See Figure 513:1 for acceptable and unacceptable patch geometries. Ensure the dimensions of a 45° re-entrant corner equal at least 4 in. Do not cut, stretch, or damage exposed reinforcing steel. Blast exposed reinforcing steel clean. Replace or repair damaged reinforcing steel, lapping new and old reinforcing as required by

the Contract. Splice corrosion damaged exposed reinforcing steel if more than 20 percent of the area of the reinforcing steel section has been lost.

Figure 513:1
Acceptability of Patch Geometry

Acceptable	Unacceptable	Acceptable
		

D. Deck Patch Classification

(1) Class A Bridge Deck Repair

Class A bridge deck repairs consist of the following:

- Removing unsound concrete to the top mat of reinforcing steel by chipping with power hand tools in accordance with Subsection 513.03, "Equipment;"
- Disposing of removed concrete;
- Replacing the removed concrete with high density concrete, latex modified concrete, VES I concrete, VES III concrete, or RSLMC;
- Notifying the Engineer before removing concrete below the top mat of reinforcing steel.

(2) Class B Bridge Deck Repair

Class B bridge deck repairs consist of the following:

- Removing unsound concrete from below the top mat of reinforcing steel and from above the bottom mat of reinforcing steel by chipping with hand tools in accordance with Subsection 513.03, "Equipment;"
- Cleaning concrete off the top reinforcing steel mat in the repair area;
- Disposing of removed concrete;
- Replacing the removed concrete with high density concrete, latex modified concrete, VES I concrete, VES III concrete, or RSLMC; and
- Notifying the Engineer before removing concrete below the mid-depth level. Remove concrete at least 1 in [25 mm] below the top mat of reinforcing steel.

(3) Class C Bridge Deck Repair

Class C bridge deck repairs consist of the following:

- Removing unsound concrete for the full depth of the deck leaving the reinforcing steel intact;
- Extending the removal to the full depth when removal of unsound concrete reaches the bottom mat of reinforcing steel;
- Providing forms in accordance with Section 502, "Forms, Falsework, and Temporary Works," to place new concrete in the full-depth opening. For areas of at least 1 yd^2 [1 m^2], support forms from the existing superstructure. For smaller areas, use wire tires to suspend the forms from existing

reinforcing bars. Remove forms after completion. Show typical forming details in the work plan submitted to the Engineer;

- Cleaning existing concrete from reinforcing steel mats in the repair area;
- Disposing of removed concrete; and
- Replacing the removed volume of concrete with Class AA concrete or Engineer approved rapid setting concrete.

E. Anodes

Embed galvanic anodes at the perimeter of the patch to protect against corrosion. Use pre-manufactured anodes containing at least [100 g] of zinc metal, in accordance with ASTM B 418-95a Type I. Provide anodes surrounded by a pair of steel tie wires in accordance with bright annealed ASTM A 82-97a and encased in a highly alkaline cementitious shell with a pH of 13 or greater. The Department will not allow chlorides or other corrosive materials within the cementitious shell. Tie anodes with integral tie wires to reinforcing steel as follows:

(1) Installation

Install galvanic anodes along the perimeter of the repair or interface as shown on the Plans. Vary anode spacing with changes in the reinforcing steel density, the level of chloride in the structure, and the corrosiveness of the local environment. Limit the spacing between the anodes to a maximum of 24 in [600 mm].

(2) Clearance

Provide enough clearance between the anodes and the substrate to allow repair material to encase the anode. Provide at least 1 in [25 mm] of cover over the tops of the galvanic anodes.

(3) Attachment

Secure the galvanic anodes close to the patch edge using the anode tie wires. Wrap tie wires around the cleaned reinforcing steel. Twist tie wires to prevent movement.

If the conditions allow, place the anode at the intersection between two bars and secure the anode to each clean bar. If the anode must tie onto a single bar, or if using less than 1 in [25 mm] of concrete cover, place the anode beneath the bar and secure it to clean reinforcing steel.

(4) Electrical Continuity

Clean exposed reinforcing steel of foreign material, such as rust or mortar, to provide an electrical connection and mechanical bond.

Measure the electrical connection between anode tie wire and reinforcing steel using a DC resistance (ohms) with a multi-meter.

Confirm electrical continuity of the exposed reinforcing steel within the repair area. If necessary, establish electrical continuity with steel tie wire.

The Engineer will approve electrical continuity if the DC resistance is less than 1 Ω.

F. Cold Weather Practices

Implement cold weather practices in one or more of the following conditions:

- The air temperature was less than 55 °F [13 °C] within 24 hr of placement.

- The air temperature will be less than 55 °F [13 °C] within 6 hr of placement.
- The substrate temperature is less than 55 °F [13 °C] during placement.

Perform cold weather practices as follows:

- Maintain a concrete mix temperature of at least 75 °F [24 °C] during placement.
- Complete placement during the warmest part of the day. Ensure rising air temperature during placement.

Place early strength concrete at air and deck temperatures greater than 45 °F [7 °C].

G. Mixing

(1) Class AA and High Density Concrete

Provide equipment in accordance with Subsection 414.03, "Equipment." Batch and mix concrete in accordance with Subsection 414.04.B, "Handling, Measuring, and Batching Materials" and Subsection 414.04.C, "Mixing Concrete",

(2) Latex Modified Concrete

Proportion and mix latex modified concrete materials in accordance with the following:

(a) *Measurement of Materials*

Proportion materials for the mixture with a mobile continuous mixer. Calibrate the proportioning equipment for each material in the presence of the Engineer. Always operate the proportioning equipment at the equipment manufacturer's recommended speed. Check and verify yields.

(b) *Mixing of Materials*

Mix materials in accordance with the equipment manufacturer's recommendations. Ensure the mixture is uniform in composition and consistency. Proceed with finishing operations steadily, completing the final finishing before a plastic surface film forms.

H. Placing

Before placing the patch, clean and dry the repair area. In a continuous operation, place Type AA, VES I, VES III, or RSLMC in the prepared area. Consolidate the repair concrete using a vibrating screed. For patch areas with a thickness of at least 3 in [75 mm], internally vibrate the fresh concrete. Provide a rough finished texture on repair areas for which the Contract requires an overlay. Where not placing an overlay, place concrete to the existing deck level and match the surface texture of the repair with the existing deck. Within 15 min of placing the patch, cover with insulating blankets that have an R value of at least 5. Continuously weigh down the blanket edges to prevent wind from blowing under the blanket. Maintain insulating blankets until the concrete reaches compressive strength or at least 24 hr, which ever is less. Provide insulating blankets year round.

I. Curing

(1) Overlay Substrate Patching

Water cure repairs in accordance with Subsection 509.04.F(3), "Water Method," for 7 days or until overlay placement. Do not use curing compound if placing overlay.

(2)Surface Patching

Water cure repairs in accordance with Subsection 509.04.F(3), "Water Method," for 7 days. If opening a deck surface to traffic in less than 7 days, cure patches using Class AA concrete for at least 24 hr and patches using VES I, VES III, and RSLMC, until the patch reaches the strength required by

the Contract. Additionally, cure all repair classes in accordance with Subsection 509.04.F, "Concrete Curing."

J. Straightedge Testing and Surface Tolerance

Performs straightedge testing in accordance with Subsection 414.04.I(5), "Straightedge Testing and Surface Correction." After floating and removing excess water, and while the concrete is still plastic, use a 10 ft [3 mm] straightedge to test the smoothness of the concrete surface. Lay the straightedge on the repaired pavement parallel to the centerline. Ensure the surface does not vary more than ⅛ in [3 mm] from the lower edge of the straightedge. Ensure the transverse slope of the pavement does not have depressions greater than ⅛ in [3 mm] when tested with the 10 ft [3 m] straightedge extending from edge to edge in a traffic lane transverse to the centerline. After curing, retest the surface and grind areas higher than ⅛ in [3 mm] above the straightedge bottom. Groove the ground surfaces to have a texture equal to the surrounding surfaces.

K. Limitation of Operations

Keep traffic off the finished surface during the curing period required by the Contract. The Department will not allow preparation work in areas adjacent to or adjoining new concrete during the curing period required by the Contract.

513.05 METHOD OF MEASUREMENT

The Engineer will measure classes of bridge deck repair before concrete placement.

The Engineer will not measure reinforcing steel used to repair existing steel with heavy deck section loss.

513.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) CLASS A BRIDGE DECK REPAIR	Square Yard [Square Meter]
(B) CLASS B BRIDGE DECK REPAIR	Square Yard [Square Meter]
(C) CLASS C BRIDGE DECK	Square Yard [Square Meter]
(D) ANODE	Each
(E) EARLY STRENGTH CONCRETE	Cubic Yard [Cubic Meter]

The Department will consider the cost of reinforcing steel, sawing, removals, lighting and other incidental items to be included in the contract unit price for *Class A Bridge Deck Repairs*, *Class B Bridge Deck Repairs*, and *Class C Bridge Deck Repairs*.

Class A Bridge Deck Repairs and *Class B Bridge Deck Repairs* will not be measured for payment when Hydrodemolition is used.

SECTION 514
DRIVEN FOUNDATION PILES

514.01 DESCRIPTION

This work consists of providing and driving piles and cutting off or building up foundation piles of the type and dimensions required by the Contract.

This work also includes providing test piles, performing load tests, and providing and placing reinforcing steel, concrete-filled steel shell piles, and pipe piles.

The Department defines piles as steel H-piles, sheet piles, steel shell piles, or precast concrete piles.

514.02 MATERIALS

A. General

Provide materials in accordance with the following sections and subsection:

Material:	Section or Subsection
Structural Concrete	509
Reinforcing Steel for Structures	511
Structural Steel	724
Steel Castings	725.02
Paint	512

B. Steel Piles

Provide structural steel in accordance with AASHTO M 270, Grade 50 (345) for steel piling.

If exposed steel piles or steel pile shell piles extend above the ground or water surface and are left exposed in the finished structure (i.e. pile bents), prime piles as shown on the Plans before driving. If the required remaining coat surface is accessible, the Contractor may apply the remaining coats after driving. Recoat splices and damaged areas above the water or ground surface. Cure paint as required by the Contract before driving.

C. Steel Shell Piles

Provide Class AA concrete for steel shell piles.

Provide steel shells greater than or equal to the thickness required by the Contract. If necessary, provide shells of greater thickness to provide sufficient strength and rigidity to permit driving with the equipment selected for use without damage, and to prevent distortion caused by soil pressures or from driving adjacent piles. Provide watertight shells to exclude water while placing concrete.

Obtain the Engineer's approval for alternate shell designs before furnishing.

D. Precast Concrete Piles

Provide Class P concrete with a Department approved corrosion-inhibiting admixture for precast prestressed concrete piles.

E. Steel Sheet Piling

For permanent applications, provide steel sheet piling in accordance with Subsection 724.01, "Structural Steel" and Subsection 514.02.B, "Steel Piles." Provide sheet piling walls with the minimum section modulus specified in the Plans. For applications using temporary sheet piling sheet piling, used steel may be used provided that it is in good condition as determined by the Engineer.

514.03 EQUIPMENT

A. Approval of Pile Driving Equipment

Provide equipment that drives permanent piles to the depths shown on the Plans without causing damage. Provide a pile driving hammer to drive piles to the tip elevations and achieve the ultimate pile capacity without exceeding driving stresses, in accordance with Subsection 514.03.A.(2), "Wave Equation." The Engineer will evaluate the pile driving equipment within 14 calendar days of receiving the information. The Engineer will base approval of pile driving equipment on a wave equation analysis if:

- Dynamic load testing is required by the Contract,
- Ultimate pile capacities exceed 270 ton [2,400 kN],
- Using precast or prestressed concrete piles, or
- The Contract requires the wave equation analysis.

If not using the wave equation analysis, the Engineer will base approval on the minimum hammer energy in Table 514:2, "Minimum Energy for Pile Hammers." Regardless of the Engineer's approval, drive piles to the bearing and tip elevations required by the Contract without causing damage.

To modify or replace the proposed equipment, resubmit the revised data for approval. The Engineer will review the revised data within 14 calendar days. The Engineer will not grant a contract time extension based on the time required for submission, review, and approval.

(1) Equipment Submittal

If the Contract requires, submit a wave equation analysis performed by a pile specialty consultant. If the Contract does not specify either the dynamic load testing or wave equation analysis, the Engineer will perform the wave equation analysis when necessary.

Submit the following pile driving equipment information to the Engineer at least 30 calendar days before driving the piles:

(a) *General*

- Project and structure identification,
- Pile driving contractor or subcontractor,
- Auxiliary methods of installation, and
- Type and use of the equipment.

(b)*Hammer*

- Manufacturer,
- Model,
- Type,
- Serial number,
- Rated energy (provide specific energy rates at specific lengths of stroke), and
- Modifications.

For diesel hammers, include charts specified in Subsection 514.03.B.1, "Diesel Hammers."

(c)*Capblock (Hammer Cushion)*

- Material,
- Thickness,
- Area,
- Modulus of elasticity (E), and
- Coefficient of restitution (e).

(d)*Pile Cap*

- Helmet weight,
- Bonnet weight,
- Anvil block weight, and
- Drivehead weight.

(e)*Pile Cushion*

- Cushion material,
- Thickness,
- Area,
- Modulus of elasticity (E), and
- Coefficient of restitution (e).

(f) *Pile*

- Pile type,
- Length (in leads),
- Weight/foot [mass/meter],
- Wall thickness,
- Taper,
- Cross-sectional area,
- Ultimate pile capacity,
- Description of splice, and
- Tip treatment description.

For wave equation analysis only provide information about the following:

- Capblock,
- Pile cap, and
- Pile cushion.

(2) Wave Equation

Use the hammer efficiencies shown in Table 514:1 for wave equation analyses.

Table 514:1
Hammer Efficiencies

Hammer type	Efficiency (%)
Diesel	72
Air or steam	
Single acting	67
Double acting	50
Gravity hammer	95

The Engineer requires from 3 hammer blows to 10 hammer blows per 1 in [25 mm] indicated by the wave equation at the ultimate pile capacity. Ensure the pile stresses resulting from the wave equation analysis do not exceed the points of impending damage, defined as follows for steel and concrete piles:

(a)*Steel Piles*

Limit the compressive driving stress to 90 percent of the yield stress of the pile material.

(b)*Concrete Piles*

Limit the tensile and compressive driving stresses in accordance with the following equations:

$$TS \le EPV + af_c$$

$$CS \le 0.85 f_c - EPV$$

where

TS = Tensile Driving Stress (psi [Mpa]),
CS = Compressive Driving Stress (psi [Mpa]),
EPV = Effective prestress value (psi [Mpa]),
f_c = Specified 28-day compressive strength of concrete (psi [Mpa]), and
a = 3.0 [0.25].

(3) Minimum Hammer Energy

Provide driving equipment with enough energy, as rated by the manufacturer, to drive piles at a penetration rate of 120 blows per 1 ft [300 mm] at the Contract required ultimate pile capacity. If not using the wave equation, use Table 514:2 to determine the minimum hammer energy needed for the ultimate pile capacity.

Table 514:2 Minimum Energy for Pile Hammers	
Pile Hammer Type	**Minimum Rated Hammer Energy, *ft-lb [J]***
Diesel	255 P [39 P]
Air or steam (single or double acting)	195 P [30 P]
Gravity	1,080 P [165 P]
NOTE: "P" is the specified ultimate pile capacity (ton) [kN] Table values are based upon the ENR formula for an average penetration rate of 120 blows per 1 ft [0.3 m]	

B. Pile Hammers

(1) Diesel Hammers

(a) *Open-End Diesel Hammers*

Equip open-end (single acting) diesel hammers with a device, such as rings on the ram or a scale (jump stick) extending above the ram cylinder, that allows visual determination of hammer stroke. Submit a chart from the hammer manufacturer equating stroke and blows per minute for the proposed hammer. The Engineer may approve a speed versus stroke calibration.

(b) *Closed-End Diesel Hammers*

Provide a hammer that attains cylinder lift at the maximum energy-bounce chamber pressure relationship in the hammer specifications. Submit a chart calibrated to actual hammer performance within 90 calendar days. Ensure the chart equates bounce chamber pressure to either equivalent energy or stroke for the hammer to be used. Equip hammers with a dial gauge, readable at ground level, to measure pressure in the bounce chamber.

Calibrate the dial gauge to allow for losses in the gauge hose. To verify the dial gauge accuracy during driving, ensure cylinder lift occurs when bounce chamber pressure matches the maximum energy specified in the hammer specifications.

(2) Air or Steam Hammers

Provide plant and equipment for steam and air hammers that maintain the volume and pressure specified by the hammer manufacturer. Equip the hammer with accurate and accessible pressure gauges. Provide a hammer with striking parts that weigh at least one third of the combined weight of the driving head and pile and totals at least 2,750 lb [1,250 kg].

(3) Gravity Hammers

The Department will not allow the use of a gravity hammer to drive concrete piles or piles with a Contract required ultimate capacity of more than 30 ton [267 kN].

Provide a hammer with a ram weighing from 2,000 lb to 3,500 lb [900kg to 1,600 kg]. Limit the drop height to 13 ft [4 m]. Ensure the ram weight exceeds the combined weight of the drive head and pile. Provide hammer guides to ensure concentric impact on the drive head.

(4) Non-Impact Hammers

Submit a written proposal to the Engineer for approval to use non-impact hammers.

(5) Additional Equipment or Methods

If using a hammer, in accordance with the minimum above requirements, does not obtain the required penetration, the Engineer may require the Contractor to provide a hammer of greater energy or, when allowed, resort to supplemental methods.

Obtain the Engineer's approval for supplemental methods.

C. Driving Appurtenances

(1) Hammer Cushion

Equip impact pile driving equipment, except gravity hammers, with a hammer cushion thick enough to prevent damage to the hammer or pile and ensure uniform driving.

Make hammer cushions from durable, manufactured material in accordance with the manufacturer's recommendations. The Department will not allow the use of wood, wire rope, or asbestos hammer cushions. Place a striker plate as recommended by the manufacturer on the hammer cushion to ensure uniform compression of the cushion material. Inspect the hammer cushion in the Engineer's presence when beginning pile driving at each structure or after each 100 hr of pile driving, whichever is less. Replace the cushion if the thickness reduces by more than 25 percent of the original cushion thickness.

(2) Pile Drive Head

For impact hammers, provide drive heads that distribute the hammer blow to the pile head. Align the drive head axially with the hammer and pile. Ensure the leads guide the drive head. Ensure that the drive head does not free-swing. Fit the drive head around the pile head to prevent torsional force transfers during driving. Maintain proper alignment of hammer and pile.

Squarely cut steel piling heads. Using a drive head, hold the longitudinal axis of the pile in line with the hammer axis.

For precast concrete and prestressed concrete piles, make the pile head perpendicular to the longitudinal axis of the pile to prevent eccentric impacts from the drive head.

To prevent damaging special types of piles, provide driving heads, mandrels, or other devices in accordance with the manufacturer's recommendations.

(3) Pile Cushion

Provide a new pile cushion for each concrete pile to prevent damage during driving. Ensure that pile cushions distribute the hammer blow throughout the cross-section of the pile. If using plywood, place at least 4 in [100 mm] of plywood before driving.

Replace the pile cushion if driving burns or compresses the cushion by more than one-half the original thickness.

(4) Leads

While driving, support the piles in line, and position the piles with leads that allow the hammer to move freely. Maintain hammer and pile axial alignment to ensure concentric impact. Provide leads that do not require a follower and allow proper alignment of battered piles.

(5) Followers

Obtain written approval from the Engineer before using a follower.

Drive the full length of the first pile in each bent or substructure unit, and every subsequent tenth pile without a follower to verify that adequate pile length develops the Contract required ultimate pile capacity.

Provide a follower that drives the piles to the Contract required penetration and length. Maintain the alignment of the follower and pile during driving.

In each substructure unit, check the final position and alignment of the first two piles installed with followers. Verify that the piles are within location tolerances before installing additional piles.

(6) Jetting

Obtain written approval from the Engineer before using jetting.

If jetting is not specified but the Engineer approves in writing, determine the number of jets and the volume and water pressure at the jet nozzles that freely erodes the material adjacent to the pile without affecting the lateral stability of the final in-place pile. Repair damage caused by jetting at no additional cost to the Department.

If required by the Contract, provide jetting equipment that delivers a consistent pressure of at least 100 psi [0.7 MPa] at two ¾ in [20 mm] jet nozzles. Maintain the lateral stability of the final in-place pile.

Remove jet pipes when the pile tip reaches at least 5 ft [1.5 m] above the prescribed tip elevation. Drive the pile to the Contract required ultimate pile capacity with an impact hammer. Control, treat, and dispose of jet water in an approved manner.

514.04 CONSTRUCTION METHODS

A. Manufacture of Piles

(1) Precast Concrete Piles

(a) *Forms*

Complete formwork in accordance with Section 502, “Forms, Falsework, and Temporary Works,” and Section 503, “Prestressed Concrete Bridge Members.” Provide access for vibration and consolidation of the concrete in the forms.

(b) *Casting*

Cast concrete in accordance with Section 509, “Structural Concrete,” and Section 511, “Reinforcing Steel for Structures.” Place the concrete so it binds with the reinforcement. Avoid the formation of “stone pockets,” honeycombs, or other defects.

Continuously place and compact the concrete. Overfill the forms, screed off surplus concrete, and finish the top surfaces to an even texture.

(c) ***Finish***

Finish exposed portions of piling as required by the Contract.

Do not finish other piling, unless otherwise required by the Contract.

(d) ***Curing and Protection***

Cure concrete piles in accordance with Section 509, "Structural Concrete." When the piles set, remove the forms. Stack the piles in a curing pile and separate them with wood spacing blocks.

Allow the piles to age at least 21 days before driving. In cold weather allow piles to cure longer as directed by the Engineer.

Cure concrete piles for use in high chloride or sulfate soils for at least 30 days before driving. Protect concrete from freezing until the compressive strength reaches at least 80 percent of the 28-day compressive strength required by the Contract.

(e) ***Prestressing***

Prestress concrete piles in accordance with Section 503, "Prestressed Concrete Bridge Members."

(f) ***Storage and Handling***

Avoid damage to piles when removing forms, and when curing, storing, transporting, and handling precast concrete piles. Transport and handle concrete piles in accordance with AASHTO *Standard Specifications for Highway Bridges* and Subsection 503.4.G, "Storage, Inspection, and Transportation."

When raising a concrete pile, suspend it, at a minimum, at the points shown on the Plans. If suspension points are not illustrated in the Plans, provide the Engineer with the location of proposed lifting points for the various lengths required for the project. For a three-point pickup, use ropes or cables supported over pulleys to equalize the supporting forces.

Place stored piles on skids made of timber or other suitable materials. At a minimum, place the skids at the pick-up points.

The Engineer will reject cracked or damaged piles.

(2) Cast-in-Place Concrete Piles

(a) ***Inspection of Metal Shells***

Before placing concrete in the driven shells, provide light for the inspection.

(b) ***Placing Concrete***

Place concrete after driving within a radius of 16 ft [5 m], or halt driving until the pile concrete within that radius cures for at least 5 days.

Provide dense, homogenous concrete for cast-in-place piles. Continuously place concrete for each pile. Direct the flow of concrete down the center of the pile to consolidate the concrete by impact. Vibrate concrete from at least 5 ft [1.5 m] below the ground surface to the top of the cast-in-place pile. Remove accumulated water before placing concrete.

After the concrete hardens, cut back the top surface to remove laitance and to expose aggregate in accordance with Subsection 509.04.D.2, "Bonding."

B. Working Drawings for Sheet Piling

Provide working drawings and design calculations for permanent steel sheet piling walls. Provide only design calculations for temporary sheet piling walls. Submit drawings in accordance with Subsection 105.02, "Plans and Working Drawings," and include the following:

- Existing ground elevations and soil properties.
- Design calculations proving that the design satisfies the AASHTO LRFD Specification design parameters including global stability and soil analysis;
- Details of elements required for the construction of the system, including complete material specifications;
- Show the sequence of construction.

C. Preparation for Driving

(1) Site Work

(a) *Excavation*

Drive piles after excavating. Remove material forced up between the piles to the elevation shown on the Plans before placing concrete for the foundation.

(b) *Preboring to Facilitate Driving*

If the Contract requires, prebore holes at pile locations to the depths required by the Contract. Seat installed piles into the end-bearing strata.

Use Engineer approved methods to make prebored holes smaller than the diameter or diagonal of the pile cross-section. Ensure the holes allow penetration of the pile to the Contract required depth. Increase the hole diameter to the smallest functional dimension if subsurface obstructions appear. After driving, fill space around the pile with sand, other approved material, or materials specified in the Contract. Unless otherwise required by the Contract, do not use a spud or punch. The Department defines a spud as a short, strong driven member, removed to make a hole for inserting a pile. Dispose of drilling material as approved by the Engineer.

The Department may require temporary or permanent casings for preboring, even not specifically shown on the Plans. The Department will not separately measure temporary or permanent casings for preboring for payment.

Protect the carrying capacity of piles and adjacent structures. If preboring disturbs the load-carrying capacities of previously installed piles or structures, restore the ultimate capacity of piles and structures as required by the Contract.

The Department considers preboring for Contractor convienience as incidental to the cost of work, and will not measure it separately for payment.

(c) *Predrilled Holes in Embankments*

If the depth of a new embankment reaches more than 6 ft [2 m], prebore or spud through it before pile driving. Make the hole diameter at least 6 in [150 mm] larger than the greatest dimension of the pile cross-section. After driving the pile, fill the space around the pile with dry sand or pea gravel. Dispose of drilling material as approved by the Engineer.

(2) Preparation of Piling

In addition to squaring up pile heads before driving, further prepare piles as follows:

(a) *Pointing*

Point steel piles as the Contract requires. Weld in accordance with Section 724, "Structural Steel." The Engineer will not require the use of a low-stress stencil to create permanent identification marks adjacent to the welds.

Obtain approval from the Engineer if substituting pile shoes for pointing steel piles or using them during hard driving.

(b) *Pile Shoes*

Make pile shoes from cast steel in accordance with Subsection 725.02, "Steel Castings," and use them at the Contract required locations. Weld to the pile in accordance with Section 724, "Structural Steel." The Engineer will not require the use of a low-stress stencil to create permanent identification marks adjacent to the welds.

D. Driving

(1) General

Drive piling to point bearing on solid foundation material at the elevation shown on the Plans. Continue driving to obtain the Contract required ultimate capacity. Drive abutment pile through compacted fill. If shown on the Plans, do not drive piling for abutments until the removal of embankment surcharge. Do not drive piles after obtaining practical refusal.

Splice piles that do not obtain the ultimate capacity at the length shown on the Plans. Drive with an impact hammer to reach the specified ultimate pile capacity.

Ensure the expected driving energy of the hammer and other driving equipment is maintained for each pile throughout driving.

If using the wave equation to determine bearing resistance, the Department considers penetration when the wave equation resistance criterion is achieved within 5 ft [1.5 m] of the tip elevation shown on the Plans. Drive piles that do not achieve the Contract required resistance within these limits to the penetration determined by the Engineer.

Place individual piles in groups, starting from the center and proceeding outward in both directions, or starting at the outside row and proceeding progressively across the group. Redrive piles that move more than ¼ in [6 mm] upward during the driving of adjacent piles.

Make the heads of piles perpendicular to the longitudinal axis of the pile. When pile driving, do not damage the completed work.

(2) Test Piles

The Engineer's order list will include the pile lengths anticipated for the finished structure. Increase the Contract required pile lengths to suit operational methods at no additional cost to the Department.

When the Contract requires, provide and drive test piles to the lengths, locations, and depths shown on the Plans or as directed by the Engineer. Make test piles

longer than the estimated length of permanent piles to provide for varying soil conditions. Prepare for driving in accordance with Subsection 514.04.B, "Preparation for Driving." Drive test piles with the same equipment to be used for permanent piles.

Drive test piles to the Contract required ultimate capacity at the estimated tip elevation. Allow test piles that do not attain the ultimate capacity at 12 in [300 mm] above the estimated tip elevation to "set up" for 24 hr before redriving. Warm the hammer before redriving by applying at least 20 blows to another pile. If redriving does not achieve the ultimate capacity required by the Contract, drive at least a portion of the remaining test pile length, and repeat the "set up" and redrive procedure. Splice and continue driving to obtain the Contract required ultimate pile capacity.

Ensure test piles used for the completed structure meet the Contract requirements for permanent piles. Remove test piles not incorporated in the completed structure to at least 2 ft [0.5 m] below finished grade.

(3) Accuracy of Driving

Drive piles so the axial alignment falls within 1:50 from the vertical or the batter required by the Contract. Keep the top of the pile horizontal within 2 in [50 mm] of the location shown on the Plans for bent caps and within 6 in [150 mm] of the location shown on the Plans for piles capped below finished ground. Place final pile at least 4 in [100 mm] away from cap faces.

The Engineer will halt driving to check the pile alignment. If the Engineer cannot internally inspect piles after installation, check the alignment before driving the final 6 ft [2 m]. The Department will not allow laterally pulling piles, splicing to correct misalignment, or splicing a properly aligned section on a misaligned pile.

Correct piles that have been:

- Driven improperly,
- Driven out of the location shown on the Plans,
- Misaligned, or
- Driven below the Contract required cut off elevation.

Replace damaged piles. Obtain approval from the Engineer for the proposed correcting or repairing methods for deficiencies.

(4) Steel Piles

Provide steel piles with the fewest splices possible, in accordance with Table 514:3.

Table 514:3
Steel Pile Splices

Plan Length, *ft [m]*	**Maximum Number of Splices Allowed to Make Plan Length (Per Pile)**
0 – 40 [0 – 12]	1
≥40 – 80 [≥12 – 24]	2
≥80 [≥24]	3

Table 514:3 does not limit the number of splices in extensions. Use cut-off lengths of steel piles for extensions.

Protect the piles from dirt and damage during loading, transporting, unloading, storing, and handling. Ensure piles do not exceed the camber and sweep of mill tolerance. The Department considers damaged steel piles unsatisfactory unless the bearing capacity equals 100 percent of the Contract required ultimate capacity determined by load tests. Perform load tests at no additional cost to the Department.

(5) Prestressed Concrete Piles

Support concrete piles at the points shown on the Plans or at quarter points during moving operations. Do not bend the pile or break the edges when raising or transporting concrete piles.

Use a pile cushion to protect the concrete pile heads in accordance with Subsection 514.03.C.3, "Pile Cushion." The Engineer will not accept concrete piles with visible defects that will affect strength or long term performance.

(6) Concrete Filled Pipe or Steel Shell Piles

Provide and handle steel shells or pipes in accordance with Subsection 514.04.C.5, "Prestressed Concrete Piles." Place cutting shoes for shells or pipes inside or outside the shell. Use high-carbon structural steel with a machined ledge for shell bearing or cast steel with a ledge designed for attachment with a simple weld.

Provide for inspection and concrete placement of cast-in-place concrete piles in accordance with Subsection 514.04.A.2, "Cast-in-Place Concrete Piles." The Department will not allow driving a pile shell or pipe after filling with concrete.

Replace broken, bent, or kinked shells.

(7) Steel Sheet Piling Walls

(a) Permanent Steel Sheet Piling Walls

Drive and cut off steel sheet piling at the pile tip elevation shown on the Plans and in accordance with Subsection 514.04.D, "Driving." Brace the steel sheet piling with waling strips when specified in the plans. If the Plans require painting, paint in accordance with Section 512, "Painting" using a Category "N" paint system.

(b) Temporary Sheet Piling

Provide temporary steel sheet piling when shown on the Plans or as needed for phased construction. Remove and dispose of temporary steel sheet piling when no longer needed.

E. Determination of Bearing Capacity

(1) General

Use Table 514:4, "Engineering News-Record Formulas," to determine the bearing resistance of the in-place pile, unless the wave equation is required by the Contract. If required, use dynamic or static load tests to verify bearing resistance of piles.

(2) Practical Refusal

The Department defines Practical Refusal as four consecutive sets of 10 blows that penetrate no more than ½ in [12 mm] per set. Discontinue driving before reaching practical refusal if driving is causing damage to the pile.

(3) Engineering News-Record Formula Method

Use Table 514:4 to determine bearing resistance using the Engineering News-Record (ENR) formula method.

Table 514:4
Engineering News-Record Formulas

Pile Hammer Type	Bearing Resistance, ft-*lb [J]*
Diesel	2E/(S+0.15) [E/(6S+24)]
Air or steam (single or double acting)	2E/(S+0.1) [E/(6S+15)]
Gravity	2E/(S+1.0) [E/(6S+150)]
NOTE: E= Energy produced by the hammer per blow in foot-pounds [joules]. Values based on actual hammer stoke or bounce chamber pressure observed (double acting diesel hammer). S= Average penetration in inches [mm] per blow for the last 5 blows to 10 blows for gravity hammers and the last 10 blows to 20 blows for other hammers.	

Apply the formulas in Table 514:4 under the following conditions:

- The hammer has a free fall (gravity and single acting hammers),
- The head of the pile is free from damages,
- Penetration is quick and uniform,
- There is no appreciable rebound of the hammer, and
- A follower is not used.

Measure the penetration per blow while driving with a warm hammer operated at full energy after a pile set period, as directed by the Engineer.

If using water jets in connection with driving, use Table 514:4 to determine the bearing resistance after withdrawing the jets.

(4) Wave Equation Method

For wave equation analysis, use the soil, pile, and drive equipment properties to determine bearing resistance required by the Contract. Reduce bearing resistance to 80 percent of its calculated value, except when wave equation analysis was calibrated to the results of a dynamic pile test. Apply safety factors to bearing resistances calculated by the wave equation as the Contract requires.

(5) Dynamic Load Tests

Provide a qualified pile specialty consultant with at least 3 years experience in dynamic load-testing and analysis to perform the dynamic load test, the Signal Matching Analysis (SMA) or Case Pile Wave Analysis Program (CAPWAP), and the wave equation analysis, including the initial wave analysis for the equipment listed on the submittal. Submit the specialty consultant's resume for approval by the Engineer.

Place the shelter within 50 ft [14 m] of the test location. Provide a floor at least 65 ft² [6 m²] and a ceiling at least 6½ ft [2 m] high. Maintain the inside temperature from 50 °F to 100 °F [10 °C to 40 °C].

Provide equipment and perform dynamic load tests in accordance with ASTM D 4945 and under the Engineer's supervision.

Place dynamic load test piles horizontally and away from other piles. Drill holes for mounting instruments near the pile head. Mount the instruments and measure the wave speed. Place the designated pile in the leads. Provide safe access for attachment of measuring equipment to the pile.

Provide an electrical power supply for the test equipment. If using field generators, provide meters to monitor power voltage and frequency.

Do not use the ENR formula or practical refusal to determine the pile bearing resistance. Perform dynamic load tests on Engineer selected piles. Perform a SMA or CAPWAP at the end of driving on the first test pile at pile-supported elements to adjust the assumed driving parameters. Wait for SMA or CAPWAP results and adjustments before driving the remaining piles. Attach the SMA or CAPWAP instrument, and start collecting data before driving the last section of pile.

Drive the pile deep enough so the dynamic test equipment indicates achievement of the Contract required ultimate pile capacity. Maintain stresses in the pile below the values specified in Subsection 514.03.A.2, "Wave Equation," by reducing the driving energy. Reduce the driving energy using additional cushions, or reduce the energy output of the hammer. If non-axial driving is indicated, immediately realign the driving system.

Do not redrive piles into bedrock after reaching plan bearing capacity and specified tip elevation. For piles not driven in bedrock, redrive each dynamic load test pile with instrumentation attached at least 24 hr after the initial driving. Warm the hammer before redriving by applying at least 20 blows to another pile. Redrive the dynamic load test pile to a maximum penetration of 6 in [150 mm] or a maximum of 50 blows, whichever occurs first.

Use SMA or CAPWAP to verify the assumptions used in the initially submitted wave equation analysis in accordance with Subsection 514.03.A, "Approval of Pile Driving Equipment." Analyze one blow from the original driving and one blow from the redriving for each test pile.

Perform additional wave equation analyses with adjustments based on the SMA or CAPWAP results. Provide a graph showing blow count versus ultimate capacity. For open-ended diesel hammers, provide a graph of the blow count versus stroke for the ultimate capacity. Provide the driving stresses, transferred energy, and pile capacity as a function of depth for each dynamic load test.

Based on the results of the dynamic load-testing, SMA or CAPWAP analyses, and wave equation analysis, the Engineer may approve the order list, production driving criteria, and provide the required cut-off elevations, or specify additional pile penetration and testing. The Engineer will provide information within 7 calendar days after receiving the order list and specified test data for the driven test piles.

Submit a complete driving record for each pile to the Engineer within 2 weeks of the completion of the pile load tests for review by the Department's Bridge Division.

(6)Static Load Tests

When the Contract requires static load tests, use the quick load compression test method for static load tests in accordance with ASTM D 1143. Submit drawings of the proposed loading apparatus for approval in accordance with the following:

- Provide a loading system that applies 150 percent of the ultimate pile capacity or 1,000 ton [9,000 kN], whichever is less.
- Construct the apparatus to gradually place increments of load without vibrating the test pile.

Drive tension piles at the location of permanent piles. The Department will not allow the use of tapered piles in their permanent locations as tension piles. Take the test to plunging failure or to the capacity of the loading system.

The Department defines the safe axial pile loads as 50 percent of the failure load.

The Department defines failure pile load as the load that produces a settlement at pile head failure in accordance with the following equations:

For piles with diameters or diagonal widths 24 in [600 mm] or less,

$$S_f = S + a + (0.008 \times D)$$

For piles with diameters or diagonal widths greater than 24 in [600 mm],

$$S_f = S + \frac{D}{30}$$

where

S_f = Settlement at failure (in [mm]),
D = Pile diameter or diagonal width (in [mm]),
S = Elastic deformation of total unsupported pile length (in [mm]), and
a = 0.15 [3.8]

Determine top elevation of the test pile immediately after driving and before load testing to check for heave. Wait at least 3 calendar days after driving an anchor or the load test piles before starting the load test. Before testing, redrive or jack to the original elevation those piles that heave more than ¼ in [6 mm].

After static testing, remove test or anchor piling not included in the finished structure. Remove the excess piling to at least 2 ft [0.5 m] below the bottom of the footing or the finished ground elevation.

Based on the results of the static load-testing, the Engineer may approve the order list and production driving equipment and provide the required cut-off elevations or specify additional tests. The Engineer will provide this information within 7 calendar days of receiving the order list and Contract required test data for the test piles driven.

F. Splices

Align and connect pile sections so that the spliced pile has a straight axis.

(1)Steel Piles

Submit a welder certification for each welder. Use welders certified for structural welding in accordance with Section 724, “Structural Steel.” The

Engineer will not require the use of a low-stress stencil to create permanent identification marks adjacent to the welds.

Before welding a surface, make it smooth, uniform, and free from detrimental material. The Engineer will allow oxygen cutting and carbon-arc gouging, chipping, or grinding for joint preparation.

Except for inspection requirements, weld in accordance with ANSI/AASHTO/AWS D1.5, Bridge Welding Code. Weld the entire pile cross-section using prequalified AWS groove weld butt joints. Use the arc method of welding for splicing. Perform welding to remove visual evidence of cracks, lack of fusion, undercutting, excessive piping, porosity, or inadequate size. Alternatively, use manufactured splices in place of full penetration groove butt welds, unless otherwise shown on the Plans.

Ensure splices for steel shell piles are watertight. The Engineer will allow the use of an approved cast steel pipe splicers.

(2) Concrete Pile Splices and Extensions

(a) *General*

The Department will not allow splicing of concrete piles. Extend concrete piles after driving. Do not drive extended concrete piles.

(b) *Prestressed Piles*

Submit drawings of proposed extensions for the Engineer's approval. Use dowels or other mechanical means to splice precast concrete or precast, prestressed concrete piles. Ensure the splice develops strengths in compression, tension, and bending at least as strong as the pile. Include reinforcing steel bars in the pile head for splicing to the extension bars.

G. Pile Cutoffs

Cut off the tops of permanent piles and pile casings at the elevations shown on the Plans. Cut embedded piles clean and straight, parallel to the bottom face of the structural member. Prevent section loss in the final cut-off elevation. Prevent damage to holes required for lifting or pile testing.

Dispose of cut-off piling lengths.

H. Defective Piles

Correct piles driven beyond the Contract required limits and piles with defects. Approved methods of correction include at least one of the following:

- Use pile at a reduced capacity,
- Install additional piles,
- Repair damaged piles,
- Replace damaged piles.

Do not force displaced piles into the position shown on the Plans. Provide remedial materials and work at no additional cost to the Department. The Engineer will accept piles with a reduced capacity and with no other remedial work at a reduced price in accordance with Subsection 105.03, "Conformity with Plans and Specifications."

514.05 METHOD OF MEASUREMENT

A. General

For pay items, *Piles, Furnished* and *Piles, Driven*, the Engineer will measure individual pile lengths to the nearest hundredth of a foot [meter]. The Engineer will round the overall total for each pile type to the nearest hundredth of a foot [meter]. The Engineer will not measure remedial piling work.

B. Piles, Furnished

The Engineer will measure each pile type, provided pile lengths, and stockpiled pile lengths required by the Contract as the *Piles, Furnished* pay item.

The Engineer will measure quantities of *Piles, Furnished* by the total plan length with approved increases for extensions as follows:

- The Department defines the total plan length as the sum of planned pile lengths for a pile type, as shown on the Plans or directed by the Engineer.
- For concrete piles, the Engineer will add provided extensions that do not exceed the length directed in writing by the Engineer.
- For steel piles, the *Piles, Furnished* quantity will equal the *Piles, Driven* quantity if the as-built *Piles, Driven* quantity exceeds the total plan length.

C. Piles, Driven

The Engineer will measure the length of piles driven as *Piles, Driven*.

D. Splices for Steel Piling

The Department will not measure steel piling splices required to achieve plan length and allowed by Table 514:3 for payment. The Department will include the cost of all splices required to achieve plan length and allowed by Table 514:3 in the unit price bid for *piles, driven*.

One steel piling splice on an individual pile will be measured for payment for piling extensions beyond plan length. Meet the following conditions before the Department measures the steel piling splice for payment:

- The plan length on an individual pile has been driven,
- The required bearing capacity for an individual pile has not been achieved at the plan length, and
- The splice is produced after condition 1 and 2 have been met.

E. Pilot Holes

The Department will measure preboring for pilot holes, when specified on the Plans or in the Contract, by the linear foot [meter] from the top of existing groundline, at the center of the pilot hole, to the final point elevation of the hole, as defined in the Plans, to a specified point elevation, designated minimum penetration into specified soil/rock classifications, or as authorized by the Engineer. The Department will not measure additional length resulting from temporary earthen fills placed by the Contractor or unapproved additional depth of the pilot hole for payment.

The Department will not separately measure or pay for pilot holes required for the Contractor's convenience. The Department will pay for pilot holes required for the Contractor's convenience in the contract unit bid price for other items in the Contract.

The Department will not separately measure or pay for temporary or permanent casings for pilot holes. The Department will pay for temporary or permanent casings for pilot holes in the contract unit bid price for other items in the Contract.

514.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) PILES, FURNISHED	Linear Foot [Meter]
(B) PILES, DRIVEN	Linear Foot [Meter]
(C) TEST PILES, FURNISHED	Linear Foot [Meter]
(D) TEST PILES, DRIVEN	Linear Foot [Meter]
(E) PILE LOAD TEST (STATIC)	Each
(F) PILE LOAD TEST (DYNAMIC)	Each
(G) METAL PILE SHOES	Each
(H) SHEET PILING, FURNISHED	Square Yard [Square Meter]
(I) SHEET PILING, DRIVEN	Square Yard [Square Meter]
(J) TEMPORARY SHEET PILING	Lump Sum
(K) PILOT HOLES	Linear Foot [Meter]
(L) PILE SPLICE (NON-BIDDABLE)	Each

The Department will consider the cost of providing and delivering piles, including steel shells for cast-in-place driven piles, to the Project, and providing and placing concrete and reinforcing steel for cast-in-place concrete piles to be included in the contract unit price for *Piles, Furnished*.

For calculating progress estimates, the Department will consider concrete piles 50 percent complete if cast as required by the Contract. The Department will pay this item on the progress estimate at 50 percent of the contract unit price or prices, based on the total linear quantity cast.

For each size of pile in the bid schedule, the price bid for furnishing may not exceed 70% of the combined price bid for furnishing and driving.

The Department will consider the cost of driving and cutting off piles to be included in the contract unit price for *Piles, Driven*.

The Department will consider the cost of load tests to be included in the contract unit price for the relevant pile load test pay item.

The Department will pay for each accepted steel pile splice at the contract price for 10 ft [3 m] of *Piles, Driven*.

The Department will not pay additionally for increased footing dimensions due to out-of-position piles.

The Department will pay for each accepted splice (by type of pile, for all piling sizes of that type) at the following rates:

Compensation Rate Per Splice	
Piling Size, in [mm]	Rate Per Splice
Steel H-Pile	$400
Steel Pipe Pile	$500
Concrete Pile Build-UP	$750

When *Temporary Sheet Piling* is not specified for payment in the Plans, the Department will consider it incidental and will pay for it in other items of work.

SECTION 515
PENETRATING WATER REPELLENT TREATMENT

515.01 DESCRIPTION

This work consists of treating concrete surfaces with a penetrating water repellent treatment solution.

515.02 MATERIALS

Provide penetrating water repellent treatment solution in accordance with Subsection 701.12, "Penetrating Water Repellent for Treatment of Concrete Surfaces."

515.03 EQUIPMENT

A. General

Provide equipment in accordance with Subsection 108.06, "Methods and Equipment," and the treatment solution manufacturer's recommendations.

B. Surface Preparation

Use at least one of the following types of equipment for surface preparation:

(1) Sand-Blasting

Provide a compressed air pressure sand-blaster to clean concrete surfaces as required by the Contract.

(2) Shot-Blasting

Provide a portable machine that uses a recyclable steel shot blast technique to clean horizontal concrete surfaces.

(3) Hot Water Pressure Washers

Provide a hot water pressure system that cleans concrete surfaces, as required by the Contract, with water at least 160 °F [70 °C] and a nozzle pressure of 2,500 psi [17 MPa].

(4) Hydroblast Washer

Provide a high pressure cold water washer unit using 7,000 psi [48 MPa] nozzle pressures to clean concrete surfaces as required by the Contract.

(5) Steam Cleaning

Provide a steam jet that uses water 320 °F [160 °C] under an operating pressure of 300 psi [2 MPA] to prepare concrete surfaces as required by the Contract.

C. Application

Provide low pressure airless spray equipment with an application pressure from 15 psi to 40 psi [100 kPa to 275 kPa].

515.04 CONSTRUCTION METHODS

A. Treatment

(1) General

Employ personnel certified by the treatment solution manufacturer to clean the concrete surface and apply the penetrating water repellent solution. Follow the manufacturer's recommendations for surface preparation and application. Before starting work, provide the Engineer with the following information:

- Treatment solution, including: brand name, manufacturer's name, and a copy of the manufacturer's unabridged application procedures,
- Equipment,
- Surface preparation methods,
- Application methods,
- Weather limitations, and
- Treatment solution manufacturer's certified personnel

(2) Surface Preparation

Clean concrete surfaces before applying the penetrating water repellent treatment solution. Remove all foreign materials from the surface.

The Department will allow the use of pretreatment cleaning agents before cleaning with water. Use solvents and hand tools to remove bonded materials, detrimental to concrete surface treatment.

The Department will allow the addition of detergents to cleaning water in proportions of 2 percent or less by weight to reduce the surface tension of the cleaning water.

During cleaning, do not remove or alter the existing concrete surface finish, or expose the coarse aggregate. Provide a uniform surface color.

After cleaning with water, remove excess moisture that may delay surface drying or inhibit surface penetration of the repellent treatment solution.

(3) Application

(a) *Preapplication Requirements*

Allow the concrete to cure for at least 28 days before applying surface treatment. After rain or water cleaning, allow concrete surfaces to dry for at least 8 hr before applying penetrating water repellent treatment solution. For formed surfaces, apply penetrating water repellent treatment after applying Class 1 through Class 6 concrete surface finishes, and before applying a Class 7 paint finish. Refer to Subsection 509.04.G, "Finishing Formed Concrete Surfaces," for definitions of surface finish classes.

Clean contaminated concrete surfaces before applying the penetrating water repellent treatment.

(b) *Inspection*

Allow the Engineer to inspect the work at least 1 day before the application of penetrating water repellent treatment. The Engineer will use the fugitive dye in the solution to gauge the uniformity of application. The Department will require re-treatment in areas with inadequate coverage.

(c) ***Application Rate***

Use the penetrating water repellent treatment solution as supplied by the manufacturer. The Department will not allow dilution or alteration of the solution.

Spray a flood coat of the solution onto concrete surfaces as required by the Contract. Adjust the application rate for vertical, tined, grooved or roughened surfaces.

(d) ***Weather Limitations***

Apply the penetrating water repellent treatment solution in accordance with Table 515:1, "Acceptable Weather Conditions During Application," and the manufacturer's recommendations, whichever is more restrictive.

Table 515:1
Acceptable Weather Conditions During Application

Weather Condition	Acceptable Range
Temperature: air or concrete surface	Above 40 °F [4 °C] and within the manufacturer's recommended application temperature range
Wind speed	Below 25 mph [40 km/hr]
Precipitation	None

(e) ***Seasonal Limitations***

Comply with the manufacturer's seasonal limitations.

(f) ***Traffic***

Keep traffic off treated surfaces until the solution dries.

B. Control of Materials

Use penetrating water repellent treatment solution in unopened containers with numbered seals and the manufacturer's label. Ensure the manufacturer marks the containers with the following information:

- Manufacturer's name and address,
- Product name,
- Date of manufacture,
- Expiration date, and
- Lot identification number.

Protect materials in the original unopened containers in a storage facility that provides safe and secure storage.

C. Sampling and Testing of Bridge Decks and Approaches

After the concrete surface treatment, the Engineer will determine the number and size of sample lots in accordance with the following:

- Determine the number of lots by dividing the surface area of the bridge deck and approach slabs (in square feet [square meter]) by 20,000 ft² [2,000 m²].
- Round to the nearest whole number, ensuring at least two lots per structure (bridge deck and approach slabs).
- Divide the surface area of the bridge deck and approach slab into lots of equal surface area.

- Ensure the width of each lot equals the width of the deck or slab.
- Determine the length of each lot by dividing the surface area of the lot by its width.

Take two core samples of treated concrete for testing from each lot of treated surface locations within the lot area selected randomly by the Engineer. Take additional samples as directed by the Engineer.

Before coring, locate rebar in the bridge deck and approach slabs to avoid rebar during coring. Make the cores 4 in [100 mm] in diameter by 4 in [100 mm] in depth. Core the concrete in the Engineer's presence and submit the cores to the Engineer.

The Engineer will test the cores for moisture absorption and depth of treatment penetration in accordance with Subsection 701.12, "Penetrating Water Repellent for Treatment of Concrete Surfaces." The Engineer will evaluate bridge deck and approach slab treatment for acceptance and payment.

Test the surface treatment independently with one core per lot to determine the adequacy of the work. The Department will not use these independent results for acceptance or payment.

D. Acceptance

(1) Concrete Surfaces Other Than Bridge Deck and Approach Slabs

The Department will base the acceptance of penetrating water repellent application for concrete surfaces other than bridge decks and approach slabs on two visual inspections by the Engineer; once after surface preparation and once after treatment. The Engineer will accept surfaces cleaned and treated as required by the Contract.

(2) Bridge Decks and Approach Slab Surfaces

The Department will base the acceptance of penetrating water repellent application for bridge deck and approach slab treatment on absorption and penetration test results. The Engineer will adjust payment for each lot by calculating a pay factor for absorption and penetration, and a combined pay factor.

(a) *Absorption Pay Factor*

The Engineer will determine the absorption pay factor for each lot using the following equations:

If A ≤ 1.000 $PF_a = 1.00$

If 1.000 < A < 1.500 $PF_a = 1.00 - (A - 1.0)$

If A ≥ 1.500 $PF_a = 0.00$

where

PF_a = Absorption pay factor, and

A = Percentage of absorption using test results from OHD L39.

(b) *Penetration Pay Factor*

The Engineer will determine the penetration pay factor for each lot using the following equations:

If D ≥ 0.25 in [6.3 mm] $PF_p = 1.05$

If 0.15 in < D < 0.25 in $PF_p = 1.00 + 0.5 \times (D - 0.15)$

[3.8 mm < D < 6.3 mm] $PF_p = 1.00 + 0.2 \times (D - 3.8)$

If 0.05 in < D < 0.15 in $PF_p = \frac{D - 0.05}{0.1}$

[1.3 mm < D < 3.8 mm] $PF_p = \frac{D - 1.3}{2.5}$

If D ≤ 0.05 in [1.3 mm] $PF_p = 0.00$

where

PF_p = Penetration pay factor, and

D = Depth of penetration in inches [millimeters] using test results from OHD L40.

(c) ***Combined Pay Factor***

The Engineer will determine the combined pay factor for each lot using the following equation:

$$PF = PF_a \times PF_P$$

where

PF_a = Absorption pay factor,

PF_p = Penetration pay factor, and

PF = Combined pay factor

The Engineer will multiply the contract unit price by the combined pay factor to determine payment for each lot. If the combined pay factor for any lot on a structure is less than 1.00, the Department will reduce the incentive portion (that in excess of 1.00) of the overall pay factors for all lots on the structure by 50 percent.

E. Core Hole Repair

Repair core holes with a cement mortar consisting of portland cement, concrete sand, water, and acrylic polymer binder. Proportion the cement mortar in accordance with the manufacturer recommendations of the acrylic polymer binder. Submit mix design for approval by the Engineer. Place mortar the day the cores are taken. Treat the patch surface with treatment solution after curing.

515.05 METHOD OF MEASUREMENT — VACANT

515.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) WATER REPELLENT (VISUALLY INSPECTED)	Square Yard [Square Meter]
(B) WATER REPELLENT (PERFORMANCE TESTED)	Square Yard [Square Meter]

SECTION 516
DRILLED SHAFT FOUNDATIONS

516.01 DESCRIPTION

This work consists of constructing drilled shafts and providing and placing reinforcing steel and concrete.

516.02 MATERIALS

A. General

Use materials in accordance with the following sections:

Material:	Section:
Structural Concrete	509
Reinforcing Steel for Structures	511

B. Concrete

Provide and modify Class AA concrete as follows:

- Limit the maximum aggregate size to ¾ in [19 mm],
- Ensure that water/cement ratio is 0.44 or lower,
- Use a High Range Water Reducing admixture to achieve 6 in to 8 in [150 mm to 200 mm] of slump at the placement start. Ensure at least 4 in [100 mm] of slump exists at the completion of placement and casing or reinforcement alignment, and
- Maintain the concrete temperature below 85 °F [30 °C] during placement.

C. Casings

For exterior casings, provide smooth, clean, watertight, steel casings that can withstand handling, driving, driving stresses, and pressures from the concrete and surrounding earth. Provide permanent casing with the dimensions specified by the American Pipe Institute tolerances for regular steel pipe. If only a single casing is used in a shaft, the casing is considered an exterior casing.

For permanent exterior casings, use steel in accordance with AASHTO M 270 Grade 36 (ASTM A 709M Grade 250), unless otherwise specified by the Contract. Weld permanent exterior casings in accordance with Section 506, “Structural Steel.” The Department defines permanent exterior casing diameters shown on the Plans as outside diameters.

When the Contract requires permanent exterior casings, or if the electing to provide a permanent exterior casing, ensure that a Registered Professional Engineer in the State of Oklahoma stamps and designs the design and calculations for these casings. Submit permanent casings and design calculations to the Engineer.

For permanent interior casings, use round corrugated galvanized steel pipe with 3 in × 1 in [75 mm × 25 mm] corrugations in accordance with AASHTO M 36. Ensure the pipe gauge stays round and can withstand the concrete pressure.

516.03 EQUIPMENT — VACANT

516.04 CONSTRUCTION METHODS

A. Contractor Qualifications

Use personnel experienced in constructing drilled shafts.

Submit an installation plan or work plan that includes the following details before constructing drilled shafts:

- List of personnel experienced in constructing drilled shafts including resumes of project experiences and documentation that verifies the information;
- Concrete mix design including results of concrete trial mix and tests for slump loss over time. Include procedures for introducing admixtures during mixing operations including set retarders;
- List of proposed equipment to be used, including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies, and concrete pumps;
- List types of casings to be used by the contractor in accordance with Subsection 516.02.C, "Casings." Include diameters and thicknesses for all permanent, temporary, and surface casings;
- Details of shaft excavation methods and procedures for maintaining horizontal and vertical alignment of the excavation;
- When the slurry method is used, include details of the methods to mix, circulate, desand, and dispose of the slurry;
- Details of methods to clean the shaft excavation, and use or disposal of the excavated materials;
- Placement of reinforcing steel including support and centering methods required to minimize lateral movement of the steel cage. Use concrete rollers except concrete sleds are acceptable in lieu of the rollers when casing is used down to the rock line; and
- Concrete placement, including proposed operational procedures for tremie and pumping methods. Include procedure that will be used to verify the outlet end is at least 5 ft into the fluid concrete.

Revise and resubmit the installation plan if it does not produce Contract required results. Submit requests for changing the top of shaft elevations with the installation plan.

B. Trial Drilled Shafts

If the Contract requires trial drilled shafts, construct them adjacent to the permanent shafts before constructing the permanent drilled shafts. Demonstrate that the methods and equipment can construct the Contract required drilled shafts.

Construct the trial shaft to the size and tip elevation of the deepest shaft shown on the Plans. To monitor excavation stability and groundwater seepage, leave completed excavation open for at least 4 hr before concreting. Clean the excavation and fill the hole completely with mix design concrete. Remove the concrete 2 ft [0.6 m] below the finished grade. The Engineer does not require reinforcing steel in trial drilled shafts.

If the Engineer determines that trial drilled shaft is unsatisfactory, modify and resubmit the installation plan and drill a new trial shaft. The Engineer will not allow changes to the installation plan without resubmission.

C. Drilled Shafts

(1) Hole Excavation

Excavate holes in accordance with the installation plan. Before drilling, excavate for structure footings supported on drilled shafts and construct embankments and fills.

Place the drilled shaft horizontally at the top of the shaft elevation within 3 in [75 mm] of the position shown on the Plans. Ensure the vertical shaft alignment does not vary by more than 1 percent of shaft depth. Ensure the battered shaft alignment does not vary by more than 2 percent of shaft depth.

Use excavation equipment and methods that provide a shaft bottom normal to the axis of the shaft within 5 percent of the shaft diameter. Measurement of the shaft bottom tolerance will be left to the discretion of the Engineer. Use excavation equipment that provides a drilled shaft diameter larger than or equal to the plan diameter minus 1 in [25 mm].

Excavate below the elevation shown on the Plans if the load bearing material does not satisfy Plan requirements. Take soil samples or rock cores as shown on the Plans to determine the character of the material directly below the shaft excavation. Immediately notify the Engineer of deviations in subsurface conditions that may change the shaft depth.

Before placing concrete, check dimensions and alignment of shaft excavations in the presence of the Engineer. The Engineer will measure final shaft depth after final cleaning.

If the sidewall of the hole softens due to excavation methods, swells due to delays in concreting, or degrades due to slurry cake buildup, over-ream the sidewall from ½ in to 3 in [12 mm to 75 mm] to sound material.

Immediately before placing concrete, clean the hole so 50 percent of each hole bottom has less than ½ in [12 mm] of sediment. Ensure the remaining 50 percent of the hole has no greater than 1½ in [38 mm] of sediment or debris. For dry holes, reduce the water depth to 6 in [150 mm] or less before placing concrete.

Use at least one of the following methods for excavation:

(a) *Dry Method*

Use the dry construction method at sites where the Engineer can visually inspect the shaft before concrete placement. For the dry method:

- Drill the shaft,
- Remove accumulated water,
- Remove loose material from the excavation,
- Place the reinforcing cage, and
- Concrete the shaft in dry conditions.

If caving, sloughing, or swelling conditions exist or if depth of groundwater seepage exceeds 6 in [150 mm], discontinue the dry construction method and use an alternative method approved by the Engineer.

(b) ***Wet Method***

Use the wet construction method or a casing construction method for shafts that do not meet the requirements for dry construction. For the wet method, use water or slurry to maintain the stability of the hole while advancing the excavation to final depth, placing the reinforcing cage, and concreting the shaft. The wet method involves the following work:

- De-sanding and cleaning the slurry,
- Final cleaning of the excavation,
- Placing the shaft concrete with a tremie or concrete pump beginning at the shaft bottom,
- Providing temporary surface casings to aid shaft alignment and positioning, and
- Providing temporary surface casings to prevent sloughing of the top of the shaft excavation.

Refer to Subsection 516.04.C.2, "Slurry," for slurry requirements.

(c) ***Casing Methods***

1) *General*

The Department will not allow casing to the bottom of the shaft. Discontinue the casing at the top of the founding stratum as shown on the Plans. Excavate below the casing using the dry or wet method. To provide design frictional load capacity, excavate into the founding stratum to the deepest length or depth shown on the Plans. Install casing in accordance with Subsection 516.04.C.3, "Exterior Casings."

2) *Temporary Casing Method*

If unable to use the dry or wet methods, use the temporary casing construction method. For temporary casing:

- Use the wet method to advance the excavation through caving material into a impervious formation,
- Set a casing,
- Complete excavation,
- Place the reinforcing cage, and
- Concrete the shaft while removing the casing.

Alternatively, drive or drill the casing into the impervious formation, then excavate.

3) *Permanent Casing Method*

Use the permanent casing construction method if shown on the Plans or where drilled shafts are in open water. For the permanent casing method, advance the excavation through caving material by driving or drilling a permanent casing to the Contract required depth or into a nearly impervious formation, whichever is deepest. Excavate to the final depth, place the reinforcing cage, and concrete the shaft. If full penetration cannot be attained during casing installation, excavate within the embedded portion of the casing. Drill a pilot hole if necessary. Ensure continuous casing from the top of the shaft to the elevation shown on the Plans. If the drilled shafts are in

open water, extend casings from above the water elevation into the ground to protect the shaft concrete from the water during concrete placement and curing.

4) *Double Casing Method*

Use the double casing construction method if the Contract requires or, as an alternative for the temporary casing method, in the presence of severe groundwater or unstable soil conditions. Make the temporary exterior casing larger than the Contract required shaft diameter and set a permanent interior casing into the top of the founding stratum after excavation completion.

Supply the interior casing with a permanent inner diameter equal to the shaft diameter shown on the Plans. Use a temporary exterior casing with an inner diameter at least 6 in [150 mm] larger than the interior casing. After placing the exterior casing, complete the excavation as shown on the Plans. Set the interior casing into the top of the founding stratum and brace it at the top. Remove the temporary casing after filling interior casing with concrete. Add concrete to maintain top of shaft elevation during removal. After the concrete initially sets, do not adjust the interior casing position.

(d)*Obstructions*

The Department defines an obstruction as unexpected manmade materials through which excavation cannot advance. The Department does not consider removal of tools, lost in the excavation, obstructions. Removal of naturally-occurring material, regardless of difficult or removal method, is not considered an obstruction.

Remove obstructions encountered during excavation. Notify the Engineer, in advance, of the proposed obstruction removal method. Include a cost estimate for excess costs in accordance with Subsection 104.03, “Differing Site Conditions,” for obstruction removal compensation. Use blasting methods if approved by the Engineer.

(2)Slurry

Before introducing it into the shaft, hydrate the slurry by premixing the material with fresh water in accordance with the slurry manufacturer’s instructions. Provide slurry tanks with the capacity for slurry circulation, storage, and treatment. The Department will not allow the use of excavated slurry pits. Use either mineral (bentonite or attapulgite) or polymer slurry.

Provide de-sanding equipment to limit slurry sand content at any point in the bore hole. Ensure slurry sand content is less than 4 percent by volume for mineral slurry, and less than 1 percent for polymer slurry. The Engineer does not require de-sanding to set temporary casings.

During drilling, maintain a slurry surface in the shaft at least 4 ft [1.2 m] above the highest expected water table elevation and at a level that prevents the hole from caving.

When there is a sudden loss of slurry from the hole, stop drilling and take corrective action to prevent slurry loss. Prevent the slurry from “setting up” in the shaft. If the slurry construction method fails to produce the Contract required results, stop and use an alternative method approved by the Engineer.

When the excavation reaches the elevation shown on the Plans and clean, allow at least 30 min for polymer slurry to stand undisturbed. Clean the excavation base with a submersible pump or air lift.

Maintain the density, viscosity, and pH of the slurry during shaft excavation in accordance with Table 516:1 for mineral slurry and Table 516:2 for polymer slurry.

Table 516:1
Acceptable Range of Mineral Slurry

Property, Method	At the Time of Slurry Introduction	In Hole at Time of Concreting
Density, [a] Density Balance (lb/ft³ [kg/m³])	64.3 – 69.1 [1,030 – 1,107]	64.3 – 75.0 [1,030 – 1,200]
Viscosity, Marsh Cone (s/qt [s/L])	28 – 45 [30 – 48]	28 – 45 [30 – 48]
pH, pH paper or meter	8 – 11	8 – 11

Note: Perform tests when slurry temperature are above 40 °F [4 °C].
[a] Density values are for fresh water. Increase density values 2.0 lb/ft³ [32 kg/m³] for salt water.

Table 516:2
Acceptable Range of Polymer Slurry

Property, Method	At the Time of Slurry Introduction	In Hole at Time of Concreting
Density, [a] Density Balance (lb/ft³ [kg/m³])	62.4 – 63.0 [1,000 – 1,010]	62.4 – 63.5 [1,000 – 1,017]
Viscosity, Marsh Cone (s/qt [s/L])	30 – 40 [32 – 42]	30 – 40 [32 – 42]
pH, pH paper or meter	9 – 11	9 – 11

Note: Perform tests when slurry temperature are above 40 °F [4 °C].
[a] Density values are for fresh water. Increase density values 2.0 lb/ft³ [32 kg/m³] for salt water

Take slurry samples using an Engineer approved sampling tool. Extract slurry samples from the base of the shaft and from 10 ft [3 m] above the shaft base. Perform four sets of tests during the first 8 hr of slurry use. When the results are acceptable and consistent, perform one test set for every 4 hr of slurry use.

Make corrections if the test results indicate unacceptable slurry samples. Place concrete when the resampling and retesting indicate acceptable values.

Provide reports of tests, signed by an authorized representative, after completion of each drilled shaft.

Dispose of slurry at approved locations.

(3)Exterior Casings

Ensure casings produce a positive seal that prevents water or other material from piping into or out of the hole. If substituting a casing with a longer or larger diameter casing through caving soils, stabilize the excavation with slurry or backfill before installing the new casing.

Consider subsurface exterior casings as temporary unless designated in the Contract as permanent casing. Remove temporary casing before completing placement of concrete in cased drilled shaft. While removing casing from the hole, maintain at least 5 ft [1.5 m] of fresh concrete in the casing above the surrounding

level of water or slurry. Ensure the excess concrete within the casing displaces fluid trapped behind the casing upward and discharges it at the ground surface without contaminating or displacing the shaft concrete.

The Department defines defects in the drilled shaft as temporary casings that are bound or fouled during shaft construction and cannot be practically removed, as determined by the Engineer.

Extend casings above the surface to keep the excavation clean through concrete placement. Cut the casing off of permanent casings at the elevation shown on the Plans and leave in place after concrete placement.

(4) Reinforcing Steel Cages for Drilled Shafts

(a) ***General***

Place the reinforcing steel cage as a unit after the shaft excavation is approved by the Engineer and before concrete placement. Tie reinforcing steel lap splices together using wire. If the concrete is not placed immediately after the cage installation, remove the cage and verify the integrity of the excavated area, and ensure loose material is removed from the bottom of the hole.

Tie and support the reinforcing steel to keep it within the Contract required tolerances. Tie spacing devices at least at fifth points around the cage perimeter or one per 12 in [300 mm] of shaft diameter. Space them at intervals no greater than 10 ft [3 m] along the length of the cage. Place spacers within 18 in [450 mm] of the top and bottom of the shaft. Use spacers that equal the shaft concrete in quality and durability.

During concrete placement, provide positive support from the top for the reinforcing steel cage. Support the cage concentrically to prevent racking and distortion. Maintain the top of the reinforcing steel cage no greater than 6 in [150 mm] above and no greater than 3 in [75 mm] below the Contract required position. Make corrections if the reinforcing steel cage is not maintained in that position. Do not construct additional shafts until the method of reinforcing steel cage support has been approved by the Engineer.

Provide additional reinforcing steel if conditions require shafts longer than shown on the Plans.

(b) ***Access Tubes for Crosshole Sonic Logging***

Provide Crosshole Sonic Logging (CSL) testing access tubes for drilled shafts if the Contract requires.

Use access tubes with 2 in [50 mm] inner diameters that are made of schedule 40 steel pipe. Provide tubes, including pipe joints, with a round, regular internal diameter that allows a 1.3 in [33 mm] diameter source and receiver probes to pass unobstructed. Make the tubes and joints watertight and corrosion free, with clean surfaces that allow a good bond between the concrete and the tubes.

Install access tubes to the full depth of each shaft for CSL testing equipment. Unless otherwise required by the Contract, install the number of access tubes in each drill shaft in accordance with Table 516:3.

Table 516:3 Minimum Number of Access Tubes per Drilled Shaft	
Planned Shaft Diameter, *ft [m]*	**Minimum Number of Access Tubes**
D≤3.0 [D≤0.9]	3
3.0 < D ≤ 4.0 [9.0 < D ≤ 1.2]	4
4.0 < D ≤ 5.0 [1.2 < D ≤ 1.5]	5
5.0 < D ≤ 6.0 [1.5 < D ≤ 1.8]	6
6.0 < D ≤ 8.0 [1.8 < D ≤ 2.4]	7
8.0 < D ≤ 10.0 [2.4 < D ≤ 3.0]	8
10.0 < D ≤ 12.0 [3.0 < D ≤ 3.7]	9

Fit tubes with a watertight shoe on the bottom and a removable cap on the top. Attach the tubes to the interior of the reinforcement cage in a regular, symmetric pattern, equally spaced around the perimeter of the cage. Install the tubes parallel to each other and vertical. Start the tubes from the shaft bottom and end at least 3 ft [0.9 m] above the shaft top. If the shaft top is subsurface, extend the tubes at least 3 ft [0.9 m] above the ground, water surface, or both.

Avoid damaging the tubes during reinforcement installation operations in the drilled shaft hole. Before concrete placement, fill the access tubes with clean water and cap the tube tops. After concrete placement, avoid breaking the bond between the access tubes and the concrete.

(5) Concrete for Drilled Shafts

Place concrete after completing excavation and placing the reinforcing steel cage. Complete concreting in a shaft and remove the temporary casing within 2 hr of beginning concrete placement. The Department will not allow retempering concrete that has developed an initial set.

Before placing concrete in a wet hole, allow water to seek its natural hydraulic head.

Using a tremie or concrete pump, place concrete in one continuous operation from the bottom to the top of the shaft. Place concrete until acceptance quality concrete reaches the top of the shaft. For a dry shaft, overflow the top with 1 ft [300 mm] of concrete. For a wet shaft, overflow the top with 5 ft [1.5 m] of concrete. Continue overflow of concrete in shafts until uncontaminated concrete is evident. Before initial concrete sets, consolidate the top 10 ft [3 m] of the shaft using Engineer approved vibratory equipment. Finish the top of the shaft from 3 in [75 mm] lower to 1 in [25 mm] higher than the elevation shown on the Plans. In wet holes, consolidate after removing water above the concrete surface.

Place the discharge end of a tremie or concrete pump at the shaft base elevation. Keep the discharge end immersed at least 5 ft [1.5 m] below the surface of the fluid concrete. Maintain a positive head of concrete in the tremie or pump during concrete placement. If the discharge end is removed from the fluid concrete column during the concrete placement and concrete is discharged above the rising concrete surface into displaced water, remove the reinforcing cage and concrete, complete sidewall removal as directed by the Engineer, and reconstruct the shaft.

If the top of the shaft is above ground, form the shaft from the top to at least 2 ft [0.6 m] below finished ground. If the top of the shaft is below ground, use a

temporary oversize surface casing to control material caving into the freshly placed concrete.

The Engineer will sample concrete for acceptance at the point of discharge into the tremie or concrete pump hopper. Cure exposed concrete surfaces in accordance with Section 509, "Structural Concrete."

(a)*Tremies*

The Department defines tremies as tubes that discharge concrete at the shaft base. Use watertight tremies to place concrete in wet or dry holes. Ensure the bottom of the tremie can be sealed and charged with concrete in the dry, and then opened in place at the bottom of the shaft. The Department will not allow the use of tremies containing aluminum parts that will come in contact with concrete. Ensure that the tremie can be lowered rapidly to retard or stop the flow of concrete.

Provide a tremie with an inner diameter from 10 in to 14 in [254 mm to 350 mm], clean and smooth surfaces, and a wall that prevents crimping or sharp bends. Fit the top with a hopper. Construct the discharge end of the tremie to allow free radial concrete flow during placement.

(b)*Concrete Pumps*

Use pumped concrete placement in wet or dry holes. Use at least 4 in [100 mm] diameter discharge tubes with watertight joints. Place the discharge tube at the shaft base elevation.

For wet holes, use pumps with a device at the end of the discharge tube to seal out water while the tube fills with concrete. If a plug is used, remove it from the hole. Alternatively, use a plug of Engineer approved material that will prevent a defect in the shaft.

(6)Application of Construction Loads

If the Contract requires Nondestructive Testing (NDT), the shaft must pass NDT before application of any loads or proceeding with the construction of the pier. If the Contract does not require NDT or the NDT passes the tests, allow concrete in the shaft to reach at least 80 percent of the specified strength before application of loads. Determine strengths from test cylinders cured at the work site under similar environmental conditions in accordance with Section 701, "Portland Cement Concrete."

(7)Nondestructive Testing of Drilled Shafts

(a)*General*

If the Contract requires, provide CSL testing to check the integrity of concrete drilled shafts. If the Contract requires CSL access tubes but CSL testing was not specified and the Engineer observes a construction problem during shaft construction, the Department will conduct CSL testing. If access tubes are not required by the Contract or installed, the Engineer may require full depth coring to determine the soundness of a drilled shaft in accordance with Subsection 516.04.C.6.g, "Core Drilling of Drilled Shaft Concrete."

(b) ***NDT Consultant***

If the Contract requires CSL testing, provide an experienced Nondestructive Testing (NDT) consultant. Submit resumes of the consulting personnel for Engineer approval before testing. Perform CSL testing and analysis under the supervision of a Registered Professional Engineer. Ensure the consultant has at least 1 year of experience in field testing and analyzing CSL testing.

(c) ***Testing Schedule***

Wait at least 24 hr after placing concrete in a shaft before CSL testing. After concrete placement, finish CSL testing within 30 calendar days for steel access tubes.

(d) ***CSL Test Equipment***

Use CSL test equipment that can perform the following functions:

- Display individual CSL records.
- Record CSL data.
- Analyze receiver responses.
- Print CSL logs.
- Test in 2 in [50 mm] inside diameter (ID) access tubes.
- Generate an ultrasonic voltage pulse to excite the source with a synchronized triggering system to start the recording system.
- Measure and record the depths of CSL probes at the time signals are recorded.
- Filter and amplify signals.

(e) ***CSL Logging Procedures***

Test perimeter tube pairs and major diagonal tube pairs. If a possible defect is indicated, conduct CSL testing between additional pairs of tubes as specified by the NDT consultant.

Perform CSL tests with the source and receiver probes in the same horizontal plane unless tests indicate potential defects. To further evaluate a questionable zone, conduct angled tests consisting of the source and receiver vertically offset in the access tubes. Make CSL measurements at depth intervals of 2 in [50 mm]. Pull the probes, starting from the bottom of the tubes, over a depth-measuring device. Remove slack from the cables before pulling to provide accurate depth measurements. Report indicated defects to the Engineer and conduct further tests to evaluate the extent of the defects.

(f) ***CSL Testing Results***

Within 72 hr of CSL testing, provide the Engineer with a preliminary report. Within 10 working days of testing, provide two copies of the final CSL testing report sealed by the Professional Engineer supervising the testing. In the final report, include the CSL logs with analyses of the initial pulse arrival time versus depth and pulse energy, or amplitude versus depth. Present a CSL log for each tube pair tested with defect zones indicated on the logs and discussed in the test report.

Include the following in the report:

- A summary of the CSL test results that covers drilled shaft identification,

- Test date,
- Shaft age at time of CSL testing,
- Drilled shaft diameter,
- Number of CSL tubes tested,
- Test length,
- Average compression velocity, and
- Defect descriptions.

Include the following in the defect description of the report:

- The CSL tube number,
- Depth below concrete top,
- Percent concrete wave speed reduction, and
- Recommended concrete condition rating.

The Engineer will evaluate the CSL test results and determine the acceptability of the drilled shaft construction.

(g)*Core Drilling of Drilled Shaft Concrete*

If the Engineer determines a drilled shaft unacceptable, the Engineer may require continuous coring of the shaft using an "NW" size core barrel, in accordance with ASTM D2113. The Engineer will specify the number, depth, and location of cores. Submit the methods and equipment for coring and grouting to the Engineer for approval before coring.

Place the cores in a crate and mark the shaft depth at each core recovery interval. Submit the cores and a log for recovered cores.

When the Engineer determines that the quality of the concrete in the shaft, represented by the core samples, is acceptable, construct above the drilled shaft. The drilled shaft will be considered defective if the Engineer determines that the quality of the concrete in a drilled shaft is unacceptable.

(h)*Abandoning CSL Access Tubes*

After completing CSL testing and obtaining the Engineer's approval to continue construction above the shafts, dewater and portland cement grout the access tubes in the drilled shafts. Submit the grout mix design and grouting method for the Engineer's approval.

(8)Defective Shafts

Correct defective shafts as required by the Contract. Submit a plan for correction to the Engineer. Corrective action may consist of, but not limited to, the following:

- Remove the shaft concrete and deepen the shaft to compensate for loss of frictional capacity in the cased zone if temporary casing cannot be removed.
- Provide straddle shafts to compensate for capacity loss.
- Provide a replacement shaft.

516.05 METHOD OF MEASUREMENT

The Engineer will measure the length of *Drilled Shafts* and *Trial Drilled Shafts* from the shaft base to the top of shaft. The Engineer will base measurements on elevations

shown on the Plans or approved by the Engineer. The Engineer will not measure corrective work or miscellaneous items, such as, soil samples and rock cores required by the Contract, rebar splices, permanent casings, lost tools and equipment, overreamed excavation, surface excavation and backfill, overflow concrete and concrete placed outside the neat lines of the shaft.

The Engineer will measure *CSL Access Tubes* if shown on the Plans.

If required by the Contract, the Engineer will measure CSL testing per drilled shaft tested. The Engineer will not measure tests for determining the extent of defects.

The Engineer will not make reductions in drilled shaft measurements due to obstructions.

516.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) DRILLED SHAFTS	Linear Foot [Meter]
(B) TRIAL DRILLED SHAFTS	Linear Foot [Meter]
(C) CROSSHOLE SONIC LOGGING	Each
(D) CSL ACCESS TUBES	Linear Foot [Meter]
(E) OBSTRUCTIONS	Lump Sum

The Department will pay for the following under a Supplemental Agreement:

- Approved obstructions,
- Nondestructive testing directed by the Engineer that reveals no structural defects, and
- Contractor soil sampling or rock coring directed by the Engineer, that reveals no structural defects.

The Department will not pay for the following:

- Nondestructive testing directed by the Engineer that reveals structural defects requiring corrective action,
- Contractor soil sampling or rock coring directed by the Engineer, that reveals structural defects requiring corrective action, and
- Tube lengths in excess of the length shown on the Plans or otherwise approved by the Engineer.

The Department will consider the cost of abandoning CSL access tubes to be included in the contract unit price for *CSL Access Tubes*.

SECTION 517
POST-TENSIONING

517.01 DESCRIPTION

A. General

Post-tensioning work consists of stressing concrete by furnishing, placing, and tensioning of post-tensioning steel in accordance with details shown in the contract documents and as specified in these specifications.

This work consists of providing and installing any appurtenant items necessary for the particular stressing system to be used, including but not limited to ducts, anchorage assemblies and grout used for pressure grouting ducts.

B. Definitions

Anchorage assembly. An assembly of various hardware components that secures the end of a tendon after stressing, transferring the tendon force into the concrete.

Anticipated set. The wedge set in the design calculation of post-tensioning forces at the time of load transfer.

Bar. Coarsely threaded, high strength steel bars, from ⅝ in to 1¾ in [15 mm to 46 mm] in diameter.

Bearing plate. Transfers the tendon force directly into a structure or the ground.

Bleed. Excess flow of water in or out of new grout.

Coupler. Transfers the prestressing force between partial length post-tensioning tendons.

Duct. Conduit that accommodates post-tensioning steel and provides a space for the grout that protects the steel.

Family of systems. Groups of post-tensioning tendon assemblies that use common anchorage devices and design.

Fluidity. Measure of time in seconds for a quantity of grout to pass through a flow cone.

Grout. Mixture of cementitious materials and water (with or without mineral additives or admixtures), proportioned to a consistency that can be pumped without segregation into the duct around the post-tensioning steel.

Grout cap. Contains the grout and forms a protective cover sealing the post-tensioning steel at the anchorage.

Inlet. Tubing or duct used to inject the grout into the duct.

Outlet. Tubing or duct that allows air, water, grout, and bleed water to escape from the duct.

Permanent stress and permanent force. Stress and force remaining in the post-tensioning steel after losses induced by the post-tensioning system.

Post-Tensioning. Method of stressing in which tendon tensioning occurs after the concrete reaches the strength required by the Contract.

Prestressing steel. Steel element of a post-tensioning tendon, elongated and anchored to provide a permanent prestressing force.

Post-tensioning scheme or layout. Pattern, size, and locations of post-tensioning tendons specified by the Designer.

Post-tensioning system. An assembly of tendons of a size and type required by the Contract that meets the system pressure testing specifications. Internal and external systems are independent of one another.

Pressure rating. Maximum estimated pressure that water in a duct or duct component can continuously exert without failure (working pressure).

Set (also anchor set or wedge set). Total movement of a point on the strand just behind the anchoring wedges during load transfers from the jack to the anchorages. Set movement is the sum of the wedge slippage with respect to the anchorage head and the elastic deformation of the anchor components. For bars, set is the total movement of a point on the bar just behind the anchor nut at transfer and is the sum of bar slippage and the elastic deformation of the anchorage components.

Strand. High-strength steel wires wound together. Strands have six outer wires helically wound around a single straight wire of a similar diameter.

Tendon. At least one post-tensioning steel element and anchorage assembly that impart stressing forces to a structural member or the ground.

Tendon size. Number of individual strands of a certain diameter or the bar diameter.

Tendon type. Location of the tendon relative to the internal or external concrete shape.

Thixotropic. Property of a material that enables it to stiffen in a short time while at rest, but to acquire a lower viscosity when mechanically agitated.

Wedge plate. Hardware that holds the wedges of a multi-strand tendon and transfers the tendon force to the anchorage assembly.

Wedge. Conically-shaped device that anchors the strand in the wedge plate.

517.02 MATERIALS

Provide Materials in accordance with the following subsections:

Material:	Subsection:
Post-Tensioning Steel Wire	723.05
Bars for Post-Tensioning	723.04
Water	701.04
Post-Tensioning Grout	701.18
Epoxy Resin and Adhesives	701.13
Magnesium Ammonium Phosphate Concrete	701.21
Elastomeric Coating System	701.13

A. Certification of Post-Tensioning Systems

Provide post-tensioning systems approved by the Department's Materials Division through certified test reports from an independent laboratory and submitted by the manufacturer.

Ensure the manufacturer tests plastic components at a certified independent laboratory accredited by the Geosynthetic Accreditation Institute (GAI) or the American Association for Laboratory Accreditation (AALA). The Department will allow an independent laboratory outside the US to certify test reports if the Department's Materials Division approves of the lab. If modifying or replacing post-tensioning components, retest the system.

Provide the Engineer with certification confirming that the plastic from the duct sample complies with the Contract required cell class, stress-crack rating, and the antioxidant amount in accordance with Subsection 517.02.G, "Duct and Pipe."

Ensure the system components are stamped with the supplier's name, trademark model number, and catalog designation size. Provide post-tensioning systems developed and tested for bar systems, internal corrugated duct, and external smooth duct applications with standard tendons containing 4, 7, 12, 15, 19, and 27 strands. Provide standard tendon sizes consisting of 0.6 in [15 mm] diameter strands.

B. Post-Tensioning System

Provide a post-tensioning system to the Engineer for approval. The Department will not allow substitution of components within an approved system. Store materials in a weatherproof building or container.

Provide tendons enclosed in anchorages and ducts. The Department will not allow systems that transfer prestressing force by bonding the strand directly to concrete. The Engineer will allow embedded anchors for bars. The Engineer will not allow systems that use formed, ungrouted voids.

C. Post-Tensioning Anchorages

Test the anchorages while unbonded to ensure they develop at least 95 percent of the ultimate tensile strength of the post-tensioning steel without exceeding the anticipated set.

Design anchorages so the average concrete bearing stress is in accordance with *AASHTO LRFD Bridge Design Specifications*. Test and provide written certification that confirms anchorages at least meet testing specifications in *AASHTO LRFD Bridge Construction Specifications*.

Galvanize the anchorage body in accordance with ASTM A 123. The Engineer will not require galvanizing for other anchorage components. Provide ferrous metal to construct the bearing surface and wedge plate. Bolt a vented, permanent fiber, reinforced plastic grout-cap to the anchorages.

Provide wedge plates with centering lugs or shoulders to align them with the bearing plate.

Cast anchorages with grout outlets for inspection from the anchorage top or front. Construct grout outlets to facilitate drilling using a straight bit. Provide an endoscope to allow the Engineer to inspect behind the anchor plate. Alternatively, construct

anchorages to facilitate inspection from the top and front, or fabricate two anchorages to provide two inspection entry locations.

D. Bar Couplers

Provide couplers in accordance with *AASHTO LRFD Bridge Design Specifications* and *Bridge Construction Specifications*. Test and provide written certification that shows that the couplers are in accordance with *AASHTO LRFD Bridge Construction Specifications*. The Engineer must approve the use and location of bar couplers for permanent applications.

E. Inlets, Outlets, Valves, and Plugs

Provide permanent grout inlets, outlets, and threaded plugs of ASTM A 240 Type 316 stainless steel, nylon, or polyolefin. Ensure nylon products have a cell class of S-PA0141. Ensure products made from polyolefin contain antioxidants with an Oxidation Induction Time (OIT) of at least 20 min, in accordance with ASTM D 3895. Test the remolded finished polyolefin material for stress crack resistance in accordance with ASTM F 2136. Use an applied stress of 348 psi [2.4 MPa] with a failure time of at least 3 hr. Provide inlets and outlets equipped with pressure rated mechanical shut-off valves or plugs. Ensure inlets, outlets, valves, and plugs are rated for a pressure of at least 150 psi [1.03 MPa]. Provide inlets and outlets with an inside diameter of at least ¾ in [20 mm] for strand and ⅜ in [10 mm] for single bar tendons and four-strand duct.

Provide dual mechanical shutoff valves when vertically grouting.

F. Permanent Grout Caps

Provide permanent grout caps made from fiber-reinforced polymer or ASTM A 240 Type 316L stainless steel. Ensure the resins in the fiber-reinforced polymer are nylon, acrylonitrite butadiene styrene (ABS), or polyester. Seal the cap with **O**-ring seals or precision fitted flat gaskets placed against the bearing plate. Place a grout vent on the top of the cap. Provide grout caps with a pressure rating of at least 150 psi [1.03 MPa]. Provide ASTM A 240 Type 316L stainless steel bolts to attach the cap to the anchorage. Provide certified test reports of the steel chemical analysis if using stainless steel grout caps.

G. Duct and Pipe

(1) General

Provide plastic duct, steel pipe, or both. Provide airtight and watertight connectors, connections, and post-tensioning hardware components that pass the pressure test. Provide smooth, plastic duct in post-tensioning systems for external tendons. Provide corrugated plastic duct in post-tensioning systems for internal.

(2) Duct or Pipe Minimum Diameter

Provide duct with an internal diameter at least ½ in [13 mm] larger than the outside diameter of the post-tensioning bar. For post-tensioning bars with couplers, provide duct ½ in [13 mm] longer than the outside diameter of the coupler.

For multi-strand tendons, provide ducts with a cross-sectional area at least two and one-half times larger than the cross-sectional area of the post-tensioning steel.

(3) Connection Tolerance Between Pipe and Duct

Directly connect steel pipe and plastic duct if the outside diameters vary by less than 0.08 in [2 mm]. Use a reducer to fit steel pipes and plastic ducts with diameters outside the tolerances required by the Contract.

(4) Steel Pipes

Use galvanized Schedule 40 steel pipes where shown on the Plans and in deviation blocks. Equip steel pipes in the tendon anchorage zones with shear transfer devices as shown on the Plans.

(5) Corrugated Plastic Duct

The Department will not allow the use of ducts manufactured from recycled material. Manufacture ducts using seamless fabrication methods.

Provide corrugated duct manufactured from uncolored, unfilled polypropylene, in accordance with ASTM D 4101. Provide polypropylene with a cell classification range from PP0340B44544 to PP0340B65884. Provide white duct with antioxidants with an OIT of at least 20 min, in accordance with ASTM D 3895. Provide duct with a non-yellowing light stabilizer. Use Table 517:1 to determine the minimum duct thickness.

Table 517:1
Duct Dimensions

Duct Shape	Duct Diameter, *in [mm]*	Duct Thickness, *in [mm]*
Flat	any size	0.08 [2.0]
Round	0.9 [23]	0.08 [2.0]
Round	2.375 [59]	0.08 [2.0]
Round	3.0 [76]	0.10 [2.5]
Round	3.35 [85]	0.10 [2.5]
Round	4.0 [100]	0.12 [3.0]
Round	4.5 [115]	0.14 [3.5]
Round	5.125 [130]	0.16 [4.0]
Round	5.71 [145]	0.16 [4.0]

(6) Testing Requirements for Corrugated Plastic Duct

Provide duct system components and accessories in accordance with Chapter 4, Article 4.1 through Article 4.1.8 of International Federation of Structural Concrete (FIB) Technical Report, Bulletin 7, "Corrugated Plastic Ducts for Internal Bonded Post-Tensioning."

Modify the requirements in FIB Technical Report, Bulletin 7, as follows:

- Conduct the lateral load resistance test (FIB 4.1.4) without using a duct stiffener plate. Use a load of 150 lbf [667 N] for all sizes;
- Ensure the wear resistance of the duct (FIB 4.1.7) is at least 0.06 in [1.5 mm] for ducts no greater than 3.35 in [85 mm] in diameter and at least 0.08 in [2 mm] for ducts greater than 3.35 in [85 mm] in diameter;
- Ensure the bond behavior of the duct (FIB 4.1.8) achieves 40 percent Guaranteed Ultimate Tensile Strength GUTS in a maximum length of 16 duct diameters.

(7)Minimum Bending Radius for Corrugated Plastic Duct

Ensure the manufacturer establishes the minimum-bending radius for the duct through testing. The test consists of modifying a duct wear test in accordance with Chapter 4, Article 4.1.7 of FIB Technical Report, Bulletin 7, "Corrugated Plastic Ducts for Internal Bonded Post-Tensioning." Provide identical test and wear test apparatus with clamp forces that are a function of the number of strands in the duct. Modify the procedure as follows:

- Do not move the sample along the strand to simulate wear.
- Ensure the test lasts 7 days.
- When the test period is complete, remove the duct.
- Ensure the wall thickness along the strand path is at least 0.06 in [1.5 mm] for ducts with diameters no greater than 3.35 in [85 mm] diameter, and at least 0.08 in [2 mm] for ducts with diameters greater than 3.35 in [85 mm].

(8)Corrugated Duct Connections and Fittings

Make splices, joints, couplings, and connections to anchorages using devices and methods that produce a smooth interior alignment. Design airtight connections and fittings. The Department will not allow the use of duct tape to join or repair duct connections.

Construct connections and fittings from polyolefin materials containing antioxidant stabilizers in accordance with Subsection 517.02.E, "Inlets, Outlets, Valves, and Plugs."

(9)Smooth Duct

Provide smooth duct manufactured from 100 percent virgin polyethylene resin in accordance with ASTM D 3350. Provide polyethylene resin with a cell class of at least 344464C. Provide resin containing antioxidants with an OIT of 40 min in accordance with ASTM D 3895. Manufacture duct with a 17.0 dimension ratio (DR) in accordance with ASTM D 3055 or ASTM F 714, for the manufacturing process used.

Provide smooth duct with a pressure rating of 100 psi [0.69 MPa]. Provide duct manufactured in accordance with ASTM D 3035 or ASTM F 714.

(10)External Duct Connections

Heat weld to make splices between sections of plastic duct, in accordance with the duct manufacturer's instructions. Alternatively, provide mechanical couplers as required by the Contract. Provide connections with a pressure rating of at least 100 psi [0.69 MPa], produce a smooth interior alignment, and connect without lips or kinks.

Make connections between embedded steel pipe and plastic duct using a mechanical coupler or a circular sleeve made of ethylene propylene deine monomer (EPDM). Provide EPDM with a pressure rating of at least 100 psi [0.69 MPa] and 100 percent quality retention in accordance with ASTM D 1171, ozone chamber exposure method B.

Provide EPDM sleeves with a wall thickness of at least ⅜ in [10 mm] and reinforced with at least four sheets of ply-polyester reinforcement. Use a ⅜ in [10 mm] wide power-seated band and Type 316 stainless steel clamps on the boot

ends to seal against grout leakage. Install the band with a seating force from 80 lbf to 120 lbf [356 N to 534 N].

(11)Corrugated Ferrous Metal Ducts

The Department will not allow the use of corrugated ferrous metal ducts.

(12)Shipping and Storage of Ducts

Provide ducts with end caps to seal the ducts from contamination. Ship the ducts in capped and covered bundles. Protect ducts against ultraviolet degradation, crushing, excessive bending, dirt, and corrosive elements during transportation, storage, and handling. Before incorporating the ducts into the bridge component, keep the end caps in place. Store ducts on a raised platform, in a dry location, protected from the sun, and covered to prevent contamination. Ensure ducts are clean before using. Wash the ducts to remove contamination if necessary.

(13)Flush Water

0.17 lb/gal [0.2 kg/L] slack lime (calcium hydroxide) or quicklime (calcium oxide).

H. Mechanical Couplers and Heat Shrink Sleeve Requirements

Construct mechanical couplers with stainless steel, plastic, or both. To construct plastic couplers, provide plastic resins for plastic ducts as required by the Contract. Make metallic components using ASTM A 240 Type 316 stainless steel.

Provide and install heat shrink plastic sleeves sized for the coupled duct. Ensure the sleeves consist of an irradiated and cross-linked, high-density polyethylene backing for external applications and linear-density polyethylene for internal applications. Provide heat shrink sleeves with an adhesive layer that withstands 150 °F [66 °C] in accordance with Table 517:2:

Table 517:2
Heat Shrink Sleeve Specifications

Property	Test Method	Minimum Requirements	
		Internal Application	External Application
Minimum fully recovered thickness	—	92 mil [2.3 mm]	111 mil [2.8 mm]
Peel strength	ASTM D 1000	29 pli [50 N]	46 pli [80 N]
Softening point	ASTM E 28	162 °F [72 °C]	216 °F [102 °C]
Lap shear	DIN 30 672 M	87 psi [600 kPa]	58 psi [400 kPa]
Tensile strength	ASTM D 638	2,900 psi [20 MPa]	3,480 psi [24 MPa]
Hardness	ASTM D 2240	46 Shore D	52 Shore D
Water absorption	ASTM D 570	<0.05%	<0.05%
Color	—	Yellow	Black

Install heat shrink sleeves in accordance with the manufacturer's recommendations.

I. System Test Requirements

For each family of post-tensioning systems, assemble systems and test the pressure required by the Contract. Test the largest and smallest assemblies from each family. Include plastic-to-steel pipe connections and segment duct couplers.

(1)External Duct Systems

For external ducts, test the following:

- The anchorage and its connection to the duct or pipe as required by the Contract for internal duct systems.
- The grout cap to anchorage fit.
- The duct and pipe assembly by maintaining a pressure of 150 psi [1.03 MPa] in the system for 3 hr. After conditioning, ensure the assembly sustains a 150 psi [1.03 MPa] internal pressure for 5 min without losing more than 15 psi [103 kPa].

(2) Internal Duct Systems

Provide an internal duct system assembly in accordance with Chapter 4, Article 4.2, Stage 1 and Stage 2 Testing of the FIB Technical Report, Bulletin 7, "Corrugated Plastic Ducts for Internal Bonded Post-Tensioning." For tests in precast segmental construction, include one duct coupler for use at the segment joint. Test the coupler by casting the coupler into a two-part concrete test block using match cast techniques. Provide blocks at least 12 in × 12 in × 12 in [300 mm × 300 mm × 300 mm]. After the concrete hardens, separate the blocks and clean bond-breaker materials from the surface. Using an external apparatus, clamp the blocks together and maintain 40 psi [276 kPa] pressure on the block cross-section throughout the test. Do not apply epoxy during this portion of the test.

When the test is complete, pressurize the duct to 5 psi [34 kPa] and lock-off the outside air source. Ensure the assembly loses no more than 2 psi [14 kPa].

Separate the duct coupler blocks from the duct system. Remove the clamping device and place a $^{1}/_{16}$ in [1.6 mm] layer of epoxy on the face of both blocks. Clamp the blocks together with a pressure of 40 psi [276 kPa]. Maintain the pressure on the block cross-section for 24 hr. Demolish the blocks after removing the clamp. Ensure the coupler ducts are intact, epoxy free, and do not show signs of failure.

Test the grout cap to anchorage seal as required by the Contract. The Department requires one test for systems that use the same anchorages and caps as external systems.

(3) Grout

Provide grouts in accordance with Subsection 701.18 "Post-Tensioning Grout." Select the post-tensioning grout based on use. Mix grout with potable water in accordance with Subsection 701.04, "Water." Maintain grout fluidity in accordance with the grout manufacturer's recommendations. Test the fluidity using a flow cone. Submit to the Engineer a copy of the manufacturer's grout QC Data Sheet for the lot numbers and shipments sent to the job site. Require the supplier to retest and recertify materials sent from the manufacturer more than 6 months before use. Store grout in a dry location near the bridge site. If stored in the open, place grout on a raised platform with waterproof covering. Do not store grout on-site for longer than one month.

(4) Post-Tensioning Steel

Test post-tensioning strand and bar in accordance with Subsection 723.05, "Post-Tensioning Steel Wire."

J. Testing by the Contractor

(1) Tendon Modulus of Elasticity Test

If the Contract requires or the Engineer directs, perform a tendon modulus of elasticity test.

To determine modulus of elasticity, bench test two samples of each tendon size before stressing the initial tendon.

For this test, ensure the bench length between anchorages is at least 40 ft [12 m] and the tendon duct is at least 2 in [50 mm] clear of the tendon. Stress the tendon at an anchor assembly with a load cell at the dead end. Tension the test specimen to 80 percent of ultimate in ten increments. Then detention from 80 percent to zero in ten decrements. For each increment and decrement, record the gauge pressure, elongations, and load cell force. Note the elongations of the tendon at the ends and the central 30 ft [9 m]. Measure the elongation to within $^{1}/_{32}$ in [1 mm]. Correct the elongations for the actual anchorage set of the dead end.

Calculate the modulus as follows:

$$E = \frac{P \times L}{A \times dl}$$

where

E = Modulus of elasticity;
P = Force in tendon, pound-force [newton];
L = Distance between wedges and dead end wedges, or length in center 30 ft [9 m] of tendon, feet [meter];
A = Cross sectional area of the tendon, square inch [square millimeter]; and
dl = Strand elongation for load P.

Submit revisions to the Engineer if the bench test varies from the modulus of elasticity on the shop drawings or working drawings by more than 1 percent.

If the elongations of the tendons do not meet the Contract required tolerances, the Engineer may require additional tendon modulus of elasticity tests.

If the source of post tensioning steel changes during the project, the Engineer will require additional test series or substantiation from previous projects. Ensure the number of tests does not exceed two per source.

Submit the test apparatus and methods to the Engineer. Conduct tests in the Engineer's presence.

(2) In Place Friction Test

For tendons longer than 100 ft [30 m], test at least one tendon in tendon group that performs the same function. The Department defines functional tendon groups as cantilever tendons, continuity tendons, draped external tendons, or continuous profiled tendons passing through at least one span. Ensure the selected tendon represents the size and length of the tendon group. The Engineer will not require the in-place friction test on projects with straight tendons in flat or precast voided slabs.

Stress the tendon at an anchor assembly with a load cell or a second, certified jack at the assembly dead end. Stress to 80 percent of ultimate tendon strength in eight increments. At each increment, record the gauge pressure, elongations, and

load cell force. Compensate for wedge seating in the live and dead end, friction in the anchorages, wedge plates, and jack. For long tendons requiring multiple jack pulls and intermediate temporary anchoring, keep an account of the elongation at the jacking end.

If the elongations fall outside the 5 percent range of the calculated elongations, investigate, and make detailed recalculations to ensure the final tendon forces are as shown on the Plans.

In reconciling theoretical and actual elongations, do not vary the friction and wobble coefficients by more than 10 percent. As the Engineer approves, correct or compensate for duct misalignment that causes elongation, at no additional cost to the Department.

The Engineer will require one successful friction test for each tendon group.

The Engineer may specify additional friction tests if forces and elongations are irreconcilable during stressing operations.

Submit the test apparatus types and test methods to the Engineer. Conduct tests in the Engineer's presence.

(3) Tests Reports Required

Submit two copies of the test report for the "Tendon Modulus of Elasticity Test" to the Engineer at least 30 days before installing the tendon.

Submit two copies of the test report for the "In Place Friction Test" to the Engineer within 2 weeks of installation of the test tendon.

(4) Application of Test Results

Reevaluate the theoretical elongations shown on the shop drawings or working drawings using the test results for "Tendon Modulus of Elasticity" and "In Place Friction." Submit revisions to the Engineer.

517.03 EQUIPMENT

A. Stressing Equipment

Use equipment provided by the supplier of the post-tensioning system.

(1) Stressing Jacks and Gauges

Equip the jacks with a pressure gauge. Provide a pressure gauge with a dial at least 6 in [150 mm] in diameter.

(2) Calibration of Jacks and Gauges

Calibrate the jacks and gauges as a unit. Ensure the calibration consists of three test cycles with the cylinder extension of the jack in various positions. At each pressure increment, average the forces from the test cycle. Calibrate the equipment in the same configuration intended for the project. Ensure the post-tensioning supplier or an independent laboratory initially calibrates jacks and gauges. Use load cells calibrated within the past 12 months to calibrate stressing equipment. For jack and gauge units, provide certified calibration charts and curves to the Engineer before the start of stressing and every 6 months thereafter, or as directed by the Engineer.

Use a master gauge to calibrate equipment after the initial calibration. Give the Engineer the master gauge in a waterproof container to protect the calibration gauge during shipment. Provide a quick-attach hydraulic manifold for the master gauge. The Engineer will keep the master gauge for the project duration.

Recalibrate using a load cell after any jack repair.

B. Grouting Equipment

Provide grouting equipment consisting of water-measuring devices, a high-speed shear colloidal mixer, a storage hopper, and a pump with connecting hoses, valves, and pressure gauges. Provide pumping equipment that can completely fill the post-tensioning duct system uninterrupted at a uniform rate within 30 min in accordance with Subsection 517.04.H(5), "Grout Operations." Provide vacuum grouting equipment before starting grouting operations.

(1) Mixer, Storage Hopper

Provide a high-speed, shear, colloidal mixer to continuously mix and produce a homogeneous, stable grout free of lumps and undispersed cement. Provide colloidal grout machinery with a charging and holding tank. Provide a blending tank equipped with a high shear colloidal mixer. Keep the holding tank agitated and at least partially full during the pumping to prevent drawing air into the post-tensioning duct. Add water during the initial mix using a flow meter or calibrated water reservoir with a measuring accuracy within 1 percent of the total water volume.

(2) Grout Pumping Equipment

Provide positive displacement type pumping equipment that can circulate the grout between operations and maintain pressure on grouted ducts. Fit the ducts with a valve that does not lose pressure when closed. Provide a continuous flow of grout that maintains a discharge pressure of at least 145 psi [1 MPa].

Provide pumps with seals that prevent foreign substances from entering, and loss of grout or water. Ensure the capacity achieves an optimal grouting rate.

Place a pressure gauge with a scale reading in increments of no greater than 20 psi [140 kPa] at the duct inlet. If using hoses longer than 100 ft [30 m], place one gauge at the pump and one gauge at the inlet.

Provide grout hoses with a diameter and rated pressure capacity compatible with the pump output.

(3) Vacuum Grouting Equipment

During grouting operations, provide the following for vacuum grouting equipment at the job site:

- Volumeter for measuring void volume,
- Vacuum pump with a capacity of at least 10 cfm [0.283 cmm] and equipped with a flow-meter that measures the amount of injected grout,
- Manual colloidal mixers, dissolvers, or both for voids less than 0.7 ft^3 [20 L], and
- Standard colloidal mixers for voids at least 0.7 ft^3 [20 L].

(4) Stand-by Equipment

During grouting operations, provide a stand-by grout mixer and pump.

517.04 CONSTRUCTION METHODS

A. Qualifications

Perform post-tensioning field operations under the supervision of a post-tensioning and with a grouting technician with at least three years experience and is an ASBI Certified Grouting Technician Holder. For segmental construction, ensure the supervisor and one grouting technician are ASBI Certified Grouting Technician Holders.

B. Shop Drawings

Submit shop drawings and work plans in accordance with Subsection 105.02, "Plans and Working Drawings." Include details about the following:

- Post-tensioning systems,
- Tendon geometry and locations shown on the Plans in accordance with the limitations of the Engineer approved post-tensioning system,
- Inlets,
- Outlets,
- High point outlet inspection,
- Anchorage inspection,
- Permanent grout caps,
- Protection system materials,
- Application limits, and
- Method and spacing of duct supports.

C. Protection of Post-tensioning Steel

(1) Shipping, Handling and Storage

Protect post-tensioning steel against damage and corrosion. The Engineer will reject damaged post-tensioning steel. Inspect reels that contain broken wires, and discard damaged strands. Provide bright and uniformly colored wire with no foreign matter or surface pitting.

Package post-tensioning steel in containers to protect them from damage and corrosion during shipping and storage. Place a corrosion inhibitor in the package or in carrier type packaging material. Provide a corrosion inhibitor with no deleterious effect on the steel, the concrete, or the steel-to-concrete bond strength. Provide corrosion inhibitor carrier packaging. Replace damaged packaging.

Ensure the shipping package clearly states that the package contains high-strength post-tensioning steel, the handling care, and information about the corrosion inhibitor. Designate low relaxation strands in accordance with ASTM A 416. The Engineer will reject undesignated strands.

(2) During Installation in the Structure

The Engineer will not consider light corrosion cause for rejection of the post-tensioning steel, but will reject any stands with pits or second loss.

D. Placing Ducts

(1) General

Fasten post-tensioning anchorages, ducts, inlet pipes, outlet pipes, miscellaneous hardware, reinforcing bars, and embedments where shown on the Plans, shop drawings, working drawings. Minimize the use of duct splices in constructing tendons.

(2) Ducts

Fasten internal ducts at intervals no greater than 30 in [750 mm] for steel pipes, 24 in [610 mm] for round plastic duct, and 12 in [300 mm] for flat ducts. Ensure straight external tendon ducts between internal duct connections at anchorages, diaphragms, and deviation saddles. Support external tendon ducts at intermediate locations as shown on the Plans or shop drawings.

Ensure smooth and continuous alignments with no lips, kinks, or dents.

Check and repair ducts before placing concrete.

Seal duct ends, anchorage connections, splices, inlets, and outlets after installation and until grouting completion. Use a plumber's plug to seal anchorage and duct terminations. Install inlets and outlets with plugs or valves in the closed position. Leave low point outlets open. The Department will not allow the use of duct tape.

(3) Splices and Joints

The Engineer will consider splices, joints, couplings, inlets, outlets, and valves part of the post-tensioning system. Use shrink-sleeve material to repair ducts. The Department will not allow the use of duct tape to repair or seal duct.

(4) Location of Grout Inlets and Outlets

Equip grout inlets and outlets with positive shut-off devices. Place grout inlets and outlets in the following positions, or as shown on the Plans or shop drawings:

- At the top of the tendon anchorage,
- At the top of the grout cap,
- At the duct high points if the vertical distance between the highest and lowest point is more than 20 in [0.5 m],
- At 3 ft [1 m] past duct high points on the down stream side opposite the grouting direction,
- At low points, and
- At major changes in the cross section of the duct.
- Extend grout tubes out of the concrete so valves can close.

(5) Tolerances

Ensure post-tensioning ducts are within the tolerances specified in Table 517:3; otherwise, ensure tendons are within ¼ in [6 mm] of the position required by the Contract.

Table 517:3 Duct Position Tolerances		
Tolerances	**Vertical Position,** ***in [mm]***	**Lateral Position,** ***in [mm]***
Horizontal tendons in slabs or in slab regions of larger members	±¼ [±6]	±½ [±13]
Longitudinal draped super-structure tendons in webs:		
Tendon over supports or in middle third of span	±¼ [±6]	±¼ [±6]
Tendon in middle half of web depth	±½ [±13]	±½ [±13]
Longitudinal, generally horizontal, superstructure tendons in top or bottom of member	±¼ [±6]	±¼ [±6]
Horizontal tendons in substructures and foundations	±½ [±13]	±½ [±13]
Vertical tendons in webs	Longitudinal ±1 [±25]	Transverse ±¼ [±6]
Vertical tendons in pier shafts	±½ [±13]	±¼ [±6]

Ensure tendon path entrance and exit angles at anchorages, concrete faces, or both are within 3° [5 percent] of the Contract required angle. Ensure smooth transitions.

Make angle changes at duct joints no greater than 3° [5 percent].

Unless otherwise directed by the Engineer, place anchorages laterally within ¼ in [6 mm] and along the tendon within 1 in [25 mm] of the positions shown on the Plans. Maintain minimum coverage of ducts.

Center anchorage confinement reinforcement around the duct in spirals, multiple **U**-shaped bars, or links. Ensure anchorage reinforcement starts within ½ in [13 mm] of the main anchor plate back.

If the reinforcement conflicts with post-tensioning duct positions, adjust the reinforcement locally as approved by the Engineer.

(6) Internal Duct Pressure Test

For tests in precast segmental construction, include one duct coupler for use at the segment joint. Test the coupler by casting the coupler into a two-part concrete test block using match cast techniques. Provide blocks at least 12 in × 12 in × 12 in [300 mm × 300 mm × 300 mm]. After the concrete hardens, separate the blocks and clean bond-breaker materials from the surface. Using an external apparatus, clamp the blocks together and maintain 40 psi [276 kPa] pressure on the block cross-section throughout the test. Do not apply epoxy during this portion of the test.

Before casting concrete, pressure-test internal ducts, except longitudinal ducts, in segments of box girders. Seal the duct and test with compressed air to determine if the duct connections are tight. Pressurize the duct to 5 psi [34 kPa] and lock-off the outside air source. Record the pressure loss for 5 min. If the duct loses more than 2 psi [14 kPa], repair the leaks as approved by the Engineer.

Separate the duct coupler blocks from the duct system. Remove the clamping device and place a $^{1}/_{16}$ in [1.6 mm] layer of epoxy on the face of both blocks.

Clamp the blocks together with a pressure of 40 psi [276 kPa]. Maintain the pressure on the block cross-section for 24 hr. Demolish the blocks after removing the clamp. Ensure the coupler ducts are intact, epoxy free, and do not show signs of failure.

E. Placing Concrete

(1) Precautions

Place and consolidate concrete without damaging or displacing post-tensioning ducts, anchorage assemblies, splices and connections, reinforcement, or embedments. Fabricate duct splices to prevent duct kinks during concrete placement. Use mandrels to maintain duct alignment and shape.

(2) Proving of Post-Tensioning Ducts

After concrete placement, to ensure clear, undamaged ducts that can accept post-tensioning tendons, pass a torpedo through the duct. Use a torpedo with the same cross-section as the duct and ¼ in [6 mm] smaller than the duct dimensions. Perform torpedo test in the presence of the Engineer. Do not make deductions to the torpedo dimensions for tolerances. For straight ducts, use a torpedo at least 2 ft [0.6 m] long. For curved ducts, determine the torpedo length so when both ends touch the outermost wall of the duct, the torpedo clears the innermost wall by ¼ in [6 mm]. Ensure the torpedo passes through the duct without excessive effort or mechanical assistance. Unless a repair clears the duct, the Engineer will reject ducts if torpedoes cannot pass.

(3) Problems and Remedies

The Engineer will reject deficient ducts. Make duct repairs as approved by the Engineer.

F. Installing Tendons

Do not install permanent tendons if grouting operations can not be completed in 7 calendar days.

Blow oil-free, compressed air through the duct to remove excess water.

Push or pull post-tensioning strands through the ducts to make a tendon. Prevent the strands from snagging on lips or joints. Round-off or cap the ends of pushed strands. Ensure a mechanical device does not rotate the strand during the post-tensioning strand installation.

Alternatively, assemble strands to form the tendon. Pull the tendon through the duct using a special, steel wire sock. The Department will not allow welding the strand ends together. Round the end of the pre-assembled tendon. Cut strands using an abrasive saw. The Department will not allow flame-cutting.

Install permanent tendons after testing as required by the Contract, except for tendons tested for the “In Place Friction Test.”

G. Post-Tensioning Operations

(1) General

Apply post-tensioning forces after concrete attains the Contract required compressive strength determined by cylinder tests. Stress and grout ducts in the presence of the Department’s Materials Engineer.

(2) Stressing Tendons

Tension post-tensioning steel with hydraulic jacks to the post-tensioning force shown on the Plans or shop drawings. The Department will not allow the use of monostrand jacks to stress tendons with at least five strands.

(a) ***Maximum Stress at Jacking***

Ensure the maximum temporary jacking stress in the post-tensioning steel is no greater than 80 percent of its Contract required ultimate tensile strength. Elongate without overstressing tendons.

(b) ***Initial and Permanent Stresses***

Anchor the post-tensioning steel at initial stresses that maintain permanent stresses shown on the Plans or shop drawings. Unless the Department's Bridge Engineer reviews and the Engineer approves otherwise, ensure the initial stress after anchor set is no greater than 70 percent of the Contract required post-tensioning steel ultimate tensile strength.

(c) ***Stressing Sequence***

Unless otherwise shown on the Plans, stress permanent post-tensioning tendons from both ends. Apply the force at one end, then the other, or at both ends simultaneously.

The Engineer will allow single end stressing in accordance with the following:

- Space limitations prohibit double end stressing.
- The calculated elongation of the post-tensioning steel at the second end is ½ in [13 mm] or less, and wedges are power-seated.
- Apply single end stressing at alternate ends of paired adjacent post-tensioning tendons to produce a symmetrical force distribution as shown on the Plans.

For construction in stages if tendons require stressing before others, install and stress them as shown on the Plans, the shop drawings, or as the Engineer approves.

(3) Strand Elongations and Agreement with Forces

Ensure measurable tendon forces and post-tensioning tendon elongation. Measure elongations to the nearest $^{1}/_{16}$ in [1.6 mm].

For the required tendon force, ensure an observed elongation within 7 percent of the theoretical elongation. Check the operation and correct variations as approved by the Engineer before continuing. Do not overstress the tendon to achieve the theoretical elongation.

If elongations at the Contract required force are outside the tolerances, the Engineer may require additional tests for "Tendon Modulus of Elasticity," "In-Place Friction," or both in accordance with Subsection 517.02.K(1), "Tendon Modulus of Elasticity Test," and Subsection 517.02.K(2), "In Place Friction Test."

(4) Friction

Submit calculations and show a tendon force diagram, after friction, wobble and anchor set losses. Base the calculations on the expected coefficients and values for

the post-tensioning system. Show these coefficients and values on the shop drawings.

If the actual friction varies from the expected friction, revise post-tensioning operations so the tendon force equals the final tendon force shown on the Plans.

When reducing friction, lubricate with graphite as reviewed by the Department's Materials Engineer and approved by the Engineer. Use lime-treated potable water to flush lubricants from the duct after stressing. Blow dry with oil-free air.

(5)Wire Failures in Post-Tensioning Tendons

The Engineer may accept multi-strand post-tensioning tendons with failed wires under the following conditions:

- The completed structure has a final post-tensioning force of at least 98 percent of the design total.
- For segmental construction with members post-tensioned together across a common joint face, the post-tensioning force across a mating joint is at least 98 percent of the post-tensioning specified for that mating joint.
- A tendon has no more than a 5 percent cross-sectional area reduction due to wire failure.

The Engineer may waive the conditions for acceptance of failed multi-strand tendons, if proposed alternative means of restoring the lost post-tensioning forces are accepted by the Engineer.

(6)Cutting of Post-Tensioning Steel

Cut post-tensioning steel with an abrasive saw from ¾ in to 1½ in [20 mm to 40 mm] away from the anchoring device. The Department will not allow flame cutting.

(7)Record of Stressing Operations

Keep a record of the following post-tensioning operations for installed tendons:

- Project number and job piece number,
- Names of the Contractor and subcontractor;
- Tendon location, size, and type,
- Date tendon was first installed in ducts,
- Reel number for strands and heat number for bars,
- Tendon cross-sectional area,
- Modulus of elasticity,
- Date stressed, and
- Jack and gauge numbers per tendon end, including the following:
  - Required jacking force,
  - Gauge pressures,
  - Elongations (theoretical and actual),
  - Anchor sets (anticipated and actual),
  - Stressing sequence (i.e. tendons to be stressed before and after,
  - Stressing mode (one end/ two ends/ simultaneous),
  - Witnesses to stressing operation (Contractor and inspector), and
  - Date grouted.

Record other relevant information. Provide the Department's Materials Engineer and the Engineer with a copy of stressing and grouting operations.

(8) Duct Pressure Field Test

After stressing and before grouting internal or external tendons, install grout caps, inlets, and outlets. Test the tendons with compressed air to determine if duct connections need repairs. Pressurize the tendons to 100 psi [690 kPa] and lock-off the outside air source. Record pressure loss for 5 min. If the duct loses more than 10 psi [69 kPa], repair leaking connections as reviewed by the Department's Materials Engineer and approved by the Engineer.

(9) Tendon Protection

Within 4 hr of stressing, install grout caps and seal other tendon openings. If the Engineer delays tendon acceptance, seal tendon openings and temporarily weatherproof the anchorage open ends. If tendon contamination occurs, replace the tendon.

H. Grouting Operations

(1) Grouting Operations Plan

At least 6 weeks before scheduled grouting operations, submit a grouting operations plan to the Engineer for review by the Department's Materials Engineer and approval by the Engineer. The Department's Materials Engineer must review and the Engineer must approve the plan in writing before permanent structure grouting begins. Ensure the plan addresses the following:

- Grouting crew and supervisor names and proof of training,
- Grouting certification,
- Material types, quantities, and brands for grouting including certifications,
- Equipment types, capacity in relation to demand and working condition, back-up equipment, and spare parts,
- General grouting procedure,
- Duct pressure test and repair procedures,
- Method to control the flow rate in ducts,
- Theoretical grout volume calculations,
- Mixing and pumping procedures,
- Grouting direction,
- Sequence of inlet and outlet pipe,
- Procedures for handling blockages, and
- Procedures for post-grouting repair.

Before beginning grouting operations, meet with the grouting crew and the Department's Materials Engineer. Discuss the grouting operation plan, testing, corrective procedures, and other relevant issues.

(2) Grout Inlets and Outlets

Ensure air-tight and dirt-free connections from the grout pump hose to inlets. Inspect valves to ensure they open and close properly.

(3)Supplies

Before beginning grouting operations, provide water and compressed air to clear and test the ducts, mix the grout, and pump it. Where water is unavailable through the public water system, provide a water storage tank.

(4)Grouting

(a)*General*

The Department will not allow grout flushing.

Complete grouting operation within 7 calendar days of post-tensioning steel installation in the duct. If it is not complete in 7 days, the Engineer will stop the work and instruct the removal of tendons. Every day before beginning grouting operations, test the accuracy of the volume-measuring component of the vacuum grouting equipment. Use water or grout for testing. Use standard testing devices with 0.5 gal [2 L] and 6.5 gal [25 L] volumes with a 4 oz [0.1 L] or less accuracy. Perform one test with each device. Ensure the results verify the accuracy of the void volume-measuring component within 1 percent of the test volume. Verify the accuracy of the vacuum grouting equipment volume component within 5 percent of the test volume. Test in the presence of the Department's Materials Engineer.

Grout tendons in accordance with the Grouting Operation Plan. Grout empty ducts.

(b)*Temperature Limitations*

Ensure the grout temperature does not exceed 90 °F [32 °C] at the grout inlet. For grouting repairs, ensure the grout temperature does not exceed 85 °F [30 °C] at the grout inlet. Use chilled water, pre-cooled bagged material, or both to maintain the temperature below the specified level. The Engineer will not allow grouting operations when the ambient temperature is 40 °F [4 °C] or less.

Check the temperature hourly.

(c)*Mixing and Pumping*

Mix the grout with metered water to produce a homogeneous grout. Continuously agitate the grout until grouting completion.

(d)*Grout Production Test*

During grouting operations, maintain the grout fluidity as recommended by the grout manufacturer. Use the target fluidity rate established by the manufacturer's representative and based on weather conditions. Determine grout fluidity using test methods in accordance with Subsection 701.18 "Post-Tensioning Grout." Perform fluidity tests for grouted tendons. Maintain the water to cementitious ratio. Use grout that tests within the Contract required flow rates.

At the beginning of daily grouting operations, perform a wick induced bleed test in accordance with Subsection 701.18 "Post-Tensioning Grout." If zero bleed is not achieved at the end of the Contract required time period, delay grouting tendons until operations are adjusted and testing shows that the grout meets this requirement.

(5)Grout Operations

Open grout outlets before beginning grouting operations. Grout tendons in accordance with the Grouting Operations Plan.

Pump grout at a rate from 16 ft/min to 50 ft/min [5 m/min to 15 m/min]. Conduct normal grouting operations at a pressure range from 10 psi to 50 psi [69 kPa to 345 kPa] measured at the grout inlet. Ensure the pumping pressure does not exceed 145 psi [1.0 MPa] at the inlet.

Use grout-pumping methods that fill the ducts and encase the steel. Before closing the outlet, ensure grout flows from the first and subsequent outlets until residual water or entrapped air is removed.

Pump grout through the duct and continuously discharge it at the anchorage and grout cap outlets. Continue pumping until free water and air are discharged, and the grout consistency coming out is the same as the grout consistency going in. Close the anchorage outlet and discharge at least 2 gal [7.5 L] of grout from the grout cap into a clean receptacle. Close the grout cap.

After uncontaminated uniform discharge begins, immediately perform a fluidity test on tendons. Use the flow cone on the grout discharged from the anchorage outlet. Ensure the measured grout efflux time is at least the efflux time measured at the pump or in accordance with Subsection 701.18 "Post-Tensioning Grout." Alternatively, check the grout fluidity using the wet density in Subsection 701.18 "Post-Tensioning Grout." Ensure the measured density falls within the values in Subsection 701.18 "Post-Tensioning Grout." Ensure the density at the final outlet is greater than or equal to the grout density at the inlet. If the Engineer deems the grout fluidity unacceptable, discharge additional grout from the anchorage outlet and test until grout achieves fluidity. Discard grout used for fluidity tests.

After bleeding and sealing outlets, elevate the grout pressure to 75 psi [520 kPa]. Seal the inlet valve and wait 2 min to detect leaks. Fix leaks as reviewed by the Department's Materials Engineer and approved by the Engineer. If no leaks are present, bleed the pressure to 5 psi [34 kPa]. Wait at least 10 min for entrapped air to flow to the high points, increase the pressure, and discharge grout at high-point outlets to eliminate entrapped air or water. Lock 30 psi [207 kPa] in the tendon.

If the grouting pressure exceeds the maximum permitted by the Contract, close the inlet, and pump the grout at the next, recently closed, or ready-to-close outlet. Maintain the one-way flow. Do not pump grout into a succeeding outlet from which grout has not flowed. Fit the outlet or inlet with a positive shut-off and pressure gauge for pumping.

Stop operations if tendon grouting completion cannot occur using the planned methods approved by the Engineer. Wait 48 hr, then fill the tendon with grout in accordance with Subsection 517.04.H.8, "Post-Grouting Operations and Inspection."

(6)Vertical Grouting

For vertical tendons, provide a standpipe at the upper end of the tendon to store bleed water and grout. Maintain the grout level above the post-tensioning plate and the highest point of the upper anchorage. Ensure bleed water rises only into the standpipe.

Discharge grout and check grout fluidity in accordance with Subsection 517.04.H(5), "Grout Operations." As grouting is completed, add grout to the standpipe to maintain the level at the highest point in the upper anchorage. After the grout hardens, remove the standpipe. In the presence of the Department's Materials Engineer, use an endoscope or probe to visually inspect for voids. Fill voids in the duct using the volumetric measuring vacuum grouting process.

For vertical tendons longer than 100 ft [30 m], or if the grouting pressure exceeds the Contract required pumping pressure, pump the grout at increasingly higher outlets that were recently closed or are ready to be closed. Maintain the one-way flow of grout. Before using an outlet for pumping, allow the grout to flow from each outlet until the air and water disappear.

(7)Construction Traffic and Operations Causing Vibrations

During grouting and for 4 hr after completion, eliminate vibrations from any sources such as moving vehicles, jack hammers, compressors, generators, pile driving, soil compaction within 300 ft [91 m] of the ends of the grouted spans.

(8)Post-Grouting Operations and Inspection

Allow the grout to cure from 24 hr to 48 hr before removing inlets and outlets. Perform inspections within 1 hr of removal. After the grout cures, remove outlets at anchorages and high points along the tendon. Drill and inspect high points along the tendon including the inlets or outlets located at the anchorages. Depending on the grout inlet geometry, the Engineer may specify drilling to penetrate the inner surface of the trumpet or duct. Use drilling equipment that automatically shuts-off when it encounters steel. Unless sounding indicates that grout caps have voids, do not drill into caps. Inspect with endoscopes or probes in the Engineer's presence. Within 4 hr of completing the inspections, fill duct and anchorage voids using the volumetric measuring vacuum grouting process.

Seal and repair anchorage, inlet, and outlet voids from inspection drilling in accordance with Subsection 517.04.I(2), "Repair of Grout Inlets and Outlets." Backfill with epoxy using an injection tube that extends to the bottom of the holes.

Post grouting inspection of tendons shorter than 150 ft [46 m] may use the following:

- For the first 20 tendons, inspect outlets at anchors and tendon high points by drilling and probing. If an inspection location contains a defect, test until 20 consecutive tendons have no voids.
- When no defects are present, reduce the inspection frequency to every other tendon. If a defect is found, inspect the last five tendons grouted. Restart the cycle of 100 percent tendon inspection.
- If tendon-grouting operations stop before filling the tendon, drill into the duct and explore the voids with an endoscope. The Engineer will not allow probing. Install grout inlets, and fill the voids with volumetric measuring vacuum grouting equipment.

(9)Grouting Report

Within 72 hr of the completion of each grouting operation, sign a grouting report and submit to the Engineer for review by the Department's Materials Engineer and approval by the Engineer.

Report the theoretical quantity of grout compared to the quantity of grout used to fill the duct. Notify the Engineer and the Department's Materials Engineer of shortages or overages.

Include the following information in the report:

- Tendon identification,
- Date grouted,
- Number of days from tendon installation to grouting,
- Grout type,
- Injection end and applied grouting pressure,
- Ratio of actual to theoretical grout quantity, and
- Summary of problems and corrective action.

I. Forming and Repairs of Holes and Block-Outs

(1) Repair of Lifting and Access Holes

Repair holes with Magnesium Ammonium Phosphate Concrete in accordance with Subsection 701.21, "Magnesium Ammonium Phosphate Concrete for Concrete Repair." Within 24 hr before casting the concrete, mechanically clean and roughen the mating concrete surfaces to remove laitance and expose the small aggregate. Blast using grit or water with a nozzle pressure of at least 10,000 psi [69 MPa]. Flush the surface with water and blow dry. Mix, place, and cure the material in accordance with the manufacture's recommendations.

When deck grooving is complete, coat the repaired holes, block-outs, and 6 in [150 mm] outside the repair perimeter with methyl methacrylate. Apply and remove excess material as recommended by the manufacturer.

As an alternate repair material, use a Type J Epoxy grout compound in accordance with Subsection 701.13 "Epoxy Resin and Other Adhesives for General Use With Concrete."

(2) Repair of Grout Inlets and Outlets

Use vacuum grouting to repair voids and blockages in accordance with Subsection 517.04.H.5, "Grout Operations." Place threaded plastic caps in inlet and outlet locations shown on the Plans. Repair inlets and outlets as shown on the Plans using an epoxy grout. Repair cracks in accordance with Section 520, "Structural Concrete Repair by Sealing and Injection." Repair spalls using Type Hepoxy in accordance with Subsection 701.13 "Epoxy Resin and Other Adhesives for General Use With Concrete."

Prepare the surface as recommended by the manufacturer.

J. Protection of Post-Tensioning Anchorages

Within 7 days of completing the grouting, protect the post-tensioning bar and tendon anchorages as shown on the Plans. The Contractor may delay the elastomeric coating application up to 90 days after grouting. Use plastic or stainless steel threaded caps to plug grout inlets and outlets. Use a Type J epoxy grout compound in accordance with Subsection 701.13 "Epoxy Resin and Other Adhesives for General Use With Concrete" to construct pour-backs at anchorages.

Remove laitance, grease, curing compounds, surface treatments, coatings, and oil

by grit or water-blasting with a nozzle pressure of at least 10,000 psi [69 MPa]. Flush the surface with water and blow-dry. Ensure clean surfaces and no standing water. For disputes, use ACI 503 for substrate testing and develop at least 175 psi [1.2 MPa] tension.

Mix and apply epoxy in accordance with the manufacturer's current standard technical guidelines. Construct pour-backs in leak-proof forms, creating neat lines. Pump the epoxy grout for proper installation. Construct forms to maintain a liquid head and ensure contact with the concrete surface. Use vents so air can escape and ensure forms are completely filled.

Coat the pour-backs and grout cap surfaces with an elastomeric coating system in accordance with Subsection 737.03 Elastomeric Coating System." Cover these surfaces with a thickness from 30 mil to 45 mil [0.76 mm to 1.14 mm]. Ensure concrete, grout caps, and other substrates are structurally sound, clean, and dry. Allow concrete to cure at least 28 days. Remove laitance, grease, curing compounds, surface treatments, coatings, and oil by grit or water-blasting with a nozzle pressure of at least 10,000 psi [69 MPa] to establish the anchor pattern. Blow the surface with compressed air to remove dust or water. For elastomeric-coated pour-backs receiving a Contract required coating, apply primer approved by the manufacturer over the elastomeric coating before applying the coating.

Construct a 2 ft × 4 ft [0.61 m × 1.2 m] concrete test block with a similar texture to the surfaces for coating. Coat a vertical face with the Contract required elastomeric coating system. Determine the number of coats necessary for a coating thickness from 30 mil to 45 mil [0.76 mm to 1.14 mm]without runs and drips. Mix and apply elastomeric coating in accordance with the manufacturer's current standard technical specifications. The Department prefers spraying, but will allow rolling. Ensure the coating manufacturer representative supervises the elastomeric coating application on the test block. Ensure personnel that apply the coatings have at least 3 years of experience with similar polyurethane systems. Submit credentials to the Engineer.

517.05 METHOD OF MEASUREMENT

The Engineer will measure concrete for post-tensioned cast-in-place concrete structures in accordance with Section 509, "Structural Concrete."

The Engineer will measure reinforcing steel for post-tensioned cast-in-place concrete structures in accordance with Section 511, "Reinforcing Steel for Structures." The following are prestressing steel unit weights:

Table 517:4
Post-Tensioning Steel Unit Weights

Post-Tensioning System, *in [mm]*	**Weight per Unit Length, *lb/ft [kg/m]***
½ [12.7] diameter 7 wire strand	0.52 [0.77]
$^{3}/_{5}$ [15.2] diameter 7 wire strand	0.74 [1.1]
1 [26] high strength deformed bar	3.01 [4.48]
1¼ [32] high strength deformed bar	4.39 [6.54]
1⅜ [36] high strength deformed bar	5.56 [8.28]
1¾ [46] high strength deformed bar	9.23 [13.74]

517.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
POST-TENSIONING	Lump Sum

The Department will consider the following to be included in the contract unit price for *Post-Tensioning*:

- Calibration of jacks and gauges;
- Providing, installing, stressing, and grouting temporary, and permanent post-tensioning tendons;
- Anchorage assemblies;
- Hardware;
- Ducts;
- Grout and grouting;
- Testing and reports;
- Anchorage protection;
- Vents;
- Inlets;
- Outlets;
- Epoxy repairs;
- Friction control lubricants;
- Flushing lubricants or contaminants from the ducts; and
- Endoscope inspection of duct work and grouting.

SECTION 520
STRUCTURAL CONCRETE REPAIR BY SEALING AND INJECTION

520.01 DESCRIPTION

This work consists of restoring the structural integrity of portland cement concrete (PCC) structures by injecting and sealing cracks, delaminations, and hollow planes with an epoxy resin system.

520.02 MATERIALS

A. Injection Ports

Provide injection ports such as tubes, fittings, or pressure plates for the epoxy resin system under injection pressures of 60 psi [0.4 MPa]. Provide a seal for each injection port.

B. Crack Sealer

Provide a sealing compound specified by the epoxy resin manufacturer to seal cracks in concrete and to anchor the injection ports.

C. Pressure Plates

The Department will allow the use of pressure plates instead of sealing compound, as approved by the Engineer. Provide clear plastic pressure plates that cover the entire crack.

D. Epoxy Resin System

Provide an epoxy resin system in accordance with Subsection 701.13.A, “General” Type D.

520.03 EQUIPMENT

Provide a pressure pot, hand pump, caulking device, injection machine, or other device to inject the epoxy resin.

Provide a special pressure fitting on the injector to prevent leaks when injecting the epoxy resin through the ¼ in [6 mm] holes in the pressure plates.

Drill the injection ports using equipment with a vacuum system to prevent dust from compacting into the cracks and laminations.

520.04 CONSTRUCTION METHODS

A. Preparation

Clean the surfaces adjacent to cracks of efflorescence, deteriorated concrete, and other surface debris detrimental to the adhesion of the surface sealing epoxy compound. Clean the interior surfaces of the cracks with air under sufficient pressure to remove loose materials entrapped within the crack including efflorescence. When sealing cracks underwater, use appropriate cleaning methods as approved by the Engineer. After cleaning, drill injection port holes using a swivel drill chuck and hollow drill bits including a vacuum attachment which will remove dust and debris

generated during drilling. Determine the spacing of the injection ports holes by the size of the crack and the depth of the crack in the concrete substrate. Generally, space the injection ports from 4 in to 8 in [100 mm to 200 mm] apart. Space the entry ports so material can travel between them. Drill the holes to a minimum depth of ⅝ in [16 mm]. Insert the injection ports in the drilled holes approximately ½ in [13 mm], allowing for a small reservoir below the injection port. Apply a quick-setting seal around the injection ports to prevent resin loss. The Engineer may approve sealing with a clear plastic plate. Prevent defacement of the concrete surface.

B. Epoxy Resin Injection

Inject the epoxy in accordance with the epoxy manufacturer's instructions. Determine the actual injection procedures and pressures in field trials, based on crack widths and depth into the substrate and sufficiency of the results. Start at the lower port. Continue pumping until sighting the resin at the port directly above or adjacent to the injection port. If material is sighted at an adjacent port, move the nozzle to the port showing resin, and seal the previous injection port. Continue this procedure to completely fill the crack. On wide cracks, the Department will allow simultaneous pumping of two or more ports.

C. Clean Up

Clean concrete surface areas of excess epoxy materials and injection ports after completing the epoxy injection work. Clean in a manner which will not damage the concrete by scraping, light sand blasting, grinding, use of solvents, or any other appropriate method approved by the Engineer. Clean excess materials so that no epoxy material or injection ports extend beyond the plane surface of the concrete.

520.05 METHOD OF MEASUREMENT — VACANT

520.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) PREPARATION OF CRACKS, ABOVE WATER	Linear Foot [Meter]
(B) PREPARATION OF CRACKS, BELOW WATER	Linear Foot [Meter]
(C) EPOXY RESIN, ABOVE WATER	Gallon [Liter]
(D) EPOXY RESIN, BELOW WATER	Gallon [Liter]

SECTION 521
PNEUMATICALLY APPLIED MORTAR

521.01 DESCRIPTION

This work consists of providing and placing pneumatically applied mortar to:

- Construct portions of structures,
- Repair concrete structures,
- Texture concrete surfaces,
- Encase structural steel members,
- Line ditches and channels, and
- Pave slopes.

This work includes preparing surfaces to receive mortar, and providing and placing reinforcing steel and anchors for reinforcement.

521.02 MATERIALS

A. General

Provide materials in accordance with the following subsections:

Material:	Subsection:
Fine Aggregate	701.05
Course Aggregate	701.06
Water	701.04
Portland Cement	701.02
Bar Steel Reinforcement – Billet Steel	723.01
Welded Steel Wire Fabric	723.02

In combinations of fine and coarse aggregates, use no more than 30 percent coarse aggregate. Provide coarse aggregate in accordance with Subsection 701.06, "Course Aggregate," with gradation in accordance with AASHTO M 43, No. 8 or No. 89. The Department will allow the reuse of clean cement-covered fine aggregate (recovered rebound). Limit the use to no more than 20 percent of the total fine aggregate.

B. Anchor Studs

If placing mortar against existing concrete or rock, provide anchor studs with at least ¼ in [6 mm] diameter expansion hook bolts placed in drilled holes to support reinforcing wire fabric or bars. Ensure individual bolts can resist a pullout force of 150 lbf [670 N].

Obtain the Engineer's approval before using driven steel studs. Use driven steel studs with a diameter of at least ⅛ in [3 mm] and a length of at least 2 in [50 mm].

521.03 EQUIPMENT

For driven studs, provide equipment that uses an explosive as the driving force and can insert the stud or pin to a depth capable of sustaining the 150 lbf [670 N] pullout force without damaging the concrete.

521.04 CONSTRUCTION METHODS

A. Proportioning

Submit the mix design to the Engineer for approval before beginning the work. Unless otherwise required by the Contract, include a cement-to-aggregate ratio based on dry loose volumes. Ensure at least one-part cement to three and one-half parts aggregate for concrete structures and steel members, and at least one-part cement to five parts aggregate for ditches, channels, and slopes. Use minimal water content to provide workability of the mix. Adjust the water content so the mix adheres and will not sag or fall from vertical surfaces, or separate in horizontal surfaces.

B. Mixing

Use the dry or wet mix process. Use a paddle or drum-type mixer designed for pneumatic application to uniformly mix the materials before charging the placing equipment. The Department will allow transit mix equipment and methods in the wet mix process.

C. Surface Preparation

(1) Earth

If placing pneumatically applied mortar against earth, grade the area as required by the Contract. Compact the area with moisture to provide a firm foundation and to prevent the mortar from losing moisture. Remove free surface water after compaction.

If the Contract requires, provide joints, side forms, headers, and shooting strips for backing or paneling. Use ground or gauging wires to establish thicknesses, surface planes, and finish lines.

(2) Forms

If placing mortar against forms, provide forms in accordance with Section 502, “Forms, Falsework, and Temporary Works.”

(3) Concrete or Rock

If placing mortar against concrete or rock, chip-away deteriorated and loose material with pneumatic or hand tools. Cut square or slightly undercut shoulders 1 in [25 mm] deep along the perimeter of repair areas. Sandblast the surface to clean rust from exposed steel and to produce a clean, rough surface. Keep the surface wet for at least 1 hr. Allow the surface to dry just before applying the mortar.

D. Installation

(1) Placement of Reinforcing Steel

Install reinforcing steel in accordance with Section 511, “Reinforcing Steel for Structures.” Place reinforcing steel in new construction as required by the Contract. Secure reinforcing steel to prevent displacement. For repair work, support reinforcing steel with anchor studs installed in the existing masonry, unless the Engineer approves the existing reinforcing steel. Space anchors no more than 12 in [300 mm] center-to-center on overhead surfaces, 18 in [450 mm] center-to-center on vertical surfaces, and 36 in [920 mm] center-to-center on top of horizontal surfaces. Use at least three anchors in each patch area.

Notify the Engineer before installing anchor studs. Place studs in locations that will prevent damage to the prestressing tendons or conduits embedded in the concrete.

In repair work areas where the mortar thickness exceeds 1½ in [38 mm], reinforce with a single mat of either 2 in × 2 in [50 mm × 50 mm] of W1.2 × W1.2, or 3 in × 3 in [75 mm × 75 mm] of W1.4 × W1.4 welded wire fabric, unless otherwise required by the Contract. Where the mortar thickness exceeds 4 in [100 mm], reinforce each 4 in [100 mm] layer of mortar thickness placed with a mat of wire fabric. Encase each mat of welded wire fabric in mortar and allow it to set before installing the next layer of mortar.

Place fabric no closer than ½ in [12 mm] to the prepared masonry surface. Place fabric parallel to and at least 1 in [25 mm] away from the finished surface. Pre-bend fabric to fit around corners and into re-entrant angles.

(2) Placement of Mortar

At the Engineer's request, submit employee credentials.

Apply the mortar with pneumatic equipment that sprays the mix onto the surface at a velocity high enough to produce a compacted, homogeneous mass. Use an air compressor and delivery hose lines to provide a pressure of at least 35 psi [240 kPa] for 1 in [25 mm] nozzles. Maintain the velocity of the material as determined by job conditions to minimize rebound.

Supply water to the nozzle at a uniform pressure of at least 15 psi [100 kPa] greater than the air pressure.

Apply mortar with minimal water content to prevent cracking from shrinkage. Unless otherwise required by the Contract or approved by the Engineer, use shooting strips to make square corners, straight lines, and a plane surface of mortar. Place the strips to minimize rebound trapping. At the end of each workday or when stopping to place construction joints, taper the mortar to a thin edge. Before placing an adjacent section, clean and wet the construction joint in accordance with Subsection 521.04.C, "Surface Preparation." Hold the nozzle from 2 ft to 4 ft [0.6 m to 1.2 m] away from the working surface. Direct the stream at right angles to the surface.

Apply enough mortar layers to obtain the thickness shown on the Plans. Obtain the Engineer's approval before applying mortar layers more than 1 in [25 mm] thick on vertical and overhead surfaces. Place layers without causing sag or decreasing the bond of the preceding coat. Allow sufficient time between successive layers in sloping, vertical, or overhanging work for the initial set to develop. While the initial set develops, clean the surface of laitance.

Remove rebound and loose sand before placing new mortar layers to prevent them from embedding in the mortar. Apply materials within 45 min of mixing, unless otherwise approved by the Engineer. After curing and before the final acceptance, sound repaired areas. Replace unsound and cracked areas.

(a) *Weather Limitations*

Apply pneumatically placed mortar on surfaces from 32 °F to 100 °F [0 °C to 35 °C], when the ambient temperature is not anticipated to drop below 35 °F [2 °C] within 24 hr after placement.

Suspend mortar application during high winds or rain.

(b)*Protection of Adjacent Work*

Protect adjacent facilities from damage or discoloration by overspray, dust, or rebound. Immediately clean contacted areas by scraping, brushing, or washing.

(3)Finishing

After completing mortar placement, cut off high spots with a sharp trowel, or screed to a true plane determined by shooting strips, the original masonry surface, or as directed by the Engineer. If using cutting screeds, lightly apply the screed without disturbing the mortar, and work the screed in an upward direction on vertical surfaces. Unless otherwise required by the Contract, give the finished mortar surface a final flash coat of ¼ in [3 mm] of mortar. Create a uniform appearance on exposed surfaces.

(4)Curing and Protecting

Cure pneumatically placed mortar in accordance with Subsection 509.04.F(3), "Water Method." If the Engineer determines that the "Water Method" is not practical, cure pneumatically placed mortar in accordance with Subsection 509.04.F(4), "Liquid Membrane Curing Compound Method." If using Subsection 509.04.F(3), cure for at least 96 hr. Protect the mortar from freezing during the curing period in accordance with Subsection 509.04.B, "Protection of Concrete from Environmental Conditions."

521.05 METHOD OF MEASUREMENT — VACANT

521.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
PNEUMATICALLY PLACED MORTAR	Square Yard [Square Meter]

SECTION 523
CONCRETE SURFACE REPAIR BY SEALING

523.01 DESCRIPTION

A. General

This work consists of sealing bridge decks and approach slabs and filling and rebonding cracks.

B. Definitions

Acrylic Resins. Thermoplastics, thermosetting polymers, copolymers of acrylic acid, methacrylic acid, esters of these acids, or acrylonitrile, used to produce synthetic rubbers and lightweight plastics.

Density. Mass per unit volume of a material.

Bulk Cure. Time required for the methacrylate monomer to harden and form a polymer.

Epoxy Penetrant. A low viscosity, two component, epoxy-resin bonding system for application to Portland-cement concrete.

Flash Point. Lowest temperature at which a material gives off explosive or ignitable vapors.

High Molecular Weight Methacrylate (HMWM). Non-fuming monomer with a low viscosity, low volatility, low initial shrinkage, and high flash point. Member of the acrylic family of monomers and polymers.

Initiators. Chemicals that start polymerization.

Monomers. Liquid molecules that a catalyst reaction converts into solid polymers.

Promoters. Chemicals used with initiators to accelerate polymerization.

Resin. Natural or synthetic, solid or semi-solid organic material of indefinite and often high molecular weight, with the tendency to flow under stress.

Shelf Life. Maximum interval during which a material may be stored and remain in a usable and safe condition.

Surface Cure. Amount of time required after placement before the HMWM treated concrete is free from surface liquid or tackiness.

Vapor Pressure. Component of atmospheric pressure caused by vapor; expressed in inches, centimeters, or millimeters of height of a column of mercury. Measures the volatility and depletion rate of monomers.

Viscosity. Resistance to flow by gases or liquids subjected to shear stress.

Working Time. Elapsed time after mixing methacrylate monomer with catalyst before solution viscosity increases. Depends on the temperature and the amount of initiators and promoters used. Varies with the manufacturer's monomer system.

523.02 MATERIALS

The Department will allow the use of either HMWM or epoxy resin to seal the cracks.

A. Materials for HMWM

(1) Monomer Materials

Provide HMWM with low volatility, which does not evaporate in accordance with Subsection 701.13(B)(10), "Type K — Monomer Materials for HMWM."

(2) Storage of HMWM Materials

Store initiators and promoters separately to prevent a violent reaction or explosion. Before shipping, obtain a material safety data sheet (MSDS) for each material with information about the following:

- Safe practices for storage,
- Handling and disposal,
- Explosive and combustion characteristics,
- Health hazards, and
- The manufacturer's recommended fire fighting techniques.

Post safety and handling information at storage areas and at the job site. Provide a copy to the Engineer.

(a) *Monomers*

Store monomers in shaded areas away from the initiator storage area. Provide storage areas ventilated to prevent the hazardous buildup of vapors.

(b) *Initiators*

Store initiators in temperatures 90 °F [32 °C] or less, and away from the monomer and promoter storage areas.

(c) *Promoters*

Store promoters in temperatures 90 °F [32 °C] or less, and away from the initiator storage area.

(3) Safety Provisions for HMWM

Train personnel to safely handle materials in accordance with the manufacturer's recommendations. Wear impervious protective gloves and splash-proof goggles while applying the HMWM. When handling solvent for cleaning and flushing, minimize personal and environmental hazards as the Engineer approves. Provide an eye wash facility and a soap and water wash station at the job site. Inform workmen of the following:

- HMWM monomer will soften gum rubber soled shoes, and
- Clothing or leather saturated with the HMWM monomer will harden and become brittle.

B. Materials for Epoxy Resin

Provide epoxy resin in accordance with Subsection 701.13(B)(11), "Type L – Materials for Epoxy-Resin."

C. Fine Aggregate (Sand) for HMWM, Epoxy Penetrants, or Both

Provide sand with a maximum moisture content of one-half of the percent absorption of the aggregate. Provide sand free of dirt and other organic materials, and in accordance with the gradations in Table 523:1.

Table 523:1 Fine Aggregate Gradations	
Sieve Size	**Percent Retained Maximum**
No. 4 [4.75 mm]	0 – 1
No. 8 [2.36 mm]	0 – 10
No. 30 [600 µm]	0 – 95
No. 50 [300 µm]	0 – 100

The gradations in Table 523:1 allow commercially available blast sands of No. 8/20 (2.36 mm/850 µm) or No. 10/20 (2 mm/850 µm). The Engineer may approve alternate gradations.

523.03 EQUIPMENT — VACANT

523.04 CONSTRUCTION METHODS

A. General

Submit to the Engineer a work plan including surface preparation techniques, materials, and the installation procedures.

For flood coats, ensure a technical representative from the manufacturer is on the site during the sealer application.

Cure new concrete for at least 28 days before applying sealers. Allow quick set concrete patches to cure for at least 48 hr before abrasive-blasting. For cracks or joints that extend to the bottom of the bridge deck, seal the bottom of the deck. The Department will not allow the use of sealers for patching decks. Place sealers in good weather (when rain or falling temperatures are not forecast) and when traffic can be diverted for the manufacturer recommended curing time.

B. Surface Preparation - HMWM, Epoxy Penetrant, or Both

Abrasively blast and remove traces of asphalt or petroleum, excess grout, and concrete curing agents. Ensure dry surfaces before applying sealers. Allow the surface to dry for at least 48 hr after rain. Clean surfaces and cracks using compressed, dry, and oil-free air with an air pressure of at least 90 psi [620 kPa].

C. Application of HMWM, Epoxy Penetrant, or Both

Apply sealers to clean, dry surfaces when the surface temperature reaches from 45 °F to 90 °F [7 °C to 32 °C]. Place the sealers and mix components in accordance with the manufacturer's recommendations or as directed by the Engineer. To initiate polymerization, catalyze the HMWM monomers with a metallic drier and peroxide.

To improve skid resistance, broadcast sand into the sealer by hand, or with a machine, before the sealer hardens on the treated area. Apply the sand at a uniform coverage rate from 0.55 lb/yd² to 0.65 lb/yd² [298.5 g/m² to 352.5 g/m²]. For HMWM, place the sand as the monomer begins to gel.

Resume traffic when the Engineer determines the surface is tack-free and the sand resists brushing by foot.

The Department will allow a slight oil to remain on the surface for several hours.

D. Sealing Individual Cracks

Seal cracks by placing sealer in the surface cracks and not on the entire deck. Use a crack comparator aid to visually determine crack size. Unless otherwise directed by the Engineer or technical representative, use sand to fill cracks wider than $^{1}/_{16}$ in [1.50 mm] before placing the HMWM. Mask across the crack in 1 ft [0.3 m] or 2 ft [0.6 m] intervals. If necessary, apply sealer several times to fill the crack. Place tape 1 in [25 mm] on both sides of the crack.

E. Flood Coats Applied to the Entire Deck

Sweep, squeegee, pour, or spray the area so the sealers can flow into the cracks. After the sealer fills the cracks, sweep excess from tining before the material begins to gel. Ensure sealer does not plug the tined surface of the bridge deck.

523.05 METHOD OF MEASUREMENT

The Engineer will measure along chords 3 ft [0.9 m] long and will include crack repairs within 6 in [152 mm] of the chord. The Engineer will not measure gallons of sealant resin for flood coats.

523.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) SEALER CRACK PREPARATION	Linear Foot [Meter]
(B) SEALER RESIN	Gallon [Liter]
(C) DECK AREA SEALED (FLOOD COATS)	Square Yard [Square Meter]

CHAPTER 600
INCIDENTAL CONSTRUCTION

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SECTION 601
RIPRAP

601.01 DESCRIPTION

This work consists of providing and placing riprap for slope protection. The Department defines the following types of riprap:

- Type I Plain,
- Type I-A Plain with Filter Blanket,
- Type II Special Plain,
- Type II-A Special Plain with Filter Blanket,
- Type III Laid Up, or
- Type IV Grouted.

601.02 MATERIALS

Provide the following materials in accordance with the following subsections:

Material:	Subsection:
Portland Cement	701.02
Fine Aggregate	701.05
Filter Fabric	712.02
Stone for Riprap	713.01
Filter Blanket	713.02

601.03 EQUIPMENT — VACANT

601.04 CONSTRUCTION METHODS

A. General

Shape and dress slopes, ditches, and protected areas to the lines and grades shown on the Plans. If the Contract requires Type III or Type IV riprap, compact the base in accordance with Subsection 501.04, "Construction Methods," before placing the riprap.

B. Filter Blanket

Place the filter blanket in one or two layers, as shown on the Plans. If material is stockpiled at the job site, follow the procedures in accordance with Subsection 106.08, "Storage and Handling of Material."

Uniformly spread each layer of filter blanket on the prepared base. If the blanket is damaged during placement, repair or replace before proceeding, at no additional cost to the Department.

Finish the filter blanket to an even surface, free of mounds and windrows.

C. Filter Fabric

Place filter fabric on a slope that is uniform, smooth, and free of debris that may damage the filter fabric.

Lay the material without stretching it. Overlap adjacent strips at least 2 ft [0.6 m] and in accordance with Subsection 602.04.D, "Filter Fabric Placement." Support the

fabric to maintain its position. The Resident Engineer must approve of the methods for fabric support and securing.

Replace or repair damaged or displaced filter fabric at no additional cost to the Department.

During shipment and storage keep the fabric wrapped in a heavy-duty covering to protect the filter fabric from the following:

- Temperatures greater than 140 °F [60 °C],
- Direct sunlight,
- Ultraviolet rays,
- Mud,
- Dirt,
- Dust, and
- Debris.

Cover or protect the filter fabric within 3 days of placement. Replace filter fabric uncovered or unprotected after 3 days, at no additional cost to the Department.

D. Types I, I-A, II, and II-A

Prepare the areas to be protected before placing the riprap, or filter blanket and riprap.

Dump the plain riprap and the special plain riprap over the area shown on the Plans and grade the area to uniformly distribute the smaller stone. Place the riprap by hand or machine to achieve the lines and thickness shown on the Plans.

E. Type III

Excavate the riprap foundation below the scour line or to the elevations shown on the Plans. Obtain the Resident Engineer's approval of the footing excavation before placing the stone or concrete riprap.

Place and work spalls into the spaces between stones. Finish the riprap surface even and tight. Remove points of stones that project beyond the finished riprap surface.

F. Type IV

Excavate the riprap foundation below the scour line or to the elevations shown on the Plans. Obtain the Resident Engineer's approval of the footing excavation before placing the stone or concrete riprap.

Place the surface of the stones in contact with the protected slope at the angle shown on the Plans. Key the individual stones into the surrounding riprap, and lay them in close contact to break joints. Prevent earth and sand from filling the spaces between the stones.

Wet the stones immediately after placement. Fill the spaces between the stones with grout, working from bottom to top. Sweep the surface with a stiff broom.

Do not grout the riprap at temperatures below 32 °F [0 °C]. In hot, dry weather, protect the work from the sun and keep moist for at least 3 days after grouting.

Grout shall consist of one part portland cement and 3 parts fine aggregate by volume, mixed with water. The Department will not allow re-tempering of grout.

601.05 METHOD OF MEASUREMENT

The Resident Engineer will not include the area of laps in the measurement of *Filter Fabric (Riprap)*.

601.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) TYPE I – PLAIN RIPRAP	Ton [Metric Ton]
(B) TYPE I-A – PLAIN RIPRAP	Ton [Metric Ton]
(C) TYPE I-A – FILTER BLANKET	Ton [Metric Ton]
(D) TYPE II – SPECIAL PLAIN RIPRAP	Ton [Metric Ton]
(E) TYPE II-A – SPECIAL PLAIN RIPRAP	Ton [Metric Ton]
(F) TYPE II-A – FILTER BLANKET	Ton [Metric Ton]
(G) TYPE III – LAID UP RIPRAP	Square Yard [Square Meter]
(H) TYPE IV – GROUTED RIPRAP	Square Yard [Square Meter]
(I) FILTER FABRIC (RIPRAP)	Square Yard [Square Meter]

SECTION 602
GABIONS AND REVETMENT MATTRESSES

602.01 DESCRIPTION

This work consists of providing and placing stone-filled wire-mesh baskets and plastic filter fabric for retaining embankments and controlling erosion.

Gabion. Square or rectangular wire-mesh basket with a thickness of at least 1 ft [0.3 m], filled with hard, durable stone.

Revetment Mattress. Rectangular wire-mesh basket with a maximum thickness of 1 ft [0.3 m].

602.02 MATERIALS

A. Material Requirements

Provide materials in accordance with the following subsections:

Material:	Subsection:
Filter Sand	703.06
Filter Fabric	712.02
Wire Baskets	732.09
Cubical Stone for Gabions and Revetment Mattresses	713.03

B. Basket Requirements

Provide twisted wire-mesh baskets, unless otherwise shown on the Plans.

For twisted wire-mesh baskets, supply gabion baskets with maximum nominal mesh openings of 3 in × 4 in [75 mm × 100 mm], and revetment mattress baskets with maximum nominal mesh openings of 2½ in × 3 in [63 mm × 75 mm].

For welded wire-mesh baskets, supply gabion baskets with maximum nominal mesh openings of 1½ in × 3 in [38 mm × 75 mm] and revetment mattress baskets with maximum nominal mesh openings of 1½ in × 3 in [38 mm × 75 mm].

Provide the same mesh style for all panels (sides and diaphragms) of the baskets. Assemble baskets to ensure each panel meets the strength and flexibility requirements in accordance with Subsection 732.09, "Wire Baskets for Gabions and Revetment Mattresses." Construct baskets with height, width, and length within 5 percent of the dimensions shown on the Plans. Install diaphragms that equally divide each gabion or revetment mattress into cells. Ensure the length of the diaphragm does not exceed one and one-half times the width of the gabion base or the horizontal width of the revetment mattress. Provide the same material for diaphragms as provided for the basket body. Secure diaphragms to the base.

602.03 EQUIPMENT — VACANT

602.04 CONSTRUCTION METHODS

A. Technical Supervision

When construction begins, ensure an experienced on-site technical representative from the basket manufacturer is present. The representative must be available as needed for consultation during gabion or revetment mattress construction.

B. Foundation Preparation

Place baskets on a smooth excavation extending to the limits shown on the Plans or directed by the Resident Engineer. Remove loose or unsuitable materials. Fill depressions to grade with suitable materials from Department-approved sources and compact to a density equal to the adjacent in-situ material. The Resident Engineer will inspect the prepared surface before allowing the Contractor to proceed with subsequent construction.

C. Filter Sand Placement

Uniformly spread filter sand on the prepared foundation surface, ensuring that segregation of the filter sand does not occur. Repair damage to the foundation surface during filter sand placement. Compact and finish filter sand to an even surface.

D. Filter Fabric Placement

Place filter fabric as shown on the Plans. Lay the fabric without folds, wrinkles, or creases, and do not stretch.

Overlap strips at adjacent and end-of-roll joints at least 2 ft [0.6 m]. Stagger overlaps at end-of-roll joints at least 5 ft [1.5 m]. Use full rolls to minimize the number of end-of-roll laps. Place the uphill or upstream layer of a lap on top.

Secure the top end of the fabric to prevent displacement. If using securing pins, place the pins in the adjacent joints, spaced on 10 ft [3 m] centers. Place securing pins through both fabric strips near the overlap midpoint.

The Resident Engineer will reject filter fabric with defects or damage. Repair torn or punctured fabric by covering the area with a layer of fabric that extends at least 2 ft [0.6 m] beyond the damaged area.

During shipment and storage keep the fabric wrapped in a heavy-duty covering to protect the filter fabric from the following:

- Temperatures greater than 140 °F [60 °C],
- Direct sunlight,
- Ultraviolet rays,
- Mud,
- Dirt,
- Dust, and
- Debris.

Cover the filter fabric within 3 days of installation. Replace filter fabric uncovered or unprotected after 3 days, at no additional cost to the Department.

E. Connections

Use the following methods to connect gabions or revetment mattresses. If Polyvinyl Chloride (PVC) coating is required by the Contract, use PVC-coated or stainless steel connections.

(1) $^{3}/_{32}$ in (2.2 mm) Tie Wire

If using $^{3}/_{32}$ in [2.2 mm] tie wire as the joint connection material, assemble the vertical edges of the adjacent gabion panels, forming groups of empty gabions.

(a) *Twisted-Wire Mesh*

Construct the joint using a single loop-double loop lacing pattern (locked loops) of $^{3}/_{32}$ in [2.2 mm] tie wire at nominal spacing of 6 in [150 mm]. Avoid using simple spiraling (looping without locking) of tie wire.

(b) *Welded-Wire Mesh*

Construct the joint using alternating single and double half-hitches (locked loops) in every mesh opening along the joint. Securely fasten lacing wire terminals.

(2) Spiral Binders

If using spiral binders with $^{7}/_{32}$ in [5.5 mm] wire or larger, rotate the spiral into position so that it passes through each mesh opening along the joint. Wrap both ends of the spiral binders at least 2 times around the mesh to secure the spiral. Place continuous, successive loops of spiral binders 3 in [75 mm] apart.

Do not use spiral binders after placing stone in the baskets.

(3) Interlocking Rings (Tiger Tites)

For gabions and revetment mattresses, use one interlocking ring in every mesh opening and lock the rings.

(4) Overlapping Rings (Spenax Fasteners)

Use overlapping rings if a 1 in [25 mm] lap can be consistently obtained. Install one ring in each mesh opening. Maintain the minimum, manufacturer-recommended air pressure in the gun used to close the overlapping rings.

(5) Alternative Fasteners

Use alternative fasteners with strengths of at least 1,400 lb/ft [20 kN/m] for galvanized gabions, 1,250 lb/ft [18 kN/m] for PVC gabions, and 800 lb/ft [12 kN/m] for revetment mattresses. Space the connections to prevent gaps exceeding 2 in [50 mm] between baskets when tested for connection tensile strength. Use fasteners that do not damage the wire's protective coating.

F. Assembly and Installation

(1) General

Place the assembled empty baskets on the prepared surface. Place the front row of baskets first, and continue placing successive rows of baskets toward the top of the slope. Ensure creases are in the correct position, and the top of each side is level. Install the baskets and avoid gaps between baskets when completed. Connect adjoining baskets in the same row before filling with stone. Avoid moving baskets after filling with stone. Connect adjacent rows of baskets along all contacting edges.

(2) Installing Connections

Make connections by joining selvage wire to selvage wire, selvage wire to edge wire, or selvage wire to mesh. Use mesh-to-mesh connections only if one of the previous connections is not possible.

Avoid using alternative fasteners (spiral binders, interlocking rings, or overlapping rings) to close stone-filled basket lids unless approved by the Resident Engineer. (The Resident Engineer may grant approval if the alternative fasteners can be installed on a stone-filled basket without stretching the basket or damaging the protective coating.)

(3) Stone-Filling

Fill baskets with stone by hand or machine. If using machines, arrange the stones by hand to minimize voids. Avoid damaging the wire coating. Maintain basket alignment throughout the filling process. Correct bulges in the mesh before continuing to fill the baskets. Fill with stone layers no greater than 1 ft [0.3 m].

Fill cells no higher than 1 ft [0.3 m] above the stone elevations in adjacent cells. Use care in placing stones in baskets; drop stones into the baskets from no higher than 3 ft [1 m].

Along exposed faces, arrange the stone by hand to ensure a neat and compact appearance. Uniformly overfill gabions and revetment mattresses by 1½ in [38 mm]. Allow for the proper closing of the lid, and provide an even, uniform surface.

Do not under-fill gabions and revetment mattresses.

(4) Connecting Wires

For gabion baskets higher than 2 ft [0.6 m] and with exposed faces, place two uniformly spaced internal connecting wires between each stone layer. Connect the back and the front faces of each basket. Loop connecting wires around two mesh openings or a single welded-wire joint on each basket face. Securely twist the wire terminals.

(5) Basket Lids

Using a lid closing tool, stretch each lid over the stone fill until the lid meets the edges of the panels. Avoid using crowbars or other single-point leverage bars to close the lid. Secure the lid with lacing wire or wire fasteners along the edges, ends, and internal-cell diaphragms. Bend wire ends into the baskets.

(6) Partial Baskets

For partial baskets, cut, fold, and re-wire the basket to address site conditions. Fold the mesh back and wire to the adjacent basket face. Assemble, install, fill, close the lid, and lace the reshaped partial basket in accordance with Subsections 602.04.F(1) through 602.04.F(5).

(7) PVC Coated Baskets

Do not install PVC coated materials until the ambient air temperature and the temperature of the PVC materials are at least 15 °F [8 °C] above the brittleness temperature of the PVC materials.

G. Backfilling

Backfill behind the gabions in accordance with Subsection 202.04.B, "Embankments."

H. Retaining Walls

Construct retaining walls on a 6 to 10 percent batter as shown on the Plans. Overlap vertical joints and offset horizontal joints in each successive layer.

602.05 METHOD OF MEASUREMENT — VACANT

602.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) GABIONS	Cubic Yard [Cubic Meter]
(B) REVETMENT MATTRESSES	Square Yard [Square Meter]
(C) FILTER FABRIC	Square Yard [Square Meter]

The Department will consider the cost of stone fill and filter sand for gabions and revetment mattresses to be included in the contract unit price for *Gabions* and *Revetment Mattresses*.

Unless otherwise shown on the Plans, the Department will consider the cost of backfill for gabions to be included in the contract unit price for *Gabions*.

SECTION 603
STEEL JETTY BANK PROTECTION

603.01 DESCRIPTION

This work consists of placing steel jetty bank protection. This consists of a mainline jetty with or without back-up jetties as shown on the Plans. The jetties consist of steel jacks connected by steel cables or reinforcing bars to a deadman anchor.

The Department will establish the length of mainline and back up jetties and the distance between lines of jetties as shown on the Plans. The Resident Engineer may direct changes to the lengths and locations of jetties, if erosive conditions have altered the landscape and rendered the Plan design ineffective.

603.02 MATERIALS

A. Steel Jack

Provide steel jacks consisting of the following:

- Three new structural steel angles, 4 in × 4 in × ¼ in × 192 in [100 mm × 100 mm × 6 mm × 4,800 mm];
- Six high strength bolts with hexagon heads and nuts, ½ in × 1½ in [13 mm × 38 mm]; and
- No. 6 double-annealed smooth-wire lacing.

B. Steel Cable

Provide used-steel oil-field cable that has been, inspected, respooled, and oil-treated. Ensure the steel cable has a diameter of at least ⅞ in [22.2 mm], or provide reinforcing steel bars of at least ¾ in [19 mm] in diameter and cable clamps for fastening.

C. Deadman

Provide deadman of concrete or timber. Ensure the concrete deadmen are Class A Concrete at least 3 ft × 2 ft × 1½ ft [0.9 m × 0.6 m × 0.5 m]. Ensure the timber deadmen are new creosoted railroad ties at least 6 in × 8 in × 96 in [152 mm × 203 mm × 2,400 mm], or creosoted timber pile cutoffs with a diameter of at least 7 in [178 mm] at the smallest end and a length of 8 ft [2.40 m].

603.03 EQUIPMENT — VACANT

603.04 CONSTRUCTION METHODS

A. Constructing Jacks

Bolt three steel angles together so each angle is perpendicular to the other two angles. Construct the jacks to a height of at least 9 ft [2.7 m], and lace with at least four wire lines as follows:

- Tie the outside lacing line at each angle.
- Pass the second lacing line through the angles 2 ft [0.6 m] from the ends.
- Pass the third lacing line through the angles 4 ft [1.2 m] from the ends.
- Pass the inside lacing line through the angles 6 ft [1.8 m] from the ends.

B. Anchoring Jacks

Use double runs of steel cable or reinforcing bars to anchor the jacks. Pass one cable or bar on each side of the jack and apply a cable clamp to hold the cables together and to keep the jack in place. For a mainline jetty, anchor the cables or bars at each end with a deadman. For backup jetties, fasten the cables or bars to the mainline at a steel jack and anchor to a deadman at the opposite end.

Minimize the use of splices and, if necessary, place splices only at a jack.

When making splices, constructing end connections to timber deadmen, or connecting backup jetties to a mainline jetty, wrap each steel cable around the jack or deadman at least twice and fasten with double cable clamps. Connect concrete deadmen as shown on the Plans. Splice reinforcing bars with a double-flare v-groove weld of at least 3 in [75 mm] in accordance with the current edition of the AWS "Reinforcing Steel Welding Code".

C. Placing the Deadman

Place the deadman in a trench and ensure the pull is at right angles to the deadman. Ensure the deadman bears on undisturbed earth. Bury the deadmen at least 6 ft [1.8 m] deep, measured to the bottom of the deadman. Backfill the trench and compact the soil to the density of adjacent in-situ soil.

603.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the steel jacks by the number of jacks constructed, placed, and anchored.

For the mainline jetty, the Resident Engineer will measure the length of steel cable from the center of the steel jack to the center of the deadman. For backup jetties, the Resident Engineer will measure the length of steel cable from the tie to the mainline jetty to the center of the deadman.

603.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) STEEL JACK	Each
(B) STEEL CABLE	Linear Foot [Meter]
(C) DEADMAN	Each

The Department will consider the cost of excavation and backfill for placing the deadman to be included in the contract unit price for *Deadman*.

Unless otherwise specified, the Department will consider the cost of excavation for placing steel jacks to be included in the contract unit price for *Steel Jack* and *Steel Cable*.

SECTION 609
INTEGRAL CURB, COMBINED CURB AND GUTTER, ASPHALT CURBING, AND HEADER CURBING

609.01 DESCRIPTION

This work consists of constructing integral curb, combined curb and gutter, asphalt curbing, and header curbing.

609.02 MATERIALS

Provide Class A concrete for integral curb, combined curb and gutter, or header curbing in accordance with Section 701, "Portland Cement Concrete."

Provide Type S5 or Type S6 asphalt concrete for asphalt curbing in accordance with Subsection 708.04, "Composition of Mixtures," except provide asphalt concrete with an asphalt content of 1.15 times the asphalt content required by the appropriate job-mix formula.

Provide sealant material in accordance with the following subsections, or as otherwise approved by the Resident Engineer:

Material:	Subsection:
For Concrete Curb	701.08
For New Concrete Pavement	701.08.F
For Most Joint Rehabilitation	701.08.F
For Integral Concrete Curb Joints	701.08.D
For Combined Curb and Gutter Joints	701.08.D

609.03 EQUIPMENT

Provide a curb machine capable of extruding a uniformly textured material to the shape and density and established line and grade required in the Contract.

609.04 CONSTRUCTION METHODS

A. Excavation

Excavate to the depth shown on the Plans, and compact the base to a firm, even surface. Replace soft or unsuitable material with material approved by the Resident Engineer, and compact.

B. Forms

Provide forms made of wood, metal, or other material that will not warp or misalign during placement of curb material. Ensure forms extend the entire depth of curb, or curb and gutter. During the placement of the concrete or asphalt, brace and secure the forms to prevent deflection from the alignment or grade shown on the Plans or directed by the Resident Engineer.

The Department will not allow shimming to the bottom of the forms to exceed 2 in [50 mm] in built-up thickness for special curb sections. Obtain the Resident Engineer's approval for fastening the built-up section to the form.

Clean, and oil or wet forms before placing the concrete. Ensure tight forms to prevent leaks.

C. Placing Concrete

Check forms, then place and vibrate concrete in accordance with Subsection 414.04, "Construction Methods."

D. Surface Finish

As soon as the curb concrete can retain its shape without support, uniformly brush the surface.

Edge formed concrete joints, including edges at expansion and contraction joints or weakened-plane joints, to the radius shown on the Plans.

E. Joints

Construct curb joints perpendicular to the subgrade and to the longitudinal axis of the curb. Construct expansion and contraction joints at locations of joints in the adjacent pavement structure and in accordance with Subsection 701.08, "Joint Fillers and Sealants."

For expansion joints, use pre-molded expansion joint filler of the thickness and at the locations shown on the Plans.

For curb and gutter contraction joints used in conjunction with asphalt pavement, saw in accordance with Subsection 609.04.H, "Extruded Method," and seal with the same material used for sealing expansion joints.

F. Curb Openings

For curb openings, omit the top portion of the separate curb or the curb portion of the combined curb and gutter, as shown on the Plans or by the Resident Engineer. If leaving the bottom portion of a separate curb, or the gutter of combined curb and gutter, make the concrete higher at the back of the curb line than at the front.

G. Curing

Cure portland cement concrete curbs or combined curb and gutter in accordance with Section 414, "Portland Cement Concrete Pavement."

H. Extruded Method

To construct an extruded, combined curb and gutter, operate the extrusion machine on a string or wire line, with the rails or forms set at a uniform depth below the finished top of curb grade.

Uniformly feed concrete into the machine. Ensure that after extrusion, the concrete maintains the shape of the section without support. Ensure the finished curb, or curb and gutter, is well compacted, with no voids or honeycombs and built to the shape, line, and grade shown on the Plans. Perform additional surface finishing immediately after extrusion. Ensure tolerances in accordance with Subsection 414.04.Q, "Tolerances."

Construct joints at the same locations needed for form construction. Unless the Resident Engineer approves other methods, saw weakened-plane joints every 20 ft [6 m].

I. Asphalt Curbing

To construct short sections or radii of asphalt curbing, the Resident Engineer may approve other methods. Ensure curbing constructed by alternative methods produces the same result as the machine-produced curbing.

Construct asphalt curbing in accordance with Subsection 411.04.A, "Stockpiling Materials," through Subsection 411.04.G, "Tack Coat," except as follows:

- Establish one edge of the asphalt curb with a string or wire line.
- Place the asphalt curb at the lowest temperature that yields the best results for the mix placed and machine used.
- Ensure the placement temperature does not vary more than 20 °F [11 °C].

J. Backfill

Backfill the back side of the curbs with soil approved by the Resident Engineer, and compact in layers no greater than 6 in [150 mm] deep. Ensure the curb remains in-place and undamaged while placing and compacting the backfill. Repair damage to the curb at no additional cost to the Department.

609.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of *Concrete Curb*, *Combined Curb and Gutter*, *Concrete Header Curbing*, and *Asphalt Curbing* along the front face of the curb, including curb openings.

609.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) CONCRETE CURB	Linear Foot [Meter]
(B) COMBINED CURB AND GUTTER	Linear Foot [Meter]
(C) CONCRETE HEADER CURBING	Linear Foot [Meter]
(D) ASPHALT CURBING	Linear Foot [Meter]

The Department will consider the cost of placing backfill for curbs to be included in the contract unit price for the relevant curb pay item.

SECTION 610

CONCRETE OR ASPHALT SIDEWALKS, DRIVEWAYS, DIVIDING STRIPS, AND TACTILE WARNING DEVICES

610.01 DESCRIPTION

This work consists of constructing concrete or asphalt sidewalks, driveways, dividing strips, and tactile warning devices.

610.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Asphalt Mixture	708.04
Portland Cement Concrete Class A	701.01
Tactile Warning Device Material	733.10

610.03 EQUIPMENT — VACANT

610.04 CONSTRUCTION METHODS

A. Concrete Construction

Form, place, and finish concrete in accordance with Subsection 414.04, “Construction Methods," except, broom-finish or burlap-drag the final surface of concrete sidewalks, driveways, and divider strips, or complete as directed by the Resident Engineer. Connect the old and new pavement with a sawed joint.

(1) Expansion Joints

Construct expansion joints to the dimensions required by the Contract and fill with the pre-molded filler as shown on the Plans.

(2) Dummy Joints

Use a jointing tool, or other method approved by the Resident Engineer, to divide the sidewalk into sections with dummy joints. Extend the dummy joints into the concrete at least one-third the concrete slab depth and to ⅛ in [3 mm] wide.

(3) Construction Joints

Form construction joints around appurtenances, extending the joints into the sidewalk, driveway, or dividing strip. Install pre-molded expansion joint filler to a thickness of ¼ in [6 mm], between the concrete and fixed structures.

(4) Curing

Use moist burlap or cotton mats to cure concrete for at least 72 hr in accordance with Subsection 414.04.J, “Curing.” During the curing period, do not allow traffic to use the surface. Prevent vehicular traffic from using the surface for additional time as directed by the Resident Engineer.

B. Asphalt Construction

Excavate and build forms in accordance with Subsection 609.04.A, “Excavation,” and Subsection 609.04.B, “Forms.” Perform asphalt construction in accordance with Subsection 411.04, “Construction Methods.” Place the asphalt material on the compacted subgrade in one or more layers, and compact to the thickness shown on the Plans.

Use a hand-operated or power roller to uniformly compact the material. The type and weight of the roller must meet the Resident Engineer’s approval. Hand-tamp areas inaccessible to the roller.

C. Backfill

Backfill the sides of sidewalks and driveways immediately after form removal and honeycombed areas are filled and pointed. Backfill using material, approved by the Resident Engineer, thoroughly compacted in layers no deeper than 6 in [150 mm] compacted. Protect the concrete or asphalt material from damage during placement and compaction.

Where the elevation of the adjacent surface is lower than the sidewalk or driveway, ensure the width of the backfill is at least 2 ft [0.6 m].

D. Protection from Traffic

Use barricades to protect sidewalks, driveways, and dividing strips from traffic. Protect concrete for 7 days and asphalt for 1 day, unless otherwise directed by the Resident Engineer.

E. Remove, Relay, or Extend Brick or Stone Sidewalks

If relaying or extending brick or stone sidewalks, prepare the subgrade in accordance with Subsection 610.04.A, "Concrete Construction." Provide a sand cushion 1½ in [38 mm] deep with a uniform, flat surface at the subgrade elevation. Before relaying sidewalk, clean the old bricks. Lay the bricks or stones close together to match the existing walk, and tamp firmly into the sand cushion.

Ensure the surface of the walk is smooth and at the grade shown on the Plans. Fill the joints with mortar grout composed of one part portland cement and two parts mortar sand by volume, by spreading an excess over the surface and sweeping into the joints. Clean the surface of the brick. Backfill the sides of the walk as required in the Contract for concrete sidewalks.

F. Tactile Warning Device

Install tactile warning device materials in accordance with the manufacturer’s specifications and as shown on the Plans.

610.05 METHOD OF MEASUREMENT — VACANT

610.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) CONCRETE SIDEWALK	Square Yard [Square Meter]
(B) CONCRETE DRIVEWAY	Square Yard [Square Meter]

Pay Item:	Pay Unit:
(C) CONCRETE DIVIDING STRIP	Square Yard [Square Meter]
(D) REMOVE AND RELAY BRICK OR STONE SIDEWALK	Square Yard [Square Meter]
(E) BRICK OR STONE SIDEWALK	Square Yard [Square Meter]
(F) ASPHALT SIDEWALK	Square Yard [Square Meter] or Ton [Metric Ton]
(G) ASPHALT DRIVEWAY	Square Yard [Square Meter] or Ton [Metric Ton]
(H) ASPHALT DIVIDING STRIP	Square Yard [Square Meter] or Ton [Metric Ton]
(I) TACTILE WARNING DEVICE	Square Foot [Square Meter]

The Department considers the cost of reinforcement, excavation, backfill, expansion joint material, rolled curb on driveways, and other related miscellaneous work to be included in the contract unit price for the relevant pay item.

SECTION 611
MANHOLES, DROP OR CURB INLETS, AND JUNCTION BOXES

611.01 DESCRIPTION

This work consists of constructing manholes, drop or curb inlets, junction boxes, or similar structures using precast concrete units, brick masonry, or cast-in-place concrete.

611.02 MATERIALS

A. General

Provide materials in accordance with the following section and subsections:

Material:	Section or Subsection:
Portland Cement	701.02
Mortar Sand	701.05
Clay Brick	714.01
Concrete Brick	714.02
Structural Steel	724
Steel Castings	725.02
Iron Castings	725.03
Precast Manholes	726.01
Portland Cement Concrete Class A	701.01

The Department will allow precast concrete units instead of brick masonry or cast-in-place concrete unless otherwise shown on the Plans, except, the Department will not allow brick masonry for the construction or rebuilding of sanitary sewer manholes.

Ensure precast structures, with slab tops that may be subject to traffic, meet HS-20 loading requirements. Ensure precast units consist of Class A concrete.

Provide coarse aggregate in accordance with Subsection 701.06, "Coarse Aggregate." Provide size No. 7 coarse aggregate for thin section concrete. If using alternative forms of concrete, provide in accordance with AASHTO M 199 (ASTM C 478).

Provide reinforcing steel for precast concrete units in accordance with Subsection 723.01, "Bar Steel Reinforcement — Billet Steel," Subsection 723.02, "Welded Steel Wire Fabric," and Subsection 723.03, "Steel Wire Strand for Prestressing." If using alternative steel, provide in accordance with AASHTO M 199 (ASTM C 478).

Provide two **T**-handles for up to the first 20 locking manhole covers and one for each additional 20 locking manhole covers.

B. Portland Cement Mortar

With brick masonry, provide mortar composed of one part portland cement and two parts mortar sand by volume, mixed with water to form a plastic consistency. Do not substitute more than 10 percent of the cement, by volume, with hydrated lime. Add the hydrated lime to the cement first.

C. Accessories

For accessories such as bolts, rivets, spacers, small **I**-beams, channels, and plates for assembling or supporting frames, grates, or covers, provide first-quality standard commercial material free of defects.

611.03 EQUIPMENT

Provide specialized equipment capable of off-loading, handling, and placing the largest single unit, subassemblies, or both. Provide lift holes or lift rings in each unit in accordance with the manufacturer's recommendation. Ensure lift devices and connection points are safe for handling above ground and in the inlet excavation.

611.04 CONSTRUCTION METHODS

A. Concrete

When constructing concrete bottoms for manholes and inlets, round the concrete to the dimensions and shape shown on the Plans. Trowel the surface to obtain a uniform, smooth, and impervious hard-fanned finish.

Ensure exposed concrete edges have at least a ½ in [13 mm] chamfer, or a rounded edge. Finish exposed concrete surfaces in accordance with Subsection 509.04.G, "Finishing Formed Concrete Surfaces."

B. Clay Brick or Concrete Brick

For brick masonry used in circular or curved walls with radii less than 2 ft [0.6 m], install stretchers every fifth course and headers for the remainder. Ensure the thickness of the joints does not exceed ¼ in [6 mm] vertical on inside faces or ⅜ in [10 mm] on horizontal faces. For brick masonry used in both straight and curved walls with radii at least 2 ft [0.6 m], install headers every fifth course and stretchers for the remainder. Ensure the thickness of the joints does not exceed ⅜ in [10 mm]. Construct vertical joints in subsequent courses half the length or width of the brick.

Lay the brick in a full bed of mortar and construct shoved joints. The Department will not allow buttered joints.

For joints on the inside or exposed face of the masonry, rub the joints fully and cut as the brickwork is built up. Build up the masonry in level courses true to the lines, grades, and dimensions shown on the Plans. Use bats to close joints around irregular openings as directed by the Resident Engineer. Thoroughly wet the brick immediately before placing. Clean and wet old brick masonry before joining new masonry to it. If the Contract requires a mortar coating, apply to the minimum thickness shown on the Plans. Apply the mortar coat while the brick masonry is clean and damp, then trowel to a uniform, smooth, impervious surface.

C. Pipe Connections

Use inlet and outlet pipe of the size shown on the Plans or as directed by the Resident Engineer. Ensure the end of the pipe is flush with the inside of the wall and tightly seal the circumference of the pipe in the wall with mortar. Remove the lip of the female end of the pipe, and press in and trowel the mortar flush with the face of the wall.

D. Special Curb

If building curbs adjacent to sewer inlets, use the same type of concrete as the regular curb or Class A concrete where no regular curb is being built. Accurately shape the forms for the curb opening to the dimensions and at the locations shown on the Plans. Ensure the forms remain in place for at least 3 days to cure the concrete, or longer as directed by the Resident Engineer.

E. Reinforcing Steel

Place reinforcing steel in accordance with Section 511, “Reinforcing Steel for Structures.”

F. Castings, Grate, and Drop Inlet Grates and Special Frames

Assemble and place castings, grates, special frames, and supports as shown on the Plans. Bed the frames of manholes and covers, and inlets and grates in a layer of mortar with a full bearing and set to the grade shown on the Plans.

Unless otherwise shown on the Plans, make the top of the casting flush with the surrounding surface.

Finish exposed surfaces of special structural steel frames and supports in accordance with Section 506, “Structural Steel.”

G. Excavation and Backfill

Excavate to the depth shown on the Plans and compact the base for manholes, inlets, or junction boxes to a firm, even surface. Replace unsuitable material with suitable material and compact as directed by the Resident Engineer.

H. Precast Units

Bed precast concrete units on a solid foundation at least 2 in [50 mm] thick that consists of clean, uniformly graded material capable of being mechanically leveled, leveled by flooding, or floated on a lean grout.

The Department will not allow the presence of clay balls or cement clumps. If using sand flooding or grout pouring for bedding, backfilling, or both, securely anchor

the units to prevent lateral or vertical movement. Immediately after placement, backfill inlet excavation and compact using incremental layers or sand flooding.

Place entrance and exit conduits (round, oval, elliptical, arch pipe, or concrete box) with flowlines as shown on the Plans.

The Department will not allow alterations of the elevation or angle to facilitate ease of installation or to make use of an existing blockout.

Set precast concrete inlet units flush with, or slightly below, the subgrade to prevent interference with the movement of the paving equipment. If precast concrete inlet assemblies are set at subgrade elevation, use a bedded brick (fired clay or concrete) leveling course to bring the inlet assembly to the final grade shown on the Plans. The Department will allow a formed and poured concrete collar. Pin the concrete collar to the inlet box and additional opening boxes as approved by the Resident Engineer.

Ensure precast concrete units provide a soil-tight connection between subassemblies and at each entrance or exit conduit blockout. If a unit is delivered with a blockout placed in error, or if a Plan revision renders a blockout unnecessary, clean the hole and fill with a concrete patch. For blockouts, the Department will allow a patch from a previous blockout hole securely grouted in place or poured, or placed using a dry-mix high-strength concrete.

Provide gasket material for use between subassemblies or between the inlet unit and entrance or exit conduits, in accordance with the Materials Division's "Approved Products List" for adhesive materials.

Seal the joints and base of precast manholes in accordance with Subsection 613.04.E, "Outlet Headwalls," to prevent water passage; except, make joints with a single natural rubber or neoprene gasket or **O**-ring in accordance with the manufacturer's recommendations.

611.05 METHOD OF MEASUREMENT

A. Manhole

The Resident Engineer will measure each *Manhole* as including the concrete bottom and up to 5 ft [1.5 m] of wall, measured from the bottom of the frame cover casting to the flowline of the outlet conduit.

B. Additional Depth in Manhole

The Resident Engineer will measure the depth of wall in excess of 5 ft [1.5 m] for *Additional Depth of Manhole*, in accordance with Subsection 611.05.A, "Manhole."

C. Special Manhole

The Resident Engineer will measure *Special Manhole* by the volume of 8 in [200 mm] thick wall constructed and make deductions for openings. The Resident Engineer will measure the concrete bottom in accordance with Section 509.05, "Method of Measurement."

D. Inlet

The Resident Engineer will measure each *Inlet* by the number of inlet provided by each type and design as shown on the Plans.

E. Additional Depth in Inlet

The Resident Engineer will measure the depth of single or double inlet boxes and additional curb opening boxes in excess of the minimum depth shown on the Plans for *Additional Depth in Inlet*.

F. Junction Boxes

The Resident Engineer will measure the volume of 8 in [200 mm] thick wall for *Junction Boxes* and make deductions for pipe openings with diameters greater than 18 in [450 mm].

611.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) MANHOLE	Each
(B) ADDITIONAL DEPTH IN MANHOLE	Vertical Foot [Meter]
(C) REPLACEMENT OF MANHOLE FRAME AND COVER	Each
(D) REPLACEMENT MANHOLE FRAME	Each
(E) REPLACEMENT OF MANHOLE COVER	Each
(F) REPLACEMENT OF MANHOLE COVER GRATE	Each
(G) INLET	Each
(H) ADDITIONAL DEPTH IN INLET	Vertical Foot [Meter]
(I) REPLACEMENT OF INLET FRAME AND GRATE	Each
(J) REPLACEMENT OF INLET FRAME	Each
(K) REPLACEMENT OF INLET GRATE	Each
(L) JUNCTION BOXES	Cubic Foot [Meter]
(M) REPLACEMENT OF CAST IRON HOOD	Each
(N) WELDED STEEL GRATE	Each

The Department will consider the cost of the following to be included in the contract unit price for the relevant pay items:

- Excavation,
- Backfill,
- Reinforcing steel,
- Frames,
- Covers,
- Grates,
- Cast Iron Hoods,
- Support beams,
- Support beams with riser plates,
- Bolts,
- Nuts, and
- **T**-handles for locking manhole covers.

SECTION 612
ADJUSTMENT OF EXISTING STRUCTURES

612.01 DESCRIPTION

This work consists of adjusting, altering, relocating, resetting, and realigning existing structures, equipment, or appurtenances. This applies to public structures shown on the Plans to remain.

612.02 MATERIALS

Provide materials of an equivalent grade to the existing structure, as shown on the Plans, or materials required by the Contract for similar work.

612.03 EQUIPMENT — VACANT

612.04 CONSTRUCTION METHODS

A. General

If required by the Contract, refurbish and reset Department-provided electrical equipment, including delivering the equipment to the project from the location shown on the Plans.

Adjust, reset, or rebuild existing structures to the final grade shown on the Plans, or as approved by the Resident Engineer. Make adjustments to existing structures in pavement after placing the final surface course.

Protect the altered, removed, or reset structure or appurtenance during transport and adjustment. Repair or replace unprotected items damaged during transport or adjustment at no additional cost to the Department.

Transport items from the storage site, and reset at no additional cost to the Department. Modify, clean, or repair the structure or appurtenances before resetting as shown on the Plans.

B. Manholes

If the Contract requires the tops of the manholes to be lowered to a new grade, remove the walls and rebuild manholes so the maximum batter of the walls does not exceed 4 in/ft [330 mm/m].

If the Contract requires manholes to be raised 1 ft [300 mm] or less to the new grade, construct the walls vertically from the top of the batter section. If the Contract requires manholes to be raised more than 1 ft [300 mm] to the new grade, remove the walls to the bottom of the batter section, or to an elevation at which the inside diameter of the manhole is at least 3 ft [0.9 m] and rebuild in accordance with Section 611, "Manholes, Drop or Curb Inlets, and Junction Boxes."

C. Inlets and Manholes

Reset or rebuild inlets manholes, or similar structures to the grade shown on the Plans in accordance with Section 611, "Manholes, Drop or Curb Inlets, and Junction Boxes."

D. Valve Boxes and Meter Boxes

Reset or remove valve boxes and meter boxes to the grade shown on the Plans without damaging. Replace damaged items at no additional cost to the Department.

E. Fire Hydrants, Valves, Water Meters, Waterlines, Manholes, Etc.

If the Contract does not require this work, coordinate with the owner of structures to lower or relocate waterlines and reset water valves, meters, manholes, and fire hydrants. If the Contract requires this work, alter these items in accordance with the requirements of the owner and Section 616, "Water Pipe and Fittings."

F. Pipe Sewers

Remove and relay pipe sewers and appurtenances in accordance with Section 615, "Sanitary Sewer Pipe Conduits."

G. Waterlines

Remove and relay or lower waterlines and appurtenances in accordance with Section 616, "Water Pipe and Fittings."

612.05 METHOD OF MEASUREMENT

The Resident Engineer will measure reset, relaid, and adjusted structures by each unit of the type and size required by the Contract.

612.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) MANHOLE ADJUST TO GRADE	Each
(B) MANHOLE REBUILT	Each
(C) INLET ADJUST TO GRADE	Each
(D) INLET REBUILT	Each
(E) VALVE BOX ADJUST TO GRADE	Each
(F) METER BOX ADJUST TO GRADE	Each
(G) FIRE HYDRANT RESET	Each
(H) VALVE RESET	Each
(I) WATER METER RESET	Each
(J) WATERLINE LOWERED	Linear Foot [Meter]
(K) WATERLINE REMOVED AND RELAID	Linear Foot [Meter]
(L) PIPE SEWER REMOVED AND RELAID	Linear Foot [Meter]
(M) REMOVE AND RESET MANHOLE FRAME AND COVER	Each

The Department will consider the cost of valve boxes, meter boxes, etc., to be included in the contract unit price for *Valves Reset* and *Water Meters Reset*. The Department will consider the cost of valves in waterlines and fire hydrant leads, and the cost of resetting to be included in the contract unit price for *Valves Reset*. The Department will consider the cost of adjusting valve boxes under pavement to be included in the contract unit price for *Valve Boxes Adjust to Grade*.

The Department will pay for separately classified extensions to fire hydrant leads for new waterlines in accordance with Section 616, "Water Pipe and Fittings." If the extensions are not classified separately, the Department will consider the cost of pipe to be included in the contract unit price for *Fire Hydrant Reset*.

SECTION 613
DRAINAGE CONDUITS

613.01 DESCRIPTION

This work consists of installing new or removing and reinstalling existing pipe conduits, including the following:

- Pipe underdrains and edgedrains at least 4 in [100 mm] in diameter; and
- Other pipe with inside diameter of at least 12 in [300 mm], used in storm drains and culverts, or drainage conduits not defined as bridges.

613.02 MATERIALS

Provide drainage conduit in accordance with Section 726, "Drainage Conduits." Provide the class of reinforced concrete pipe, the sheet thickness of corrugated steel and corrugated aluminum pipe, and the heights of fill above the tops of pipes as shown on the Plans.

Unless otherwise required by the Contract, provide Class III reinforced concrete culvert pipe.

If the type of pipe is not shown on the Plans, the type is optional. Provide the same type of pipe for each application, unless the Resident Engineer approves an alternative in writing.

Provide materials in accordance with the following subsections:

Material:	Subsection:
Joint Filler	726.01.B
Standard Bedding Material	703.08
Cover Material For Pipe Underdrains	703.06

For jacking operations, provide the type, size, class, and quantity of pipe shown on the Plans.

613.03 EQUIPMENT — VACANT

613.04 CONSTRUCTION METHODS

A. General

Begin installing pipe conduits at the outlet or the lowest point of the line. If installing a main or submain drainage conduit with at least one lateral or tributary,

construct the tributary lines after completing the main or submain drainage conduit so ensure drainage during construction.

Replace cracked and deformed conduits before final acceptance at no additional cost to the Department. Provide for drainage during construction.

Join new and existing storm drain appurtenances as shown on the Plans or as approved by the Resident Engineer. Protect structures from damage during construction. Ensure storm drain conduits do not project beyond the inside wall of other sewers or sewer appurtenances. Install the invert or flow line of the drainage conduit to the grade line shown on the Plans, unless otherwise directed by the Resident Engineer. Establish the center and grade lines in the trench at intervals no greater than 25 ft [7.5 m]. The Department will allow an interval increase to 50 ft [15 m] if using a laser device to establish the center and grade lines, except when establishing the center and grade lines of manholes or appurtenances, set the first interval at 25 ft [7.5 m].

Seal drainage conduit dead ends, wyes, and tees by cementing stoppers in place. When temporarily stopping storm drain work, prevent trash or debris from entering conduits using a non-watertight stopper to close the end of conduits with diameters 24 in [600 mm] or less.

Place edge drain conduit in an excavated trench lined with separator fabric. Provide surfacing above the trench backfill as shown on the Plans. Construct splices in accordance with the manufacturer's

recommendations. Use elbow outlet fittings of high-impact polyethylene or equivalent material to transition between the edge drain conduit and the edge drain outlet laterals.

Place the edge drain and under drain outlet laterals and headwalls on a smooth grade, backfill the trenches with native material, and compact as shown on the Plans.

Install the outlet lateral and connect to the edge drain within 48 hr of placing the edge drain.

To repair damaged edge drain conduit, splice with an undamaged section of conduit. Make repairs at no additional cost to the Department.

Upon completion and before acceptance by the Resident Engineer, cover lateral outlets and clear the headwalls of debris.

B. Excavation

Excavate only as much trench for pipe conduit as can be laid within 2 calendar days, unless otherwise directed by the Resident Engineer. Excavate only as much trench for pavement edge drain conduit as can be set and backfilled in 1 calendar day.

Protect existing pavement from damage during excavation and placement of pavement edge drain. Repair damages at no additional cost to the Department.

After completing the embankment to the height required by the Contract (above the flow line grade), excavate trenches to place conduits in embankment fill.

Excavate trenches to the width shown on the Plans, from the bottom of the trench to at least 2 ft [0.6 m] above the top of the conduit.

Provide additional excavation to accommodate the bells at every joint. Ensure the size and depth of the additional excavation relieves any load on the bell and provides firm bedding under the conduit and adequate space to construct the joint.

Place concrete cradle or refill as shown on the Plans or directed by the Resident Engineer.

Compact the full length and width of the trench bottom. Remove and replace soft or unsuitable material and replace with suitable material as directed by the Resident Engineer. For cross drains, excavate to a grade line with a longitudinal camber as shown on the Plans.

Unless otherwise required by the Contract, excavated materials not used on the Project as embankment or backfill becomes the property of the Contractor for removal and disposal.

The Department will consider trench excavation as unclassified excavation as defined in accordance with Subsection 202.01, "Description."

C. Bedding

Place the following classes of bedding material in accordance with the type and size of conduit, as shown on the Plans or as directed by the Resident Engineer:

Class A. Bedding material in accordance with Subsection 703.08, "Standard Bedding Material."

Class B. Bedding material in accordance with Subsection 703.08, "Standard Bedding Material."

Class C. Bedding material in accordance with Subsection 703.08, “Standard Bedding Material.”

Class D. Bedding material in accordance with Subsection 703.08, "Standard Bedding Material," and compacted in the bottom of the trench as shown on the Plans.

Underdrain bedding. Bedding material of granular backfill material in accordance with Subsection 703.06.B(1), “Coarse Cover Aggregate,” compacted in the bottom of the trench as shown on the Plans.

Edge drain bedding. Bedding material in accordance with Subsection 701.06, “Coarse Aggregate” size 57.

Compact backfill material placed above bedding material in accordance with Subsection 202.04.B, “Embankments.”

D. Separator Fabric

Install separator fabric in accordance with Section 325, “Separator Fabric for Bases,” as shown on the Plans.

E. Outlet Lateral Headwalls

Construct outlet headwalls in accordance with Section 509, “Structural Concrete,” and place at each outlet lateral, as shown on the Plans or as directed by the Resident Engineer.

F. Rodent Screen

Install rodent screens in each outlet lateral line and fasten to the outlet end of the edge drain lateral pipe.

G. Laying Pipe

Place pipe on a foundation of bedding material approved by the Resident Engineer to the center and grade lines shown on the Plans, with the bell facing upstream. Ensure the conduit remains in place.

Lower the pipe into the trench without dropping. Use hoisting equipment to place the pipe. Clean the inside of the barrel before lowering the pipes into the trench. Avoid damaging the pipe or trench. Replace damaged pipe or repair damaged trench at no additional cost to the Department.

Start laying the pipe at the outlet or the lowest point of the line. Ensure the bottom of the pipe contacts the shaped bedding along the entire length.

Lay paved or partially lined pipe so the longitudinal centerline of the paved segment conforms to the flow line. When placing elliptical and elliptically reinforced pipes, ensure the major axis is within 5° of a horizontal plane through the longitudinal axis of the pipe.

Do not fill or ram material under pipe to raise the pipe to grade.

Embed under drain pipe in the bedding material and place at the center and grade lines shown on the Plans. Lay perforated pipe with the perforations facing down. Place under drain pipe with a top-of-pipe identification marker facing up.

Fasten metal screens to the outlet end of the subdrain pipe. Provide mesh screens with ½ in [12 mm] openings, fabricated of steel wire with diameters of 0.04 in [1 mm], or 0.08 in [2 mm] after galvanization. Ensure the wire mesh meets the requirements of ASTM A 740. Permanently seal the dead end of the pipe with end caps.

At under drain pipe outlets, provide and set a marker post as shown on the Plans.

H. Joining Pipe Conduit

When joining pipe conduit sections, ensure the ends are fully inserted and the inner surfaces are flush.

Construct joints with mortar, cold applied mastic-rubber gaskets, or plastic joint material as shown on the Plans. Ensure the joints are concentric and reasonably watertight. Keep the inside of the pipe free of joint material. Join flexible conduit with an external or internal coupling device, or with a twist-lock coupling system integrated into the wall of the conduit. Fasten the coupling system to the conduit and ensure the system does not release during installation, handling, and backfilling operations. The Resident Engineer will accept coupling systems based on the field conditions and will not accept systems that repeatedly release.

The Resident Engineer can approve or reject the coupling system, regardless of it being on the Material's Division "Approved Products List."

I. Backfilling

Allow the Resident Engineer access to the trench for inspection of the conduit before backfilling.

Ensure smooth inside joints and clean barrels. Before backfilling, replace misaligned, settled, or damaged pipes. After inspection and approval by the Resident Engineer, backfill the pipe trench with material as shown on the Plans preventing displacement of or damage to the pipe. Place standard bedding material over pipes,

except pipe under drains, to the depth shown on the Plans. Place and compact backfill in accordance with Subsection 202.04.B, "Embankments."

J. Jacking Pipe Conduit

Install pipe conduit by jacking, boring, or pushing as shown on the Plans or directed by the Resident Engineer. Install the pipe conduit to the center and grade lines shown on the Plans. Use methods and equipment for jacking and boring pipe conduit as approved by the Resident Engineer. Prevent operations from interfering with existing underground utilities. Keep the disturbed area to a minimum.

Install jacked, bored, or pushed pipe conduits at least 18 in [460 mm] below the ground line or subgrade. Cut an "X" in the curb or surface above both sides of the pipe conduit crossings as approved by the Resident Engineer.

Only use a circulation medium (water or other fluids) in boring or jacking operations with the written approval of the Resident Engineer. Use minimum pressure when applying the circulation medium. Keep the circulation medium in the casing throughout jacking and boring operations.

Install pipe conduit by jacking under railroad embankments, highways, streets, or other facilities without interfering with operation of the railroad, highway, street, or other facility, and without damaging the embankment or structure.

Install pipe conduit using jacking in accordance with the size, type, and class shown on the Plans. If the strength of the pipe conduit is not rated for the additional pressure of jacking operations, reinforce the pipe conduit to withstand jacking pressure at no additional cost to the Department.

If jacking or pushing pipe conduit with an inside diameter greater than 2 in [50 mm] under railroads, highways, streets, or other facilities, bore or remove the soil during the jacking or pushing operation. If jacking or pushing pipe conduit with an inside diameter of 36 in [915 mm] or less under railroads, highways, streets, or other facilities, install the pipe conduit using a combination of boring and jacking. Use a boring auger or bit with a diameter smaller than that of the pipe conduit. Jack the pipe conduit as the boring auger drills out the material. Bore no more than 1 ft [0.3 m] ahead of the pipe conduit.

If the grade of the pipe conduit at the jacking end is below the ground surface, excavate pits for jacking. Continuously dewater the pits until backfilling is complete.

Provide heavy-duty jacks for installing the pipe conduit in the embankment. Apply even pressure to the jacks. Provide a jacking head, and bracing between the jacks and the jacking head to ensure the pipe conduit receives uniform pressure. Provide a jacking frame or backstop. Set the pipe conduit on guides braced together to support the sections of pipe conduit, and to direct it to the center and grade lines shown on the Plans. If pipe conduit sections are less than 6 ft [1.8 m] long, place two sections in the guide frame at the same time. Lubricate the joints to minimize breakage. Place the jacking assembly in line with the grade of the pipe conduit. Push the pipe conduit through the embankment with jacks and excavate earth material ahead of the pipe conduit removing the material through the pipe conduit.

Excavate at least one-third the circumference of the pipe conduit to accommodate the underside of the pipe conduit. Ensure the excavated area conforms to the shape and grade of the conduit. Unless otherwise specified, create a clearance of 2 in

[50 mm] or less for the upper half of the pipe conduit. Where the excavation conforms to the pipe conduit's shape, taper the clearance to zero.

The Department will allow a steel cutting edge around the head and for not less than the upper two-thirds of the conduit and extending a short distance beyond the end of the conduit. Construct the steel cutting edge, and mount and use it so as to ensure that clearance between the outside of the conduit and the undisturbed earth will be not more than ½ in [12 mm]. If When excavating inside the pipe, do not exceed the outside diameter of the conduit or extend more than 12 in [300 mm] beyond the lead edge of the cutting head; this will provide for final trimming by the cutting edge and eliminates any void space except that clearance allowed above regarding the steel cutting head.

Perform jacking operations without interruption to prevent the pipe conduit from becoming firmly set in the embankment.

Stop jacking operations at the first signs of caving. Make corrections and install measures to prevent future caving before restarting, as approved by the Resident Engineer.

Use grout to fill cavities or voids created by jacking operations, as approved by the Resident Engineer. Remove conduit damaged by jacking operations, and replace at the no additional cost to the Department.

K. Re-laying Culvert Pipe

Clean the culvert pipe before re-laying and install in accordance with Subsection 613.04.G, "Laying Pipe."

613.05 METHOD OF MEASUREMENT

The Resident Engineer will not deduct from the length of pipe measurements for the following:

- Wye branches, and
- Standard manholes for conduits 12 in [300 mm] or less in diameter.

The Resident Engineer will make deduct from the length of pipe measurements for the following:

- Special structures, and
- Manholes and all structures for conduits larger than 12 in [300 mm] in diameter.

The Resident Engineer will measure the length of drainage conduit, edge drain conduit, and edge drain outlet laterals along the conduit center and grade lines.

The Resident Engineer will calculate the volume of standard bedding material Class A, Class B, and Class C as follows:

- Calculate the theoretical cross-sectional area using the width of the trench and the height of the bedding material as shown on the Plans;
- Deduct the theoretical cross-sectional area of the embedded portion of the pipe using the outside diameter as shown on the Plans; and
- Multiply the difference by the length of the drainage conduit completed in place.

The Resident Engineer will measure pipe under drain cover material using the width

and depth of the trench shown on the Plans, and will not deduct the volume of the under drain pipe.

The Resident Engineer will calculate the volume of trench excavation by multiplying the width of the trench shown on the Plans, the length of the drainage conduit completed in place, and the trench depth determined as follows:

- Cut areas – the average depth from the lower excavation line to the finished subgrade shown on the Plans.
- Fill areas – the depth from the lower excavation line shown on the Plans to 2 ft [0.6 m] above the drainage conduit.

The Resident Engineer will establish the lower excavation line (used in determining the depth of trench excavation) by subtracting the thickness of the drainage conduit wall (as determined below) and the depth of bedding material below the outside surface of the drainage conduit shown on the Plans from the flow line elevation shown on the Plans. The Resident Engineer will determine the thickness of the drainage conduit wall as follows:

- For rigid drainage conduit, the actual wall thickness; and
- For flexible drainage conduit, the height of the corrugation or actual wall thickness.

In adjacent excavation and embankment areas, the Resident Engineer will establish an equitable measurement elevation.

The Resident Engineer will measure jacked conduit along the centerline of the conduit.

613.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) REINFORCED CONCRETE PIPE, ROUND, ELLIPTICAL OR ARCH	Linear Foot [Meter]
(B) CORRUGATED GALVANIZED STEEL PIPE, ROUND OR ARCH	Linear Foot [Meter]
(C) MILL PRECOATED CORRUGATED GALVANIZED STEEL PIPE	Linear Foot [Meter]
(D) CORRUGATED ALUMINUM PIPE	Linear Foot [Meter]
(E) CORRUGATED POLYETHYLENE PIPE	Linear Foot [Meter]
(F) CAST IRON PIPE	Linear Foot [Meter]
(G) POLYVINYL CHLORIDE (PVC) PIPE	Linear Foot [Meter]
(H) PERFORATED PIPE UNDERDRAIN	Linear Foot [Meter]
(I) NON-PERFORATED PIPE UNDERDRAIN	Linear Foot [Meter]
(J) EDGE DRAIN CONDUIT – PERFORATED	Linear Foot [Meter]
(K) EDGE DRAIN OUTLET LATERAL – NONPERFORATED	Linear Foot [Meter]
(L) PREFAB. CULV. END SECT., ROUND, ELLIPTICAL, OR ARCH	Each
(M) CULVERT END TREATMENT	Each
(N) SLOPED CONCRETE END SECTION	Each

Pay Item:	**Pay Unit:**
(O) SPECIAL END SECTIONS OF REINFORCED CONCRETE	Each
(P) GALVANIZED STEEL CULV. END SEC., ROUND OR ARCH	Each
(Q) OUTLET LATERAL HEADWALL	Each
(R) STANDARD BEDDING MATERIAL, CLASS A	Cubic Yard [Cubic Meter]
(S) STANDARD BEDDING MATERIAL, CLASS B	Cubic Yard [Cubic Meter]
(T) STANDARD BEDDING MATERIAL, CLASS C	Cubic Yard [Cubic Meter]
(U) PIPE UNDERDRAIN COVER MATERIAL	Cubic Yard [Cubic Meter]
(V) TRENCH EXCAVATION	Cubic Yard [Cubic Meter]
(W) JACKED CONDUIT	Linear Foot [Meter]
(X) RE-LAYING CULVERT PIPE	Linear Foot [Meter]

The Department will pay for different sizes and types of pipe as separate pay items.

The Department will consider the cost of removing unsuitable material to be included in the contract unit price for *Trench Excavation*, and will consider the replacement with suitable material to be included in the contract unit price for the relevant bedding material pay item.

The Department will pay for separator fabric in accordance with Section 325, “Separator Fabric for Bases.”

The Department will consider the cost of standard bedding material Class D, earth backfill, sheeting, shoring, stoppers (plugs), and joint filler to be included in the contract unit price for the relevant pay item.

The Department will include the cost of under drain pipe outlet markers to be included in the contract unit price for the relevant pipe under drain pay item.

The Department will consider the cost of constructing pilot tunnels and conduit used in jacking operations to be included in the contract unit price for *Jacked Conduit*.

The Department will consider the removal and disposal of excess material to be included in the contract unit price for other relevant excavation and removal pay items.

SECTION 614
WICK DRAINS AND STRIP DRAINS

614.01 DESCRIPTION

This work consists of installing prefabricated wick drains and strip drains.

614.02 MATERIALS

A. Wick Drains

Provide prefabricated wick drains with a free-draining, flexible-plastic core wrapped in a non-woven filter fabric. Fabricate the core with drainage channels. Provide a rigid wick drain capable of withstanding lateral earth pressures due to embedment and surcharge, so the vertical flow capacity through the core will not be adversely affected.

Ensure the prefabricated drains resist wet rot, mildew, bacterial action, and insects. Provide prefabricated drains with discharge capacities of at least 1.5 gal/min [5.68 L/min] if measured under 1 gradient at 40 psi [276 kPa] in accordance with ASTM D 4716.

The prefabricated drains must be Alidrain, Ameridrain (Type 407), Mebra Drain, or an approved equivalent. Provide Type B Certifications for these drains in accordance with Subsection 106.04, “Material Certifications.”

For other materials, submit samples of the prefabricated drain for evaluation and approval at least one month before beginning work.

B. Strip Drains

Provide strip drains that are flexible, prefabricated, rectangular shaped, composite products. The drain conduit must consist of a polyolefin inner core completely wrapped by a filter fabric.

Ensure the inner core supports the fabric that acts as a filter, stiffener, and flow channel for water draining downgrade to the outlet laterals. Permanently bond the filter fabric to the core protrusion. Ensure at least 70 protrusions from the inner core per square foot [753 protrusions per square meter] of strip drain surface. Ensure at least 90 percent of the protrusions are bonded to the filter fabric.

Provide non-woven filter fabric that consists of long chain synthetic polymers composed of at least 85 percent by weight polyolefins, polyesters, or polyamides.

Interconnect the horizontal and vertical flow of water within the strip drain for the full height of the core at all times. The drainage core with the geotextile laminated to one side of the core must provide a flow rate of at least 1 qt/sec/yd [1 L/sec/m] of width when tested in accordance with ASTM D 4716 under the test conditions in Subsection 614.02.A, “Wick Drains,” with a gradient of 1.

If core construction separates the flow channel into two or more sections, consider the flow rate on the in-flow face to determine the core acceptability.

Attach the geotextile to the core to prevent folding, wrinkling, or other movement during handling or after placement. Use nonwater-soluble, heat-sealing, or other

bonding methods recommended by the manufacturer. Use adhesive in areas of the geotextile fabric where flow is not expected.

If heat sealing, maintain the required strength values of the geotextile. Encapsulate the collector pipe by extending the geotextile below the bottom of the core length.

Avoid exposing the fabric to ultraviolet radiation. The Resident Engineer will reject fabric that is exposed for more than 30 days from the manufacture date to the completion of installation.

(1)Handling and Storage

The manufacturer will provide the strip drain wrapped in black plastic or in covered rolls for storage, handling and placement.

(2)Strip Drain Assembly Materials Certification

Provide a Type A Materials Certification for strip drains in accordance with Subsection 106.04, “Material Certifications,” for tests, except for composite in-plane flow and compressive strength. For strip drain in-place flow and compressive strength, provide a Type B Materials Certification in accordance with Subsection 106.04, “Material Certifications.” Provide a 9 ft [2.7 m] sample of the strip drain from each lot or shipment to the Department's Materials Engineer for inspection and testing.

The Resident Engineer will not require a fabric bond to the core if the structural integrity of the drain is defined and provided by the core alone.

614.03 EQUIPMENT

Install drainage wicks with equipment that will cause the least amount of subsoil disturbance during the installation operation.

Install the drainage wick using a sleeve or mandrel that intrudes into the soil. Ensure the sleeve protects the wick material from tears, cuts, and abrasions during installation. Provide a sleeve with a cross sectional area no greater than 12 in² [7,741 mm²]. To minimize disturbance to the subsoil, intrude the sleeve into the subsoil using static or vibratory methods; the Department will not allow impact methods.

Ensure the sleeve has an “anchor” rod or plate at the bottom to prevent the soil from entering the bottom of the sleeve during installation and to anchor the bottom of the drain when the sleeve is removed.

At least two weeks before installing the drainage wicks, submit the details of the sequence and method of installation to the Resident Engineer.

614.04 CONSTRUCTION METHODS

A. General

The Resident Engineer will allow the installation of wick drains when the minimum experience requirements are met. The minimum experience requirement consists of successfully completing three wick drain installation projects. Identify the three projects by project name, location, description, size, completion date, and contract manager.

Construct a work platform to install the drains. Keep the work platform in place and allow it to become part of the embankment.

B. Wick Drains

Before installing drainage wicks, demonstrate that the equipment, method, and materials produce an installation that meets the Contract requirements. Install trial wicks at locations directed by the Resident Engineer.

The Resident Engineer's approval of the method and equipment to install the trial wicks does not constitute acceptance of the method for the remainder of the Project. If the Resident Engineer decides the method of installation produces unsatisfactory wick, alter the method, equipment, or both.

Locate, number, and mark drainage wicks. Take precautions to preserve the markings. Ensure drainage wick locations do not vary by more than 6 in [150 mm] from the locations shown on the Plans or directed by the Resident Engineer. Install drainage wicks from the working surface to the depth shown on the Plans or to a depth where the soil resists an effort at further penetration using equipment that meets the minimum requirements. The Resident Engineer may revise the Plan limits and vary the depths, spacing, or the number of wicks.

Check the equipment for plumbness before advancing each wick, and ensure it does not deviate by more than 4 percent from the vertical.

The Resident Engineer will reject wicks that are visibly damaged or are out of place by more than 6 in [150 mm].

Provide the Resident Engineer with a means to determine the linear quantity of wick material at each wick location. During installation of the wick, provide a means of determining the depth of the drainage wick.

Splice or connect the drainage wick material to ensure wick material continuity. Ensure a length of wick drain protrudes above the surface at each wick installation to secure the wick drain to the strip drain. Neatly cut the wick material at the upper edge.

To loosen stiff upper surface soils before installing the drainage wicks, use auguring or other methods, provided that augering does not extend more than 2 ft [0.6 m] into the soils.

Complete the drain from the elevation of the obstruction to the working surface. Notify the Resident Engineer where obstructions are encountered below the working surface that cannot be penetrated using equipment meeting the minimum requirements. Install a new drain 18 in [455 mm] from the obstructed drain as directed by the Resident Engineer.

Protect instrumentation devices. Replace damaged instrumentation devices at no additional cost to the Department.

C. Strip Drains

Lay strip drains flat and straight with minimal slack. Place strip drain products with a hard back and protrusions so the core back lies next to the ground with the studs pointing up. Ensure splices are neat and made in accordance with the manufacturer's recommendations using kits provided by the manufacturer. Secure the wick or strip drains and ensure the drains remain connected and in place throughout the construction process.

Use end dumping for the first layer of embankement to avoid damage to the drains from equipment traffic. Construct a 2 ft [0.6 m] “bridge lift” over the horizontal drains using low ground pressure equipment and light compaction.

614.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of prefabricated strip and wick drains (including trial drains) along the centerline of the drain.

614.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) PREFABRICATED WICK DRAIN	Linear Foot [Meter]
(B) PREFABRICATED STRIP DRAIN	Linear Foot [Meter]

The Department will pay for the volume of work platforms as *Unclassified Borrow* or *Unclassified Excavation* in accordance with Section 202, "Earthwork."

The Department will consider the cost of auguring stiff soils to be included in the contract unit price for *Prefabricated Wick Drain*.

SECTION 615
SANITARY SEWER PIPE CONDUITS

615.01 DESCRIPTION

This work consists of constructing sanitary sewer pipe.

Refer to the Oklahoma State Department of Health (OSDH) Regulations, the manufacturers’ recommendations, ASTM, ANSI, AWWA, and the Public Utility for whom the work is to be performed for additional specifications. The Special Provisions, Plans, Public Utility Specifications, Supplemental, or Standard Specification will govern over the OSDH minimum regulations.

615.02 MATERIALS

Provide materials in accordance with Section 726, “Drainage Conduits.” Mark the pipe with the appropriate specification number (e.g. AASHTO, ASTM, ANSI, NSF, AWWA).

A. Pipe

Before delivery to the jobsite, subject concrete pipe to an in-plant hydrostatic test of 10 psi [70 kPa] in accordance with ANSI/ASTM C 497. Coat concrete sanitary sewer pipe with two coats of coal tar base paint, each at least 16 mil [0.40 mm] thick. Allow each coat to dry for 24 hr.

Provide plastic pipe bearing the seal of the National Sanitation Foundation (NSF) with a Standard Dimension Ratio (SDR) no greater than 35.

As an alternative, use cast-in-place reinforced concrete boxes for sanitary sewer installations. Ensure the precast concrete boxes pass the same hydrostatic test.

B. Joints

Provide joints in accordance with Section 726, “Drainage Conduits,” except, make joints with a single natural rubber or neoprene gasket, or **O**-ring, in accordance with the manufacturer’s recommendations.

Provide reinforced concrete pipe joints in accordance with ANSI/ASTM C 443, with a 1:1 cement mortar collar formed using a diaper.

Provide vitrified clay pipe joints in accordance with ANSI/ASTM C 425.

Ensure Polyvinyl Chloride (PVC) pipe, fittings, and in-line tees dimensionally conform to ASTM D 3034, with an SDR of 35.

615.03 EQUIPMENT — VACANT

615.04 CONSTRUCTION METHODS

A. General

Begin construction of pipe conduits at the outlet or low point of the line. If the construction involves the building of a main or submain pipe conduit with one or more laterals or tributaries, start construction of tributary lines after completing the main or submain pipe conduit to the point at which the tributary or laterals discharge into it.

During construction, make provision for the sewerage of the system. Connect sanitary sewers or sewer appurtenances to other sanitary sewers or to sewer appurtenances as shown on the Plans, or approved by the Resident Engineer. Do not allow sewer pipe to project beyond the inside wall line of other sewers or sewer appurtenances.

(1) Setting Grade Lines

Use the grade line shown on the Plans, Supplemental Drawings, or established by the Resident Engineer as the elevation of the invert or flowline of the sewer. Establish the grade line and alignment using batterboards and a top line. When laying pipe, maintain a top line over a span of three-grade stakes. As each batterboard is erected, sight the top line to ensure the accuracy of the grade stakes and the batterboard setting. Ensure the Inspector is alerted of errors, discrepancies, or displacement of grade stakes.

(2) Using a Laser Device

Establish the batterboards at intervals of no more than 25 ft [7.5 m]. If a laser device establishes line and grade, increase the batterboard interval to 50 ft [15 m]. Always set the first batterboard at 25 ft [7.5 m] when laying out a manhole or appurtenance.

(3) Accommodating Water Mains

Separate sanitary sewers and water mains vertically and horizontally in accordance with the OSDH regulations. Horizontally place the sewer at least 10 ft [3 m] from existing or proposed water mains and 50 ft [15 m] from potable water wells. Where sewers cross water mains (either above or below), provide a vertical clearance of at least 2 ft [0.60 m]. If a water main crosses under a sewer provide structural support to the sewer. Install sewer pipe joints at least 10 ft [3 m] from water lines, unless otherwise approved by the Resident Engineer. When impossible

to meet these horizontal and vertical separation requirements, construct and pressure test the sewer line to ensure it is watertight before backfilling.

(4) Closing Dead Ends

When constructing ends, seal the dead ends of sewers, wyes, and tees by cementing stoppers in place. Securely place tight-fitting watertight stoppers or bulkheads in or across the end of sanitary sewer lines.

B. Excavation

Excavate in accordance with Subsection 613.04.B, "Excavation."

C. Bedding

Place bedding in accordance with Subsection 613.04.C, "Bedding."

D. Laying Pipe

Lay pipe in accordance with Subsection 613.04.G, "Laying Pipe."

E. Joining Pipe Conduit

Construct joints in accordance with the manufacturer's recommendations.

Before joining pipes, clean and dry the surfaces of the joint surface of the pipe. Keep trenches free of water until the joints become water tight.

Avoid realigning the pipe after completing the joint unless the pipe is removed and a new joint is constructed.

F. Backfilling

Backfill in accordance with Subsection 613.04.I, "Backfilling."

G. Field Testing

Provide written notification to the Resident Engineer 24 hr before testing.

Leakage tests may include water or low pressure air testing. Ensure outward or inward leakage, exfiltration or infiltration, does not exceed 200 gal per 1 in [1,860 L per 100 mm] of pipe diameter per mile [kilometer] per day. Perform an exfiltration or infiltration test with a positive head of at least 2 ft [0.60 m].

Conduct deflection tests on flexible pipes at least 30 days after placing the final backfill. Ensure the pipe deflection does not exceed 5 percent. Make the deflection test with a rigid ball or mandrel with a diameter equal to 95 percent of the inside diameter of the pipe. Do not use mechanical pulling devices, unless otherwise approved by the Resident Engineer.

Perform lamping in the presence of the Inspector. As required by OSHA regulations, use explosion-proof devices to provide a mechanical method of exchanging the air within the sewer line. Correct the pipe alignment as directed by the Resident Engineer at no additional cost to the Department. Ensure three-quarters of the pipe barrel is visible from manhole to manhole or appurtenance.

H. Inspection

The public utility will assign a representative to the Project to coordinate compliance with the utility specifications. The utilities representative will answer to the Resident Engineer. Direct all negotiations, decisions, instructions, interpretations, and matters influencing the work to the Resident Engineer.

615.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of *Polyvinyl Chloride (PVC) Pipe* and *Sanitary Sewer Service Line* along the pipe center and grade lines. The Resident Engineer will include the length of the riser pipe in the measurement for *Sanitary Sewer Service Line*.

The Resident Engineer will not include the following for measurement:

- The length of line within manholes and special structures.
- The length of vertical pipe or fittings required for drop manholes.

615.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) POLYVINYL CHLORIDE (PVC) PIPE	Linear Foot [Meter]
(B) SANITARY SEWER SERVICE CONNECTION	Each
(C) SANITARY SEWER SERVICE LINE	Linear Foot [Meter]

The Department will consider the cost of installing an in-line tee and bracing for riser pipe to be included in the contract unit price for *Sanitary Sewer Service Connection*.

The Department will consider the cost of the line within manholes and special structures, the vertical pipe or fittings required for drop manholes, earth backfill, sheeting, shoring, and concrete cradles to be included in the contract unit price for the relevant pay item.

The Department will consider the cost of all fittings and adaptors to connect service to the existing line to be included in the contract unit price for *Sanitary Sewer Service Line*.

The Department will consider the cost of testing to be included in the contract unit price for the relevant pay item.

SECTION 616
WATER PIPE AND FITTINGS

616.01 DESCRIPTION

This work consists of constructing waterlines and service lines.

616.02 MATERIALS

Provide materials in accordance with Section 733, "Miscellaneous Materials."

A. Pipe

Provide pipe as shown on the Plans with AASHTO, ASTM, ANSI or AWWA specifications numbers for quality control and installation.

Provide pipe or fittings with a pressure rating of at least 200 psi [1.4 MPa].

Provide plastic pipe bearing the seal of the National Sanitation Foundation (NSF), with a Standard Dimension Ratio (SDR) not exceeding 14 and an Outside Diameter (OD) equal to the OD of the equivalent size ductile iron pipe.

For cast or ductile iron pipe, provide the following minimum thickness class:

- 4 in to 8 in [100 mm to 200 mm] diameter – Class 51; and
- 10 in [250 mm] and larger diameter – Class 50.

Wrap cast and ductile iron pipe with a loose-fitting, slip-on polyethylene film that covers the entire pipe and fittings.

B. Joints

Provide packing and jointing materials for pipe joints and fittings in accordance with the AWWA and the public utility.

C. Fittings

Provide copper fittings for copper waterlines and cast or ductile fittings for other waterlines. Provide bronze service clamps for standard water service connections. Provide couplings with factory-installed brass bushings in accordance with ASTM B 62 and AWWA C 800 for Standard Corporation stop threads.

616.03 EQUIPMENT — VACANT

616.04 CONSTRUCTION METHODS

A. Supplemental Drawings

Provide supplemental pipe and fitting installation drawings. Ensure the installation drawings include the following:

- Profiles with a horizontal scale no greater than 100 ft to 1 in [12 m to 10 mm] and a vertical scale no greater than 10 ft to 1 in [1.2 m to 10 mm]. Ensure both scales are clearly indicated,
- The brand name and model number of materials,
- Installation instructions,
- Thrust block sizes and locations,
- Fitting locations,
- Disinfection methods, and

- Methods and materials for making connections to the existing lines.

Identify drawings by station number and lateral positioning.

Perform pipe and fitting work in accordance with the more stringent specifications or regulations from the following:

- The public utility, or
- The Oklahoma State Department of Health (OSDH).

After Resident Engineer approval, the installation drawings become part of the Contract. Ensure the details, dimensions, and quantities on the installation drawings are in accordance with the Contract requirements, regardless of the Resident Engineer's approval.

B. General

Excavate the trench to at least 30 in [760 mm] below the surface of the natural ground or established subgrade.

During construction, provide for trench drainage. Suspend pipe-laying operations during rain or when the trench cannot be kept free of water. Place a watertight plug in the open end of the main when stopping construction.

Before excavating the water line trench, locate intersecting sewer lines, house sewer lines, and sewers within 10 ft [3 m] of the water line as shown on the Plans. Prevent waste discharge into the trench.

Immediately restore disturbed sewers to a tight operating condition at no additional cost to the Department.

Horizontally and vertically separate sanitary sewers and water mains in accordance with OSDH Regulations. Place water mains at least 10 ft [3 m] horizontally from existing or new sanitary sewer lines. Where water mains cross sanitary sewers (either above or below), provide a vertical clearance of at least 24 in [600 mm]. Where a water main crosses under a sewer, provide structural support for the sewer. Install sewer pipe joints at least 10 ft [3 m] from water lines, unless otherwise approved by the Resident Engineer. When impossible to meet these horizontal and vertical separation requirements, construct and pressure test the sewer line to ensure it is watertight before backfilling.

Block bends, tees, crosses, outlet assemblies, valves, and plugs with concrete, except where the fittings have flanged, welded or harnessed joints. Place concrete blocking so the joints are accessible for repairs.

C. Excavation

Excavate in accordance with Subsection 613.04.B, "Excavation."

D. Bedding

Place bedding in accordance with Subsection 613.04.C, "Bedding."

E. Laying Pipe

Lay pipe in accordance with Subsection 613.04.G, "Laying Pipe."

F. Joining Pipe Conduit

Join pipe conduit in accordance with the manufacturers' recommendations and AWWA requirements. Before joining pipe conduit, clean and dry the joint surfaces of the pipe. Keep trenches free of water until the joints become watertight.

Avoid realigning the pipe after completing the joint unless the pipe is removed and a new joint is constructed.

G. Connecting to Existing Lines

Where shown on the Plans or directed by the Resident Engineer, make connections to existing lines.

H. Removal of Existing Lines

Abandon existing lines that are no longer used. If the Contract requires removal of existing lines, remove at no additional cost to the Department.

I. Setting Valves

Locate valves as shown on the Plans or directed by the Resident Engineer. Unless otherwise required by the Contract, set valves with the stem up and caulk the joints as required by the Contract. Clean the parts of foreign material.

J. Setting Fire Hydrants

Locate fire hydrants as shown on the Plans or directed by the Resident Engineer. Before placing a hydrant, remove foreign material from within the body. Tighten the stuffing boxes, and open and close the hydrant valve to ensure the parts are fully functioning. Ensure the hydrant leads are cast or ductile iron pipe.

Block the back side of the hydrant opposite the pipe with concrete between the hydrant and the vertical face of the trench end to keep the hydrant from moving. Place each hydrant on a stone or concrete slab at least 4 in [100 mm] thick and 16 in [400 mm] square. Around the drain of the hydrant, place at least 7 ft^3 [2 m^3] of broken stone, gravel, or brick bats. Compact soil backfill to the elevation of the surrounding ground surface, at least 5 ft [1.5 m] from the hydrant, in accordance with Subsection 613.04.I, "Backfilling."

K. Dead Ends

Close dead ends with caps or plugs for spigot and bell ends. Caulk caps and plugs, and brace with a concrete block. Place a 2 in [50 mm] blowoff on pipes up to 4 in [100 mm] in diameter.

L. Backfilling

Backfill in accordance with Subsection 613.04.I, "Backfilling."

M. Field Testing

Provide written notification to the Resident Engineer 24 hr before testing. Test the installed pipe for pressure and leakage in accordance with AWWA Standard C 600. Ensure the working pressure of the pipe does not exceed two-thirds of the rated pressure of the pipe. Ensure leakage does not exceed 10 gal/in [93 L/100 mm] of pipe diameter per mile [kilometer] per 24 hr at 150 psi [1,034 kPa] testing pressure.

Disinfect new, cleaned, or repaired water mains in accordance with Rules and Regulations Governing Operation of Public Water Supply Systems. Allow water with

50 ppm to 100 ppm of chlorine to stand 24 hr and develop a residual of at least 10 ppm. Drain the spent solution and replace with potable water before using the line. Alternatively, use methods listed in the latest AWWA Specifications. Obtain safe bacteriological samples on two consecutive days before using new, cleaned, or repaired water mains.

N. Inspection

The public utility will assign a representative to the Project to coordinate compliance with the utility specifications. The utilities representative will answer to the Resident Engineer. Direct all negotiations, decisions, instructions, interpretations, and matters influencing the work to the Resident Engineer.

616.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of water pipe, including crosses, tees, sleeves, outlet assemblies, and plugs. Each pipe size constitutes a separate pay item, which the Resident Engineer will measure along the centerline with no deductions for the space occupied by fittings, valves, and other materials.

The Resident Engineer will measure each valve size as a separate pay item.

616.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) DUCTILE IRON PIPE (LINED)	Linear Foot [Meter]
(B) POLYVINYL CHLORIDE (PVC) PIPE	Linear Foot [Meter]
(C) COPPER WATER SERVICE PIPE	Linear Foot [Meter]
(D) VALVES	Each
(E) CORPORATION STOPS	Each
(F) METER INSTALLATION	Each
(G) FIRE HYDRANTS	Each
(H) SUPPLEMENTAL DRAWINGS	Lump Sum

If a pay item for supplemental drawings does not exist the Department will pay in accordance with Subsection 105.02, “Plans and Working Drawings.”

The Department will consider the cost of the following to be included in the contract unit price for the relevant pipe pay item:

- Installation of bends, tees, crosses, sleeves, outlet assemblies, plugs, and other fittings,
- Connections to existing lines,
- Removal of abandoned lines,
- Excavation,
- Bedding material, and
- Blocking.

The Department will consider the cost of testing to be included in the contract unit price for the relevant pay item.

The Department will consider the cost of the following to be included in the contract unit price for *Fire Hydrants*:

- Drainage stone,
- Blocking, and
- Fire hydrant extensions.

The Department will consider the cost of the following to be included in the contract unit price for *Corporation Stops*:

- Tapping,
- Service clamp, and
- Coupling.

The Department will consider the cost of the following to be included in the contract unit price for *Meter Installation*:

- Meter can,
- Meter setter with ground key angle stop,
- Crushed stone, and
- Fittings for a complete installation

The public utility will specify the materials for corporation stops and meter installations.

SECTION 619
REMOVAL OF BUILDINGS, STRUCTURES, AND OBSTRUCTIONS

619.01 DESCRIPTION

This work consists of the following:

- Removing and disposing of specified obstructions;
- Salvaging designated materials;
- Backfilling the resulting trenches, holes, and pits;
- Removing abandoned items;
- Restoring the site to match the surrounding conditions; and
- Removing and recycling or disposing of production equipment for oil fields.

Comply with current local, state, and federal regulations pertaining to the removal and disposal of facilities, referred to as buildings and structures.

619.02 MATERIAL — VACANT

619.03 EQUIPMENT — VACANT

619.04 CONSTRUCTION METHODS

A. General

The Contractor will be provided with the National Emissions Standards for Hazardous

Air Pollutants (NESHAP) inspection report(s) to support the Contractor's notification to DEQ, as required.

Inform the Resident Engineer of the proposed methods before removing buildings, structures, or obstructions.

Raze, remove, and dispose of buildings, foundations, and other obstructions that are on the right-of-way as required by the Contract. Observe contract provision regarding the removal or disposal of utilities and structures by others.

Remove portions of a system or configuration as required by the Contract to ensure the remaining parts continue to function as intended.

Remove salvageable material required by the Contract without damaging sections that are readily transportable. Store this material at locations shown on the Plans or directed by the Resident Engineer. Destroy unusable and perishable material. Dispose of nonperishable material outside the Project limits with the written permission of the property owner. Submit copies of property owner agreements to the Resident Engineer. Address hazardous materials in accordance with Subsection 107.15, :Hazardous Materials," and provide documentation to the Resident Engineer after disposal.

Remove building, structures, and other obstruction to 1 ft [0.3 m] below the surrounding ground elevation, and break basement floors to provide drainage from the basement as approved by the Resident Engineer, provided no hazardous materials are present. Fill basements or cavities left by structure removal to the level of the surrounding ground, and if within the prism of construction, compact them in accordance with Subsection 202.04.B, "Embankments," and Subsection 202.04.D, "Selective Subgrade Topping."

Repair and replace damaged items due to negligence as approved by the Resident Engineer, at no additional cost to the Department.

B. Removal of Bridges, Culverts and other Existing Structures

Make arrangements to accommodate traffic before removing bridges and culverts.

If shown on the Plans, remove existing structures in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions."

(1)Structures to Remain Property of Department

If structures are to remain the property of the Department, use an approved method of dismantling steel superstructure and wood bridges that ensures the material is not damaged. Before dismantling, paint steel members with match marks using steel stencils and obtain the approval of the Department's Bridge Engineer. Dismantle steel members at the original field splices and support on falsework during dismantling operations, or dismantle as approved by the Resident Engineer.

Cut piers, abutments, and piling 1 ft [0.3 m] below the ground line cover with native soil. For channel changes, cut piers, abutments, and piling to the elevation of the channel excavation shown on the Plans. Neatly stack salvaged lumber and similar material on the right-of-way outside the ditch line. Break up old concrete and similar materials, and place in the fill in accordance with

Subsection 202.04.A(5)(b)1), "Rock Fill," or dispose of as directed by the Resident Engineer.

Remove the substructures of existing structures to the natural stream bottom. Remove parts outside of the stream 1 ft [0.3 m] below natural ground surface. To accommodate new structures, remove old substructures within the new structure limits.

Do not leave material in the channel.

Perform blasting or other removal operations that may damage new construction, before starting new construction.

(2) Structures to Become Property of the Contractor

If structures or material become the property of the Contractor, remove and dispose of the material in accordance with Subsection 104.10, “Final Cleanup.” Remove piers, abutments, piling, and substructures in accordance with Subsection 619.04.B(1), “Structures to Remain Property of Department.”

C. Removal of Culvert and Sewer Pipe

Unless otherwise required by the Contract, carefully remove salvageable culvert and sewer pipe avoiding damage to the pipe. Remove and store pipes in accordance with Subsection 106.08, "Storage and Handling of Materials."

D. Removal of Pavement, Sidewalks, Curbs, Etc.

Break concrete pavement, base course, and other similar materials designated for removal into pieces no heavier than 150 lb [68 kg]. Stockpile at locations shown on the Plans.

If the Contract requires the removal of asphalt concrete or portland cement concrete pavement, saw the joint to the line and depth, as approved by the Resident Engineer, to prevent under-break or shatter of adjacent areas.

E. Structures Abandoned

Remove abandoned structures to at least 6 in [150 mm] below the foundation grade of the new structure. Tightly plug with concrete each end of abandoned sewer lines or other similar structures.

Remove abandoned manholes and similar structures depth shown on the Plans, fill the voids, and compact in accordance with Subsection 202.04, “Construction Methods.” Prepare areas for pavement or other construction over abandoned structures by backfilling and compacting in uniform layers not exceeding 6 in [150 mm] deep in accordance with Subsection 202.04, “Construction Methods.” Consolidate other areas over abandoned structures by flushing with water during backfill operations.

F. Disposal of Materials

Abandoned material will become the property of the Contractor. Remove and dispose of in accordance with Subsection 104.09, "Removal and Disposal of Salvaged Materials, Structures, and Obstructions." Drop inlet grates and frames, manhole covers and frames, concrete or clay pipe, water pipe, goosenecks, valves, stops, valve boxes, or material of value will become the property of the Contractor, unless otherwise shown on the Plans or required by the Contract.

G. Site Clearance

Comply with the current local, state, and federal environmental protection regulations and the following:

- Clear obstructions and maintain surface drainage, drainage structures, and appurtenances.
- If live utility lines are damaged, contact the utility owner and provide for repairs at no additional cost to the Department.
- Ensure a licensed inspector performs NESHAP inspections for buildings and structures required by the Contract for demolition, and submit a copy of the NESHAP pre-demolition inspection and notification to the Resident Engineer before demolition.
- If anticipated, regulated friable or non-friable asbestos containing material is encountered, notify the Resident Engineer in writing. The Department will require up to 60 days for the abatement disposal of the asbestos containing material. The Department will arrange for the removal of asbestos containing material. Proceed with the building removal as directed by the Resident Engineer. The Contractor may abate the asbestos containing material, at no additional cost to the Department, subject to approval from the Engineer, and oversight by the Department's Environmental Programs Division.
- Use a licensed well-driller to plug abandoned water wells in accordance with Oklahoma Water Resources Board (OWRB) Chapter 35, Subchapter 11. Provide written notification to the Resident Engineer of wells, ground water, or monitoring not shown on the Plans.
- Provide written notification to the Resident Engineer of oil wells, gas wells, injection wells, and all associated gathering/distribution lines not shown on the Plans. The Oklahoma Corporation Commission has regulatory oversight for Oil and Gas Conservation (OAC 165:10).
- Remove and dispose of septic tank contents be licensed hauler and in accordance with all local, state, and federal rules and regulations. Address any hazardous materials encountered in accordance with Subsection 107.15, "Hazardous Materials," and provide documentation to the Resident Engineer after disposal.
- Plug or cap abandoned sewer lines, water lines, and similar structures in accordance with local ordinances.
- Remove refuse in accordance with ODEQ, Solid Waste Management regulations, OAC 252:515. Submit copies of the dump receipts to the Resident Engineer for every load removed from the Project.
- Notify the Resident Engineer of underground storage tanks not shown on the Plans, including petroleum or butane tanks. The Resident Engineer will coordinate the removal of underground tanks.

619.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of pipe removed, calculated by multiplying the number of sections by the commercial lengths, or by measuring the pipe in place before removal.

619.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) REMOVAL OF STRUCTURES AND OBSTRUCTION	Lump Sum
(B) REMOVAL OF SPECIFIED ITEMS	Linear Foot [Meter], Square Yard [Square Meter], Cubic Yard [Cubic Meter], Lump Sum, or Each
(C) SAWING PAVEMENT	Linear Foot [Meter]
(D) REMOVAL OF EXISTING BRIDGE STRUCTURE	Lump Sum
(E) NESHAP PRE-DEMOLITION INSPECTION AND NOTIFICATION	Each
(F) OIL FIELD EQUIPMENT REMOVAL	Lump Sum

If pay items for removal of buildings, structures, and obstructions do not exist, the Department will consider the cost associated with each to be included in the contract unit price for other relevant items of work.

The Department will consider the cost of removing, preserving, storing, and disposing of salvageable material to be included in the contract unit price for the relevant pay items.

The Department will consider the cost of excavating, removing, disposing of, backfilling, and compacting cavities created by removed buildings, structures, and obstructions to be included in the contract unit price for the relevant pay items.

SECTION 620
REMOVAL OF UNDERGROUND STORAGE TANKS

620.01 DESCRIPTION

This work consists of removing underground storage tanks.

Comply with the Oklahoma Corporation Commission (OCC) and Oklahoma Department of Environmental Quality (ODEQ) rules, regulations, codes, and guidance documents, including the OCC "UST Removal Guidebook," the American Petroleum Institute Bulletin 1604 for Recommended Practices for Removal of Underground Storage Tanks, and with all other current local, state, and federal regulations pertaining to the removal and disposal of underground storage tanks.

620.02 MATERIAL — VACANT

620.03 EQUIPMENT — VACANT

620.04 CONSTRUCTION METHODS

A. General

Schedule the date for the removal of underground storage tanks with the Resident Engineer. The Resident Engineer shall report this date to the Department's Environmental Programs Division. Report this date to the appropriate regulatory entity (OCC, ODEQ, etc.). The Department will allow the regulatory inspector to be on-site during the removal operation.

Tank removal and sampling activities shall be performed by appropriately qualified and licensed professionals, as required by law (ex. OCC Remover, OCC Remediation Consultant, etc.). Use a laboratory pre-approved by the ODEQ.

A tank closure report shall be prepared in accordance with applicable local, state and federal rules and regulations, and in consultation with the Department's Environmental Programs Division. Submit the analytical results and tank closure report(s) to the Resident Engineer. The Resident Engineer shall provide this documentation to the Department's Environmental Programs Division.

B. Removal of Tanks

The tanks become the property of the Contractor upon removal from the ground. Remove the tanks from the job site within 72 hours of removal, as per the OCC "UST Removal Guidebook." Provide the Department with a Certificate of Destruction for each removed tank.

C. Removal of Contaminated Soil

Return all loose soils to the pit to minimize open excavation safety hazards. However, if gross evidence of contamination is observed, the excavation may be left open for further assessment at the discretion of the Resident Engineer and the Environmental Programs Division.

If required, the management of contaminated soil shall be coordinated with the

Department's Environmental Programs Division. The Department will pay for additional excavation for removal of contaminated soil in accordance with Subsection 620.06, “Basis of Payment.”

620.05 METHOD OF MEASUREMENT — VACANT

620.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) REMOVAL OF UNDERGROUND STORAGE TANK	Each
(B) REMOVAL OF CONTAMINATED SOIL	Cubic Yard [Cubic Meter]

The Department will consider cost of the laboratory soil analysis to be included in the contract unit price for the relevant pay items.

REMOVAL OF UNDERGROUND STORAGE TANKS AND CONTAMINATED SOIL
CERTIFICATE OF DESTRUCTION

Scrapping/Disposal Company:	**Site of Destruction:**	**Tank Removal Contractor:**

Tank Information:
Tank No.: Size:
Location:
Company:
Address:
City: State: Zip:
Destruction Date:

I certify that the above described tank has been rendered unusable for storage of fluids, and the tanks and removed sludge were disposed of in accordance with applicable local, state, and federal regulations.

Print Name Signature Title

Subscribed and sworn to before me on this ___ day of ___, in the year 20___.

My Commission Expires: _____

Notary Public

SECTION 622
PIPE RAILING AND MISCELLANEOUS PIPE WORK

622.01 DESCRIPTION

This work consists of providing and erecting pipe railing with steel and concrete posts, and miscellaneous pipe work.

622.02 MATERIALS

Provide materials in accordance with Subsection 732.02, "Guide Posts."

For standard black steel pipe, provide two coats of aluminum paint (finish field coat) in accordance with Subsection 730.02, "Requirements for Paint Systems."

Provide concrete posts in accordance with Section 504, "Bridge Decks, Approaches, Rails, and Parapets."

Provide reinforcement in accordance with Subsection 723.01, "Bar Steel Reinforcement – Billet Steel."

622.03 EQUIPMENT — VACANT

622.04 CONSTRUCTION METHODS

A. Pipe Railing

Submit Shop Drawings of the railing details to the Resident Engineer. Allow 10 days for approval. Join the pipe railing to posts with fittings. Make splices using male and female connections with dimensions no greater than the outside dimension of the pipe railing. Weld railing in accordance with Subsection 724.03, "Welding." Secure railing posts with fittings as shown on the Plans.

B. Miscellaneous Pipe

Install miscellaneous pipe for conduit and drains in concrete curbs, sidewalks, or retaining walls as shown on the Plans, or as directed by the Resident Engineer. Ensure the pipes are completely embedded in the concrete.

622.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of *Pipe Railing* from center to center of the end posts, not including the length of steel and concrete posts.

622.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) PIPE RAILING	Linear Foot [Meter]
(B) MISCELLANEOUS PIPE WORK	Linear Foot [Meter]

The Department will consider the cost of steel and concrete posts to be included in the contract unit price for *Pipe Railing*.

If a pay item for *Miscellaneous Pipe Work* does not exist, the Department will consider the cost of miscellaneous pipe work to be included in the contract unit price of other relevant pay items.

SECTION 623
GUARDRAIL AND END TREATMENTS

623.01 DESCRIPTION

This work consists of constructing guardrail, end treatments, posts, blockouts, and other appurtenances. The Department defines the following types of guardrail:

- Beam Guardrail Steel **W**-Beam Single,
- Beam Guardrail Steel **W**-Beam Double,
- Beam Guardrail Steel Thrie Beam Single,
- Beam Guardrail Steel Thrie Beam Double,
- Beam Guardrail Steel Transition Section,
- Guardrail Anchor Unit, or
- Guardrail End Treatments (GET).

Use GETs that are designed as **W**-Beam guardrail terminals. Provide GETs with anchors capable of supporting the rail tensile strength developed during a downstream impact and remaining crashworthy for end-on impacts. Ensure the GETs satisfy the National Cooperative Highway Research Program (NCHRP) Report 350 for a test level 3 (TL-3) terminal and are approved for use on the National Highway System.

623.02 MATERIALS

Provide materials in accordance with the following sections and subsections:

Material:	Section or Subsection:
Portland Cement Concrete Class A	701
Epoxy Resin Adhesive	701.13
Reinforcing Steel	723
Requirements for Paint Systems	730.02
Guardrail Posts	732.01
Spacer Blocks (Blockouts)	732.01
Beam Guardrail Elements	732.01
Fittings (Steel Hardware)	732.01
Reflective Sheeting for Guide Posts	733.05
Non-Shrink Grout	733.07

Ensure the GETs are manufactured with new material and assembled in accordance with the manufacturer's standards. Provide a GET capable of flattening and bending the guardrail away from the impacting vehicle.

Ensure the guardrail elements are continuous 12-gauge sections; either one 26 ft [8.0 m] long section, or two 13 ft [4.0 m] long sections.

623.03 EQUIPMENT — VACANT

623.04 CONSTRUCTION METHODS

A. Setting Posts for Guardrail or Barrier Posts

Set posts for guardrail as shown on the Plans. Dig post holes in compacted soil. Keep the bottoms of the holes free of loose material to ensure a stable post foundation.

Space the posts as shown on the Plans and set plumb with the front faces in a straight line. For curves, set posts a uniform distance from the edge of the pavement.

Set the tops of the posts to the elevations shown on the Plans or as approved by the Resident Engineer.

After placing the posts, backfill the holes with material approved by the Resident Engineer. Compact each layer of material to a depth no greater than 6 in [150 mm]. Ensure compaction operations do not change the alignment of the post.

Posts for guardrail may be machine driven. Fill surface depressions resulting from driving the posts. Use material similar to the in-situ material and compact.

B. Rail Elements

Erect rail elements in a smooth, continuous installation. Tighten all bolts except adjustment bolts. Provide bolts with lengths that extend beyond the nuts.

If field painting rail elements, first apply a rust-inhibitive primer to correct damage to the shop coat of paint. Field paint surfaces before erecting rail elements inaccessible to painting after erection. Uniformly apply the number of coats of paint required in the Contract by brush or pressure spray.

Protect the following with two coats of zinc rich paint:

- Abraded galvanized surfaces with exposed base metal,
- The threads of fittings, and
- Fasteners and cut ends of bolts.

Install double-faced guardrail as shown on the Plans.

Do not modify anchor-bolt holes or slots to accommodate connections in the field. Obtain Resident Engineer approval for modifications to standard guardrail design. Ensure modifications pass Department inspection before installing.

C. Placing Metal Plate Rails and Fittings

Fasten metal plate rails to the posts as shown on the Plans. Overlap the rail sections at least 6 in [150 mm] in the direction of traffic so the end of the previous plate rail covers the start of the succeeding plate rail.

Use only one type of metal plate guardrail on the Project, unless otherwise shown on the Plans.

D. Guardrail Anchor Units

Construct guardrail anchor units as shown on the Plans. If encountering rock harder than medium sandstone (surface outcropping, massive boulders, and ledge rock under overburden) during construction of the concrete anchor, proceed as follows:

(1) For Surface Outcroppings

Drill four spaced and patterned holes with 2 in [50 mm] diameters. Fill half of each rock hole with pourable epoxy grout, insert full depth anchor bolts, and stabilize them. Fill the remainder of the hole with epoxy. Expel air bubbles and voids from the holes.

(2) For Rock With Soil Overburden 18 in [450 mm] Deep or Less

Use the following steps:

- Drill four spaced holes for the anchor bolts.
- Drill four additional holes with a diameter of 2½ in [64 mm], each 12 in [300 mm] from the center of the concrete anchor and spaced 90° apart.
- Fill half of each outer hole with pourable epoxy grout.
- Insert, plumb, and stabilize one number 9 reinforcing steel bar per hole, cut to the length needed for the anchor unit.
- Cut the reinforcing steel bar to a length that allows insertion of at least 12 in [300 mm] into the rock and a clearance of 2 in [50 mm] above the top of the concrete anchor.
- Fill the remainder of the hole with epoxy and expel the bubbles.
- Tie the 6 × 6-W1.5 × W1.5 wire mesh to the bars after the grout dries.
- Spread pourable epoxy grout on the surface between the rock and concrete for positive bond.
- Construct the upper portion of the anchor unit as shown on the Plans.

(3) For Rock Encountered Deeper Than 18 in [450 mm]

Construct the anchor in accordance with the procedure for soil with overburden 18 in [450 mm] deep or less, and omit the four additional anchors.

E. Guardrail End Treatments (GET)

Ensure experienced workers fabricate and install the GET as shown on the Plans and ensure the end treatment remains intact, redirects side vehicular impacts, and flattens the rail element to attenuate head-on vehicular impacts.

Construct GETs with certified, crash-tested hardware. Ensure NCHRP 350 TL-3 certification for substituted hardware. Obtain the Resident Engineer's approval of substitution GET component hardware and ensure it passes Department inspection before installation.

F. Blockouts

For safety end treatments, use certified blockouts meeting the minimum requirements of NCHRP 350 TL-3. Provide a letter of certification with substitutions. Obtain the Resident Engineer’s approval of substitutions before installation.

Provide certification of blockouts used in safety end treatments. Ensure that composite or synthetic blockouts used in safety end treatments attached to bridges or permanent concrete walls have been crash-tested and certified.

G. Guardrail Bridge Connection (GBC)

Ensure experienced workers fabricate and install the GBC as shown on the Plans and ensure the bridge connection remains intact, redirects side vehicular impacts, and

flattens the rail element to attenuate vehicular impacts at the approach ends of the bridge rail.

Construct GBCs with approved NCHRP 350 TL-3 designs, using only certified and crash-tested hardware. Provide NCHRP 350 TL-3 certifications for substitute hardware, except for posts an blockouts, which may not be substituted without an actual crash test certification. Obtain the Resident Engineer's approval of substitution GBC component hardware and ensure it passes Department inspection before installation.

623.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of guardrail from center to center of the supporting posts.

The Resident Engineer will measure *Blockouts* using the length of the guardrail from the first blockout to the beginning of the next anchor unit.

623.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
*(A) BEAM GUARDRAIL **W**-BEAM SINGLE*	Linear Foot [Meter]
*(B) BEAM GUARDRAIL **W**-BEAM DOUBLE*	Linear Foot [Meter]
(C) BEAM GUARDRAIL THRIE-BEAM SINGLE	Linear Foot [Meter]
(D) BEAM GUARDRAIL THRIE-BEAM DOUBLE	Linear Foot [Meter]
(E) BEAM GUARDRAIL TRANSITION SECTION	Each
(F) GUARDRAIL ANCHOR	Each
(G) GUARDRAIL END TREATMENT	Each
(H) BLOCKOUTS	Linear Foot [Meter]
(I) GUARDRAIL BRIDGE CONNECTION	Each

SECTION 624
FENCES

624.01 DESCRIPTION

This work consists of the constructing fence and gates. The Department defines the following styles of fence:

- Fence, Style WWF (Woven Wire Fence),
- Fence, Style SWF (Strand Wire Fence),
- Fence, Style CLF (Chain Link Fence),
- Fence, Style GDF (Glare Deflector Fence), and
- Fence, Metal Panel.

624.02 MATERIALS

Provide materials in accordance with the following section and subsections:

Material:	Section or Subsection:
Portland Cement Concrete Class A	701
Requirements for Paint Systems	730.02
Fence, Style WWF	732.06
Fence, Style SWF	732.06
Fence, Style CLF	732.07
Fence, Style GDF	732.08

If not shown on the Plans, provide posts, hardware, and fittings in accordance with Section 732, "Materials for Guard Rail, Guide Posts, Bridge Rail, Miscellaneous Railing, and Fences." Provide the same kind of material for posts, hardware, and fittings throughout the project, unless otherwise approved in writing by the Resident Engineer.

Provide reinforcing steel in accordance with Section 511, "Reinforcing Steel for Structures."

624.03 EQUIPMENT — VACANT

624.04 CONSTRUCTION METHODS

A. General

Perform clearing and grubbing to construct the fence in accordance with Section 201, "Clearing and Grubbing."

Install the style, type, and class of fence as shown on the Plans. Install fence gates at locations shown on the Plans or as directed by the Resident Engineer.

Upon receipt of the Notice to Proceed, existing fencing on the right-of-way becomes the responsibility of the Contractor.

At intersections with existing fences or at locations with required fencing breaks, make post spacing adjustments. Ensure cross fencing connections include an end post placed perpendicular to the right-of-way fence or at the angle of the cross fence.

Maintain constructed fences and gates.

(1) Concrete

If the Plans show embedding posts, braces, or anchors in concrete, install temporary guys or braces to hold the posts in position until the concrete sets. Do not install materials on posts, or strain guys and bracing, until 5 days after placement of the concrete, unless otherwise approved by the Resident Engineer.

(2) Driving Option

As an option to setting fence posts in concrete footings or placing in tamped earthen holes, the Resident Engineer may approve driven line posts. For the driving option, protect the tops of wooden line posts and ensure the posts are sharpened by the supplier before treating with preservative.

The Resident Engineer will reject wood posts with split or damaged tops. Do not field sharpen or taper dress the post tips.

Use a fitted impact head for metal posts to minimize post deformation or damage to the galvanized or painted finish. After driving the metal posts, clean damaged tops and paint with a zinc-rich paint.

The Resident Engineer will reject metal posts with severely deformed or poorly painted tops.

(3) Offset Control

Perform adequate plumb and offset (alignment) control to ensure a smooth profile and alignment. In shallow depressions, use longer posts and barbed wire fans to maintain a smooth top-of-fence profile. If necessary, use strengthened fence construction and movable water gates for installations over deep ravines.

Do not fill swales or ravines to facilitate fence construction. Maintain the existing drainage.

(4) Installations in Rock

For driven installations using mechanical or pneumatic equipment, the Department defines refusal as 1 in [25 mm] or less entry per minute of driving with a 60 lb [27 kg] hammer delivering at least 60 blows per minute.

For installations in earth and in rock softer than medium sandstone, adhere to the following criteria:

- Ensure the driven posts reach the minimum embedment as shown on the Plans, or reach refusal.
- For refusal encountered at 24 in [0.6 m] or deeper, keep the post in place and top cut to the profile control.
- For refusal encountered at depths less than 24 in [0.6 m], pull the post and install a concrete footing to the dimensions shown on the Plans for earth installations.

For installations in surface-level, medium or harder sandstone, adhere to the following criteria:

- Drill a hole of the diameter and depth for footings in rock for the type of post shown on the Plans.
- Insert, plumb, and brace the post.
- Fill the hole with lean grout (thin hydraulic cement).

For installations in medium to hard rock under a layer of earth, adhere to the following criteria:

- If rock is encountered at any depth less than the minimum driven embedment (as shown on the Plans), auger the earth.
- Consider as a regular concrete-embedded earth footing.
- Drill a hole of the diameter for footings in rock for the type of post shown on the Plans to a depth yielding the total minimum earth embedment, or the minimum rock embedment, whichever occurs first.
- Fill half of the rock hole with an approved type of lean grout and insert, plumb, and brace the post.
- Fill the remainder of the rock hole with lean grout.
- Place concrete for the earth footing above the grouted rock hole.

Provide driven posts in earth at least 24 in [0.6 m] where refusal is reached, or the minimum earth embedment as shown on the Plans. The Resident Engineer will require the minimum rock embedment unless the total minimum earth embedment is reached first. With these conditions met, the Department will allow top cutting the post to profile control.

(5) Aligning Posts

Set the tops of posts to the grade and alignment shown on the Plans.

Only cut the post tops as shown on the Plans, specified in this section, or approved by the Resident Engineer.

After cutting wood posts, paint the tops with a preservation solution. Do not flame cut. Clean and paint cut areas on metal posts with a single coat of zinc-rich paint. Attach wire or fencing of the required size and type to the posts and braces as shown on the Plans.

Install wire to the elevations shown on the Plans and stretch wire taut.

(6) Grounding the Fence

At locations where an overhead power line (electric transmission, distribution, or secondary line) crosses a fence, ground the fence in accordance with the following:

- Install a galvanized or copper-coated steel ground rod 8 ft [2.4 m] long with a diameter of at least ½ in [13 mm] directly below the point of crossing.
- Drive the rod vertically until the top is 6 in [150 mm] below the ground surface. Use a No. 6 solid copper conductor or equivalent to connect each fence element to the grounding rod.
- Braze or fasten the connections with approved non-corrosive clamps.

At locations where a power line runs parallel or nearly parallel to and above the fence, ground the fence at each end and gate post and at intervals no greater than 1,500 ft [450 m].

Maintain grounding of fences on abutting property equivalent to the existing protection.

B. Fence, Style WWF (Woven Wire Fence)

This style of fence consists of woven wire fabric with smooth, barbless, or barbed wire strands on a steel post system, wood post system, or both.

(1) Alignment

Install WWF to the general alignment, angles, corners and attachment types at culverts as shown on the Plans. In general, construct fences on the permanent right-of-way line. To construct the right-of-way fence, clear the work area of obstructions, level the ground, and remove minor irregularities.

(2) Setting Posts

Provide line posts of the size shown on the Plans and install on the permanent right-of-way line, to a line shown on the Plans, or on a line approved by the Resident Engineer, and in a true line on the property owner's side. Embed posts in the ground to the depth shown on the Plans, tamping and firmly setting. Space line posts as shown on the Plans. Set additional posts at abrupt changes in grade, alignment, location, or at locations directed by the Resident Engineer.

For small depressions, provide extra-length posts (fan posts) if not practical for the fence to closely follow the contour of the ground. At these locations, close the space below the bottom of the fence fabric with wire, stretched taut between posts, either on horizontal lines or fanned at no greater than 6 in [150 mm] spacing, as shown on the Plans or as approved by the Resident Engineer. Stretch the wires taut, and fasten to the posts to prevent vertical movement of the wires.

The Department will allow pouring concrete for posts footings without forming if the excavation is stable and does not cave or slide. Form footings if directed by the Resident Engineer.

(3) Placing Fencing

Fasten barbed wire, barbless wire, or smooth wire to all fan, end, corner, gate or stretcher posts, and to line posts as shown on the Plans. Use tools designed for the purpose in accordance with the manufacturer's recommendations. Apply the tension for stretching with mechanical fence stretchers or single-wire stretchers designed for the purpose. Stretch strands taut to a tensile force of 300 lb [136 kg] as shown on the Plans, or to a tensile force recommended by the manufacturer.

Splice strand wire and wire fabric using a mechanical device of a type approved by the Resident Engineer or make a wire splice by carrying the ends of wires 2 in [50 mm] past the splicing tools and wrap them around both wires backward from the tool for at least five turns.

Attach wire to the private property side of the fence posts; on curves, place wire-fabric on the side of the post that will maintain the wire in a taut condition. Stretch woven wire fabric uniformly tight with an approved mechanical tensioning device conforming to its location on the posts as shown on the Plans. Place stays parallel, straight, and uniformly spaced, as shown on the Plans. Staple each woven fabric wire and strand wire to wood posts or fasten with approved fittings to steel posts. Cut or splice woven wire at stretcher or wood posts to prevent buckling or undue stretching.

Build attachment assemblies as shown on the Plans. For attachments to culvert or bridge end walls, drill the holes with a drill of the same size as the expansion device. Do not chip or break the concrete.

C. Fence, Style SWF (Strand Wire Fence)

This style of fence consists of smooth, barbless, or barbed wire strands on a steel post system, wood post system, or both. Construct Strand Wire Fence (SWF) in the same manner as WWF, in accordance with Subsection 624.04.B, "Fence, Style WWF (Woven Wire Fence)." Ensure the SWF has the type and number of strands of wire as shown on the Plans or as approved by the Resident Engineer. Install the fence on the permanent right-of-way line.

D. Fence, Style CLF (Chain Link Fence)

This style of fence consists of chain link fabric fencing on a galvanized steel or aluminum alloy post system with or without barbed wire, smooth tension wire, or climb barrier systems.

(1) Alignment

Align CLF in accordance with Subsection 624.04.A, “General,” and Subsection 624.04.B(1), “Alignment.”

(2) Setting Posts and Placing Fencing

Perform alternate line post driving in accordance with Subsection 624.04.A, "General." Dig post holes to the minimum size and spacing shown on the Plans. Set posts plumb, centered in the hole, and to the lines shown on the Plans. Place posts in the concrete before the initial set. Ensure the posts are puddled and supported plumb until the concrete is fully set. Allow concrete to cure at least 5 days before stretching wire on the posts. Set post braces before placing wire.

Attach wire to the private property side of the fence posts; on curves, place wire on the side of the post that will maintain the wire in a taut condition. Stretch the wire slightly above the tension recommended by the manufacturer to address the affects of seasonal temperatures, and allow the wire to slack when the mechanical pullers are released. Attach pullers to the full width of the wire and make ties in at least seven locations on each post before releasing the wire. The Contractor may pull wire from both directions and joint by inserting one picket. Place smooth tension and barbed wire after placing the proper size of fabric.

(3) Concrete Wall for Fence

Across ravines, where it would not be practical to set posts and follow the ground line with the fence, set posts in a concrete wall as shown on the Plans and at locations directed by the Resident Engineer. If constructing a wall across a dry wash or periodically wet ravine, provide drainage. The Department will allow a partial wall on each bank with a water gate or fan in the center, or culverts through a solid wall.

E. Fence, Style GDF (Glare Deflector Fence)

This style of fence consists of a mesh fence on ground-embedded posts, guard rail posts, parapet wall, or concrete median barrier.

(1) Alignment

In general, construct GDF in the median, between opposing lanes of traffic, as shown on the Plans.

(2) Setting Post and Placing Fencing

Set posts and place fencing in accordance with Subsection 624.04.D(2), "Setting Posts and Placing Fencing." For fence mounted on guardrail, bolt the fence post to the guardrail post using bolts as shown on the Plans. For fence mounted on a parapet wall or median barrier, cast or drill holes in the wall and fit them with pipe sleeves as shown on the Plans. The Department will allow threaded pipe flanges firmly attached to the top surface of the barrier wall as an alternate attachment method.

Space terminal posts at intervals no greater than 100 ft [30 m], or as shown on the Plans. Truss diagonal braces from the brace end of the line post to the terminal post, and fasten with a brace band. On curves, place the wire fabric on the side of the post that will maintain the wire in a taut condition. Install glare deflector fence fabric as shown on the Plans, and fasten to the line posts with wire ties at 14 in [350 mm] intervals and to the top and bottom tension wire with wire ties or hog rings at intervals no greater than 12 in [300 mm]. Tighten the chain link glare deflector fence to provide a smooth, uniform appearance. Install stretcher bar-bands at intervals no greater than 11 in [280 mm].

624.05 METHODS OF MEASUREMENT

The Resident Engineer will measure the length of each continuous run of fence along the ground line of the fence from outside to outside of end posts. The Resident Engineer will not include the length of connections to cross fences in the measurement of fences.

The Resident Engineer will measure gates as complete units of the size, type, and class required by the Contract.

624.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) FENCE, STYLE WWF	Linear Foot [Meter]
(B) GATE, STYLE WWF	Each
(C) FENCE, STYLE SWF	Linear Foot [Meter]
(D) GATE, GALVANIZED STEEL	Each
(E) FENCE, STYLE CLF	Linear Foot [Meter]
(F) GATE, STYLE CLF	Each
(G) FENCE, STYLE GDF	Linear Foot [Meter]

The Department will consider the cost of connections to cross fences to be included in the contract unit price for the relevant fence pay item.

The Department will pay for the cost of Class A concrete and reinforcing steel used in the construction of concrete wall for fence, if required by the Contract, in accordance with Section 509, " Structural Concrete," and Section 511, "Reinforcing Steel for Structures."

SECTION 625
REMOVAL AND STORAGE OR RECONSTRUCTION OF FENCING AND GUARDRAIL

625.01 DESCRIPTION

This work consists of removing and storing, or reconstructing, fencing and guardrail.

625.02 MATERIALS

Provide salvaged materials in good condition from the existing installation for reconstruction. Replace other materials.

Provide paint in accordance with Subsection 730.02, “Requirements for Paint Systems.” Unless otherwise required by the Contract, provide aluminum paint for refurbishing. Provide zinc-rich paint in accordance with Subsection 730.02, “Requirements for Paint Systems.”

625.03 EQUIPMENT — VACANT

625.04 CONSTRUCTION METHODS

A. Removal and Storage

Store removed material at the location shown on the Plans, or as directed by the Resident Engineer. When removing material, prevent damage to posts, cable, fence, plates, or fittings. Coil and tie cable or fence before storing. Box or tie fittings together in bundles. Stack metal plates and posts on blocks off the ground.

B. Reconstruction of Guardrail or Fence

When reconstructing guardrail or fence, remove and temporarily store until the resetting operation. Reconstruct guardrail or fence in accordance with Section 623, "Guardrail and End Treatments," and Section 624, "Fences."

Replace lost or damaged material at no additional cost to the Department.

Coat newly-cut holes with zinc-rich paint. After erecting metal plate rail, clean abrasions of existing paint and apply one coat of aluminum paint to damaged and primed areas. After the first coat dries, apply a second coat of aluminum paint to all plate rail and fittings in accordance with Subsection 623.04.B, “Rail Elements.”

If required by the Contract, set Department-provided guardrail at locations shown on the Plans in accordance with Section 623, “Guardrail and End Treatments.”

625.05 METHOD OF MEASUREMENT

For removal and storage of guardrail or fence, the Resident Engineer will measure the length from center to center of end posts before removal.

For removal and reconstruction of guardrail or fence, the Resident Engineer will measure the length from center to center of end posts after reconstruction and approval.

625.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) REMOVE AND STORE FENCE	Linear Foot [Meter]
(B) REMOVE AND RECONSTRUCT FENCE	Linear Foot [Meter]
(C) REMOVE AND STORE GUARDRAIL	Linear Foot [Meter]
(D) REMOVE AND RECONSTRUCT GUARDRAIL	Linear Foot [Meter]

SECTION 626
MONUMENTS

626.01 DESCRIPTION

This work consists of constructing concrete monuments or markers.

626.02 MATERIALS

Provide materials in accordance with the following sections:

Material:	Section:
Portland Cement Concrete Class A	701
Reinforcing Steel	723

The Department will provide the bronze plates used for markers or monuments.

626.03 EQUIPMENT — VACANT

626.04 CONSTRUCTION METHODS

Construct monuments and right-of-way markers using reinforced concrete in accordance with Section 509, “Structural Concrete,” and as shown on the Plans. Provide monuments and right-of-way markers with a carborundum finish.

Replace monuments or right-of-way markers, damaged during construction before final acceptance, at no additional cost to the Department.

Set and plumb monuments and right-of-way markers to the depth shown on the Plans. Compact select backfill, approved by the Resident Engineer, to stabilize and secure the monuments or right-of-way markers.

626.05 METHOD OF MEASUREMENT — VACANT

626.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) MONUMENTS	Each
(B) RIGHT-OF-WAY MARKERS	Each

Pay Item:	Pay Unit:
(C) RIGHT-OF-WAY MARKERS REMOVED AND RESET	Each

If the Contract requires the placement of bronze plates only (e.g. in the end posts of bridges or face of curbs), the Department will consider the cost of placing bronze plates to be included in the contract unit price for other relevant pay items.

SECTION 627
CONCRETE LONGITUDINAL BARRIER

627.01 DESCRIPTION

This work consists of constructing longitudinal concrete barrier with concrete and reinforcing steel.

The Department will consider alternative designs that meet exterior dimensions, and test and performance criteria required by the Contract. Submit alternative designs to the Resident Engineer for approval.

627.02 MATERIALS

Provide materials in accordance with the following sections:

Material:	Section:
Portland Cement Concrete Class A	701
White Concrete	701
Reinforcing Steel	723

627.03 EQUIPMENT — VACANT

627.04 CONSTRUCTION METHODS

Measure, batch, and mix concrete for the longitudinal concrete barriers in accordance with Subsection 414.04, “Construction Methods.”

Build forms for the barriers in accordance with Section 502, “Forms, Falsework & Temporary Works.”

Place reinforcing steel for the barriers in accordance with Section 511, “Reinforcing Steel for Structures.”

Place the concrete for the barriers in accordance with Section 509, “Structural Concrete.”

Ensure exposed concrete surfaces are smooth and dense. Finish concrete surfaces in accordance with Subsection 509.04.G, “Finishing Formed Concrete Surfaces.”

After removing the forms, fill rough areas, holes, and porous spots. Cut bolts, wires, or other appliances, used to hold the forms, ¼ in [6 mm] below the surface and fill the depressions with cement mortar. Finish exposed surfaces in accordance with Subsection 509.04.G, “Finishing Formed Concrete Surfaces.”

627.05 METHOD OF MEASUREMENT — VACANT

627.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) CONCRETE LONGITUDINAL BARRIER, DESIGN 1	Linear Foot [Meter]
(B) CONCRETE LONGITUDINAL BARRIER END SECTIONS	Each

The Department will consider the cost of concrete and reinforcing steel used in the construction of longitudinal concrete barriers and end sections to be included in the contract unit price for the relevant pay items.

SECTION 628
HIGH-TENSION CABLE BARRIER

628.01 DESCRIPTION

This work consists of providing and installing complete sections of high-tension cable barrier or wire rope systems, including crashworthy end treatments, concrete socketed foundations, concrete anchors, and other appurtenances or hardware fittings.

628.02 MATERIALS

Provide materials in accordance with the following sections, subsections, and external reference:

Materials:	Section, Subsection, or External Reference:
Portland Cement Concrete, Class AA (≥4,000 psi)	701
Reinforcing Steel	723
Anchor Bolts and Nuts	724.02
Galvanizing (Bolts, Nuts and Washers)	AASHTO M 232
Fittings (Steel Hardware)	732.01
Reflective Sheeting	733.05

A. Rigging Screws (Turnbuckle)

Provide rigging screws (for tensioning the cable) that are galvanized after threading in accordance with ASTM A 153. For installations longer than 1,000 ft [300 m], include at least one rigging screw per 1,000 ft [300 m] strand. For installations 1,000 ft [300 m] or less in length, include one rigging screw per strand near the center of the strand installation.

Provide rigging screws that will develop minimum tensile loads without yielding to 36,800 lb [16.7 metric ton].

B. Wire Ropes

Provide galvanized, ¾ in [19 mm] diameter, 3 × 7 wire rope in accordance with AASHTO M30 Type I Class A coating, except with a breaking strength of at least 39,000 lb [17.7 metric ton]. The Department requires samples for proof testing to ensure the wire ropes and connections meet or exceed the minimum breaking load for the rope. Verify the wire rope is pre-stretched during manufacturing to ensure a minimum modulus of elasticity of 11,805,090 lb/in² [8,300 kg/mm²] after pre-stretching.

C. Threaded Terminals (swaged type)

Provide shop or field swaged threaded terminals. Ensure the threaded terminals are right-hand or left-hand threaded M24 X 3 pitch in accordance with ANSI B 1.13M. The Department will allow threaded terminals of stainless steel construction or galvanized after processing in accordance with ASTM A 153.

Ensure the body of the threaded terminal provides at least 6 in [150 mm] wire rope engagement depth. Ensure the fully fitted ropes develop a Minimum Breaking Load (MBL) of 36,800 lb [16.7 metric ton].

D. End Terminals

Provide end terminals placed within the "Clear Zone", as defined by AASHTO *Roadside Design Guide*, with the following characteristics:

- Comply with National Cooperative Highway Research Program (NCHRP) Report 350,
- Meet Test Level 3 (TL-3) requirements, and
- Have an FHWA letter of acceptance.

The Resident Engineer may approve the use of other terminals in locations where impacts are unlikely, or if properly shielded by impact attenuators.

Provide end terminals fabricated from materials in accordance with ASTM A 36 and galvanized after fabrication in accordance with ASTM A 123. Ensure welding required by the Contract is performed by a certified welder in accordance with AWS D1.1.

E. Posts

Provide socketed posts with caps, placed in metal or plastic sleeves installed in a concrete foundation. Provide posts fabricated from materials meeting or exceeding ASTM A 36 and galvanized after fabrication in accordance with ASTM A 123. Ensure welding required by the Contract is performed by a certified welder in accordance with AWS D1.1.

Provide domestically produced posts cold-formed from hot-rolled milled steel of the dimensions shown on the Plans. Prevent debris from entering the socket by providing a fitting gasket to tightly seal each post. Provide and place reinforcing steel in concrete foundations as shown on the Plans.

F. Delineating High Tension Cable Barrier

Provide high tension cable barrier installations delineated with retroreflective sheeting. Provide Type VIII retroreflective sheeting in accordance with

ASTM D 4956. Provide yellow or white sheeting the same color as the adjacent edge line.

Apply the sheeting to the last five posts at each end of the installation and, for the remainder of the installation, at least every 50 ft [15 m]. Attach the sheeting near the top of the post in accordance with the manufacturer's recommendations. Ensure at least 7 in² [4,500 mm²] of sheeting is visible when viewed on a line parallel to the roadway centerline. For median installations, apply the sheeting to both sides of the post. For roadside installations, apply the sheeting only to the side facing traffic.

628.03 EQUIPMENT — VACANT

628.04 CONSTRUCTION METHODS

A. General

At the locations shown on the Plans or as directed by the Resident Engineer, provide crashworthy impact attenuators or end treatments for high-tension cable barrier systems. Ensure the high-tension cable barrier systems and end treatments satisfy the NCHRP Report 350 for test level 3 (TL-3) or test level 4 (TL-4) and are approved for use on the National Highway System. Ensure the manufacturer provides an FHWA letter of acceptance before approval by the Resident Engineer and installation. Use a high-tension cable barrier system of four wire ropes with a maximum post spacing of 10.5 ft [3.2 m], center to center.

Locate and align the cable barrier system as shown on the Plans or as directed by the Resident Engineer. Ensure proper wire rope height as required by the Contract. Ensure the surface between the cable barrier system and the edge of the traveled way is smooth, without edge drop-offs, holes, depressions, or slope changes.

Space posts as shown on the Plans. Set posts plumb and in line.

Place and tension the cable barrier system in accordance with the manufacturer's recommendations immediately after initial installation. Recheck the tension two to three weeks after the initial tensioning and adjust if necessary. Complete a tension log form, signed by the person performing the tension reading, that includes the following:

- Time,
- Date,
- Location,
- Ambient temperature,
- Final tension reading, and
- The manufacturer's recommended tension chart.

Submit the log to the Resident Engineer upon completion of the high-tension cable barrier work.

B. Foundations

Construct concrete foundations in accordance with Section 509, "Structural Concrete," and the manufacturer recommendation. Ensure the top of the footing conforms to the slope of the surround surface. Construct concrete foundations in-place as shown on the Plans and to the grade directed by the Resident Engineer. If an obstruction prevents construction of the foundation at the location shown on the Plans, the Resident Engineer will direct a new location.

Place end terminal foundations in excavations of natural, undisturbed ground to the size and shape required by the wire rope safety cable manufacturer, based on soil type and ground conditions. If over-excavation is unavoidable, ensure the sides of the excavation are vertical, and use additional concrete to completely fill the excavated area. Anchor each of the fours cables independently to a concrete end anchor.

Alternatively, form and cast the foundations, then backfill using mechanical vibration to achieve at least 95 percent compacted density.

Excavate the foundations to the depth determined by the manufacturer's design engineer, but to no less than 12 in [300 mm] in diameter and 36 in [900 mm] in depth. Ensure excavated materials do not fall back into the hole.

C. Placement

Install the cable barrier system on a slope no steeper than 6H:1V. Install the cable barrier system at least 8 ft [2.4 m] from the traveled way or hazardous objects.

For slopes located within a median ditch, do not place the cable barrier from 1 ft [0.3] of the toe of slope to 8 ft [2.4 m] up the slope.

628.05 METHOD OF MEASUREMENT

For concrete-socketed foundations and anchors, the Resident Engineer will measure the volume of concrete in accordance with Subsection 509.05, "Method of Measurement."

628.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) HIGH-TENSION CABLE BARRIER (TL-3)	Linear Foot [Meter]
(B) HIGH-TENSION CABLE BARRIER (TL-4)	Linear Foot [Meter]
(C) END ANCHORS	Each
(D) GUARDRAIL TRANSITION	Each

The Department will consider the cost of the excavation, backfilling, reinforcing steel, and other incidentals to be included in the contract unit price for *End Anchors*.

The Department will consider the cost of the following to be included in the contract unit price for *High-Tension Cable Barrier (TL-3)* or *High-Tension Cable Barrier (TL-4)*:

- Anchor bolts,
- Nuts,
- Washers,
- Ground rod,
- Socket or sleeve,
- Excavation,
- Backfilling,
- Caps, and
- Other incidental work necessary to construct the cable barrier system.

The Department will pay for Class AA concrete used in the construction of concrete anchor units and foundations in accordance with Section 509, "Structural Concrete."

SECTION 629
MAILBOXES

629.01 DESCRIPTION

This work consists of placing mailboxes on public rights-of-way within the roadway "Clear Zone", as defined by the AASHTO *Roadside Design Guide*, to ensure public safety and safe access for mail delivery and retrieval.

Refer to the Plans for a summary of the various sizes, types, quantities, and locations of mailboxes.

629.02 MATERIALS

A. Mailboxes

Provide mailboxes made of light metal or formed thermoplastic in accordance with USPS requirements. Provide mailboxes with dimensions, nomenclature, and marking in accordance with AASHTO, “A Guide for Erecting Mailboxes on Highways,” Appendix C.

Property owners are responsible for providing newspaper tubes of the appropriate material and dimensions, and placing names on mailboxes.

B. Post Systems

(1) Wood Post

Provide a support post system consisting of a 4 in × 4 in [100 mm × 100 mm] nominal wood post capable of withstanding the elements and soil-borne attacks (treated or untreated.) The Resident Engineer will allow the post to be smooth and square, or rough sawn. Ensure that surface splintering is not hazardous. The Department will allow a natural, oiled, or painted surface finish.

The Resident Engineer will allow an alternative wood post with a 4½ in [114 mm] nominal diameter, treated or untreated, and capable of withstanding the elements and soil-borne attacks. Remove bark and, if finishing the surface, use oil or paint.

(2) Metal Posts

Provide metal posts (e.g. steel pipe, cold rolled shape, hot rolled member) with strength in bending equal to or less than a standard weight steel pipe (Schedule 40) with a nominal diameter of 2 in [50 mm]. Use the following equation to calculate:

$$SM_{40} \times YS_{40} \geq SM_N \times TYS_N$$

where

SM_{40} = Section Modulus of Schedule 40, 2 in [50 mm] steel pipe,
YS_{40} = Yield Strength of Schedule 40, 2 in [50 mm] steel pipe (36,000 psi [250 MPa],
SM_N = Section Modulus of new post system, and
TYS_N = Tested Yield Strength of new post system.

The Department will allow round or square, aluminum or aluminized steel tubing if the section is capable of supporting the mailbox array and withstanding lateral loads caused by mail and paper delivery and retrieval.

The Contractor may use commercially available metal post systems integrating a mailbox support arm for one to five mailboxes. Provide patented materials in accordance with Subsection 107.03, "Patented Devices, Materials, and Processes."

(3) Post-to-Box Attachment

Provide post-to-box attachment fittings capable of preventing separation of the mailbox from the post if the installation is struck by an automobile or light truck.

(4) Basis of Acceptance

Provide Type D certification for the basis of acceptance of materials. The Resident Engineer will provide visual inspection.

629.03 EQUIPMENT — VACANT

629.04 CONSTRUCTION METHODS

A. General

Provide mailbox designs capable of withstands wind loads, lateral loads, or both. If the Resident Engineer approves, use a concrete footing or a footing of native soil mixed with cementitious material to ensure the posts remain upright. Do not exceed the dimensions or strength criteria for specified posts in accordance with Subsection 629.02, "Materials." If directed by the Resident Engineer, provide weakened plane joints for posts at the ground surface to guarantee bending or failure during vehicular impact.

Accepted post designs include use of a concrete footing or installation of the posts through an asphalt or portland cement concrete surface. Embed the posts no deeper than 2 ft [0.6 m], or to the depth recommended by the manufacturer or supplier. If using a metal post system with an anti-twist device, embed no deeper than 10 in [250 mm] into the ground.

Mailboxes placed on public right-of-way are privately owned. Coordinate with mailbox owners and USPS to ensure that owners receive mail deliveries during construction. Allow mailbox owners to claim salvageable items from existing mailbox installations for the duration of the Contract, not to exceed a maximum of 60 days.

Mount no more than two mailboxes on a single-post support system, unless otherwise approved by the Resident Engineer. Mount newspaper receiver tubes below the mailbox, or on the post under the mailbox.

If using alternate-design mailbox support system (not included in the Contract or on standard drawings), obtain Department-approval before installing. The Department will not approve (under any circumstances) rigid, massive, or unyielding mailbox support systems or housings that may cause heavy damage to impacting vehicles, or cause severe injury or death.

Install support systems using a cantilever arm to maximize the post offset where terrain allows.

B. Placement

Place mailboxes at locations where access is allowed by law. Never place mailboxes with access from the through lanes of a freeway or at other prohibited

locations. Horizontally space single-post support systems by at least three-quarters of the exposed height of the post, including the mailbox.

Place mailboxes on the right-hand side of the road in the direction of the delivery route. On one-way streets, the Department will allow mailboxes installed on the left-hand side of the road. Set the bottom of the box at the elevation specified by USPS, from 3 ft to 4 ft [0.9 m to 1.2 m] above the roadway. Offset the face of the mailbox from the edge of the traveled way as shown on the Plans. On residential streets and rural roads, adjust the lateral placement and clearance of mailbox systems as directed by the Resident Engineer.

Place mailboxes at driveways on the near side in the direction of the delivery route.

Place mailboxes located at intersecting and through roads as shown on the Plans.

629.05 METHOD OF MEASUREMENT

The Resident Engineer will measure mailbox installations as single (one mailbox per support system) or multiple (two or more mailboxes per support system).

The Resident Engineer will measure each existing mailbox within the Project limits affected by the construction as *Removal of a Mailbox Installation* or *Remove and Reset Mailbox.*

Mailbox will be measured as each mailbox installed, regardless of the installation.

629.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) MAILBOX INSTALLATION-SINGLE	Each
(B) MAILBOX INSTALLATION-MULTIPLE	Each
(C) MAILBOX	Each
(D) REMOVAL OF MAILBOX INSTALLATION	Each
(E) REMOVE AND RESET MAILBOX	Each

The Department will consider the cost of removing, storing, and reconstructing the mailbox installation, including the serviceable, crashworthy support system and the mailbox to be included in the contract unit price for *Remove and Reset Mailbox*.

The Department will consider the cost of installing owner-provided newspaper tubes to be included in the contract unit price for the relevant pay items.

The Department will pay for base and surfacing for all-weather turnouts in accordance with the appropriate sections of Chapter 300, "Bases," and Chapter 400, "General Requirements for Surfaces."

SECTION 640
FIELD OFFICE OR LABORATORY

640.01 DESCRIPTION

This work consists of providing a field office on the project and a laboratory building at asphalt or ready-mixed concrete plants, for the independent and exclusive use of Department personnel for the duration of the Project.

640.02 MATERIALS

The Resident Engineer will direct a time and location for the installation of the field office or laboratory.

Provide a mobile unit or a permanent structure for the field office or laboratory building. Weatherproof and maintain the buildings as approved by the Resident Engineer.

Provide buildings with the following characteristics:

- Outside dimensions of at least 8 ft × 16 ft [2.4 m × 4.8 m];
- Inside ceiling height of at least 7 ft [2.1 m];
- Floors;
- At least four windows that can be opened, closed, and locked; and
- Two doors near opposite ends of the building that can be locked.

Furnish field office buildings with an office desk and at least one chair. Ensure the building is wired for electricity and has at least three double wall plugs and three overhead ceiling lights. Provide buildings capable of maintaining an interior temperature from 70°F to 80°F [21°C to 27°C].

Provide required utility services, including telephone service.

Ensure laboratory buildings meet the following requirements:

- Locate the building at the plant site, at a location convenient to the physical control center of the plant and in view of delivery, loading, and unloading, as approved by the Resident Engineer.
- Equip the building with a 3 ft × 6 ft [0.9 m × 1.8 m] work bench.
- Provide a gas or electric oven and hot plate.
- Provide an inside cold water supply line, plumbed to a potable water supply.
- Provide a pressurized, dry-chemical, ABC-rated fire extinguisher of at least 20 lb [9 kg] rated capacity. Place the fire extinguisher on a wall at a location approved by the Resident Engineer. Maintain the fire extinguisher in a completely charged condition. Ensure the local fire authority inspects, approves, and tags for serviceability at least every 12 months.
- For building units used as the laboratory for asphalt extractions, provide a fume hood for removing flammable organic vapors generated by routine laboratory testing. Ensure the fume hood adheres to the following characteristics:
  - Fireproof with an explosion-proof motor, blower, and light.
  - Interior dimensions of at least 3 ft [0.9 m] wide by 1¾ ft [0.53 m] deep by 2½ ft [0.76 m] high.

- Tempered safety glass front panel which slides up at least 2 ft [0.6 m] to provide access to the fume hood, and slides down to fully enclose the fume hood.
- Produce a volume of airflow per minute at least 14 times the nominal external volume of the fume hood.
- Vent the exhaust from the fume hood to the outside atmosphere.
- Equip the fume hood with an air bypass that prevents "jet-stream" effects as the front panel closes.
- Include catalog cut sheets, brochures, and specifications with the fume hood.

640.03 EQUIPMENT — VACANT

640.04 CONSTRUCTION METHOD

Remove the field office or laboratory building or mobile unit from the project or plant site as directed by the Resident Engineer.

640.05 METHOD OF MEASUREMENT

On optional tied projects, if bid as a tie, the Department will delete at least one field office and one laboratory from the tied portion of the Proposal. Maintain the remaining field offices on the job sites, and the remaining laboratories at the plant sites, until tied projects are complete.

640.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) FIELD OFFICE	Each
(B) LABORATORY	Each

The Department will consider the cost of utility connections and site preparation for the field office and laboratory to be included in the contract unit price for *Field Office* and *Laboratory*. The Department will pay for these items in full once in place and fully operational. If the Contractor does not maintain the Laboratory or Field Office in a working condition, the Department may reduce the amount of payment proportional to the time the facility was not in working condition.

SECTION 641
MOBILIZATION

641.01 DESCRIPTION

This work consists of the Contractor's preparatory operations, including moving personnel and equipment to the project site, and establishing the Contractor's offices, buildings, and facilities.

641.02 MATERIALS — VACANT

641.03 EQUIPMENT — VACANT

641.04 CONSTRUCTION METHOD — VACANT

641.05 METHOD OF MEASUREMENT — VACANT

641.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
MOBILIZATION	Lump Sum

The Department will pay in two installments; except, if the first pay estimate submitted is the final estimate, the Department will pay the total lump sum bid.

If the lump sum price for *Mobilization* is less than or equal to the "Maximum Amount Payable for Mobilization Item" as defined in Table 641:1, "Mobilization Payment Schedule," the first payment for *Mobilization* will be 50 percent of the lump sum price. The Department will pay this amount on the first estimate following partial mobilization and construction initiation. The Department will make the final payment on the estimate following substantial mobilization.

If the lump sum price for *Mobilization* is more than the "Maximum Amount Payable for Mobilization Item" as defined in Table 641:1, the first payment for Mobilization will be 50 percent of the "Maximum Amount Payable for Mobilization Item." The Department will pay this amount on the first estimate following partial mobilization and construction initiation. The Department will pay the remaining 50 percent of the "Maximum Amount Payable for Mobilization Item" on the estimate following substantial mobilization. The Department will pay the difference in the lump sum price for *Mobilization* and the "Maximum Amount Payable for Mobilization Item" (the overbid amount) when the project is complete in accordance with Subsection 105.17.B, "Project Completion."

Estimates are due in accordance with Subsection 109.06, "Progress Payments." The Department will not consider mobilization in determining this date.

The Department will not pay for demobilization and remobilization due to shutdowns, suspensions of the work, or other mobilization activities.

For contracts that include multiple tied projects, the "Total Original Contract Amount Including Mobilization" in Table 641:1 is the sum of the original contract amounts of the separate tied projects. For contracts that contain multiple mobilization items, the sum of

mobilization items will be subject to the limitation of the "Maximum Amount Payable for Mobilization Item."

The Department will pay lump sums for mobilization in accordance with the following:

Table 641:1 Mobilization Payment Schedule	
Total Original Contract Amount, Including Mobilization, *$*	**Maximum Amount Payable For Mobilization Item**
>0 – 500,000	10% of total contract amount
>500,000 – 4,000,000	$50,000 + 5% × (total contract - $500,000)
>4,000,000	$225,000 + 4% × (total contract - $4,000,000)

The Resident Engineer's field office and laboratory is a separate pay item not included in this work.

SECTION 642
CONSTRUCTION STAKING

642.01 DESCRIPTION

This work consists of providing, placing, and maintaining construction layout stakes for the proper prosecution and inspection of the work.

642.02 MATERIALS — VACANT

642.03 EQUIPMENT — VACANT

642.04 CONSTRUCTION METHODS

Stake the line and grade of construction features.

Depending on the availability of the Department's survey staff, the Contract may require either Construction Staking – Level I or Level II.

A. Construction Staking – Level I

(1) Department Responsibilities

The Department will perform the following construction staking activities:

- Locate and reference the centerline or control line of permanent construction;
- Stake the right-of-way lines (for construction purposes only);
- Identify and verify bench marks;
- Take original and final cross sections for earthwork construction features to obtain volumes for pay quantities;
- Set major control points on the tangents and at the beginning and ending points of curves on the centerline or control line; and
- Establish bench marks for bridges and special structures.

If the survey centerline and the construction reference line are not the same, the Resident Engineer will set the major control points on the construction reference line.

(2) Contractor Responsibilities

Perform the following construction staking activities:

- Set additional stakes and other horizontal or vertical controls to establish a correct work layout;
- Stake the centerline or control line of temporary features;
- If the Contract requires measurement of earthwork quantities using photogrammetry, clear and grub the entire Project before taking the original photos or beginning the excavation work;
- Place stakes for line and grade to maintain the tolerances specified in the Contract for the operation being performed; and
- On grade stakes, mark the station number and the distance from the centerline of construction.

Preserve survey stakes and bench marks and reset if damaged, lost, or removed. Provide qualified staff with appropriate equipment to perform construction layout work. The Department will not allow the use of Department employees or Department-owned equipment for construction staking work that is the responsibility of the Contractor.

B. Construction Staking – Level II

(1) Department Responsibilities

The Department will take original and final cross sections for earthwork construction features to obtain volumes for pay quantities.

(2) Contractor Responsibilities

Perform the following construction staking activities:

- Locate and reference the centerline of permanent construction;
- Stake the right-of-way lines (for construction purposes only);
- Identify and verify bench marks;
- Set major control points on the tangents and at the beginning and ending points of curves to mark the centerline;
- Establish bench marks for bridges and special structures.
- Set additional stakes and other horizontal or vertical controls to establish a correct work layout;
- Stake the centerline or control line of temporary features;
- If the Contract requires measurement of earthwork quantities using photogrammetry, clear and grub the entire Project before taking the original photos or beginning the excavation work;
- Place stakes for line and grade to maintain the tolerances specified in the Contract for the operation being performed; and
- On grade stakes, mark the station number and the distance from the centerline of construction.

If the survey centerline and the construction reference line are not the same, the Resident Engineer will set the major control points on the construction reference line.

Preserve survey stakes and bench marks and reset if damaged, lost, or removed. Provide qualified staff with appropriate equipment to perform construction layout work. The Department will not allow the use of Department employees or Department-owned equipment for construction staking work that is the responsibility of the Contractor.

Notify the Resident Engineer if bench marks or major survey control points previously established by the Department have been destroyed, damaged, or removed. The Resident Engineer will re-establish the control points.

C. Error Correction and Resident Engineer Notification

Provide platforms and equipment for safe access to check the staking. If significant errors occur, resurvey to the satisfaction of the Resident Engineer.

Regardless of inspection or acceptance of the layout by the Department, the Contractor is responsible for establishing the proper dimensions, grades, and elevations for the work. The Resident Engineer will resolve plan errors.

Notify the Resident Engineer of plan errors by the end of the next working day. The Resident Engineer will perform special surveys to determine corrective action for plan errors. Measure the profiles of existing highway features that will connect to the project for 100 ft [30 m]. If the profiles of the project and the existing features do not match, immediately notify the Resident Engineer. Ensure the surface of the finished Project creates a smooth ride for the entire length of the Project.

Verify the original cross sections. If requested, the Department will provide original cross sections. Resolve disputes regarding the Department's original cross sections before beginning earthwork activities in the disputed areas. The Resident Engineer may suspend Contract time if the dispute resolution stops work that is critical to the timely completion of the Project. If requested, the Resident Engineer will provide the completed final cross sections. For a dispute regarding original or final cross sections, jointly gather the cross section data with the Resident Engineer's surveyors to resolve the dispute.

Perform survey work, compilation of field notes, and documentation in accordance with the ODOT "Guide for Construction Staking."

642.05 METHOD OF MEASUREMENT

Unless specified in the Contract, the Department will measure the volumes of pay quantities and perform survey control of permanent facilities.

642.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) CONSTRUCTION STAKING LEVEL I	Lump Sum
(B) CONSTRUCTION STAKING LEVEL II	Lump Sum

The Department will make a partial deduction of payment for staking if the notifications specified in Subsection 642.04.C, "Error Correction and Resident Engineer Notification," are not made.

The Department will pay for construction staking in accordance with the following:

- 25 percent on first pay estimate
- 25 percent when 10 percent of the contract work is completed
- 25 percent when 50 percent of the contract work is completed
- 15 percent when 75 percent of the contract work is completed
- 10 percent when the Resident Engineer verifies that all construction features have been properly placed and completed, the Contractor has submitted all staking documentation to the Engineer, and the Engineer has accepted the staking documentation.

CHAPTER 700
MATERIALS

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SECTION 701
PORTLAND CEMENT CONCRETE

701.01 MIX DESIGN AND PROPORTIONING

The Department requires that all portland cement concrete be air entrained. The Department will allow portland cement concrete produced using portland cements, blended hydraulic cements, and hydraulic cements.

A. Classes of Concrete

If the Plans do not show the concrete class, provide concrete in accordance with the following:

Class AA. Use Class AA concrete in superstructures.

Class A. Use Class A concrete for pavements and substructures (pier caps, columns, abutments, retaining walls, and reinforced concrete not requiring Class AA concrete).

Class AP. Use Class AP concrete in shoulders, merge areas, and gore areas for portland cement concrete (PCC) pavements.

Class C. Use Class C concrete for soil erosion control structures.

Class P. Use Class P concrete for precast prestressed concrete members.

Table 701:1 specifies the requirements for each concrete class:

Table 701:1
Concrete Classes

Class of Concrete	Minimum Cement Content, *lb/yd³ [kg/m³]*	Air Content, *%*	Water/Cement Ratio [a], *lb/lb [kg/kg]*	Slump [b], *in [mm]*	Minimum 28-day Compressive Strength [c], *psi [MPa]*
AA	564 [335]	6.5 ±1.5	0.25 – 0.44	2 ±1 [50 ±25]	4,000 [27.6]
A	517 [307]	6 ±1.5	0.25 – 0.48	2 ±1 [50 ±25]	3,000 [20.7]
AP	470 [279]	6 ±1.5	0.25 – 0.48	2 ±1 [50 ±25]	3,000 [20.7]
C	395 [234]	6 ±1.5	0.25 – 0.62	3 ±1 [75 ±25]	2,400 [16.5]
P	564 [335]	5 ±1.5	0.25 – 0.44	3 ±1 [75 ±25]	As required by the Contract

[a] Use the weight of each material to calculate the water to cement ratio (W/C) using the following equation:

W/C = Water/ (Cement + Cement Substitutes)

Determine the water use by adding the water measured into the batch, the water used in admixtures, and the free water on wet aggregate and subtracting the water absorbed by dry aggregate.

[b] Ensure the slump reflects a workability appropriate for the application. If using a high-range water-reducing admixture, limit the slump to a maximum of 9 in [230 mm].

[c] Compressive strength is based on the average of the results of three test cylinders. The contract documents specify Class P concrete compressive strengths.

Ensure Class A concrete for paving has flexural strength of at least 650 psi [4.5 MPa] at 28 days or 700 psi [4.8 MPa] at 56 days. Determine the flexural strength at the mix design stage and obtain certification from the concrete supplier.

B. Cement Substitution

The Department will allow a substitution of a portion of the cement content at the concrete batch plant. Provide cement substitutes in accordance with Section 702, "Supplementary Cementitious Materials." Make cement substitutions on a one-to-one basis by weight [mass] in accordance with Table 701:2. Refer to Subsection 701.02.A(1), "Portland Cement," and Subsection 701.02.A(3), "Hydraulic Cement," for portland cement and hydraulic cement specifications.

Table 701:2
Cement Substitutes for Portland and Hydraulic Cement

Cement Substitutes	Maximum Percent by Weight [Mass]
Fly ash or pozzolans only	20
Slag only	50
Silica fume only	10
Combination of fly ash or pozzolans, and silica fume	30
Combination of fly ash or pozzolans, slag, and silica fume	50

Refer to Subsection 701.02.A(2), "Blended Hydraulic Cement," for blended hydraulic cement specifications.

Table 701:3
Cement Substitutes for Blended Hydraulic Cement

Cement Type	Material	Maximum Percent by Weight [Mass]
IP (XX)	Fly ash	30 – (XX)
	Silica fume	10
	Slag	50 – (XX)
	Combinations	See Table 701:2
IS (XX)	Fly ash	20
	Silica fume	10
	Slag	50 – (XX)
	Combinations	See Table 701:2
Note: (XX) is the percentage of pozzolan in the IP cement or the amount of slag in the IS cement.		

Ensure portland cement is at least 50 percent of the cementitious materials including substitutions at the cement production and the concrete batch plant. For concrete mix design purposes, consider the intended concrete use and weather conditions when determining cement substitutes.

Ensure the substitutions do not exceed the limits specified in Table 701:2 and Table 701:3. Limit combinations to individual limits.

C. Proportioning

Design and produce concrete mixtures in accordance with Table 701:1, "Concrete Classes." Base the mix design on absolute volume for the concrete class required by the Contract and the consistency for concrete placement. Proportion the coarse and fine aggregate in accordance with ACI 211.1. Use the least amount of fine aggregate

and mixing water to produce the workability for placement conditions. Ensure high early strength concrete meets the minimum strength within 72 hr of placement. Submit the mix design to the Resident Engineer at least 14 days before production. The Department will not allow placing PCC to begin until the Resident Engineer approves the mix design. Include the following information with each mix design:

- Project identification,
- Contractor's and Producer's name and address,
- Mix design designation,
- Mix design intended use,
- Expected travel time from batch to placement,
- If the concrete will be pumped,
- Aggregate sources, gradation, moisture content, and saturated surface dry batch mass,
- Water source and test reports required by Subsection 701.04, "Water,"
- Fine aggregate fineness modulus,
- Cement type and source,
- Type of cement substitutions, if used, and source,
- Type of admixtures and sources,
- High Range Water Reducer, if used in accordance with Subsection 701.03.C, "High Range Water Reducer (HRWR) Concrete Mixture,"
- Material proportions,
- Unit weight,
- Air content,
- Slump,
- Water to cement ratio,
- Compressive strengths at 7 days and 28 days,
- Compressive strengths at 72 hr for high early strength concrete, and
- Flexural strength at 28 days or 56 days for Class A used for concrete paving.

Submit new mix designs if:

- The Resident Engineer rejects the mix design,
- Material sources change, or
- The mix design produces unacceptable workability or production test results.

D. Tests and Samples

For concrete sampling and testing, use the procedures in Table 701:4.

Table 701:4
Concrete Sampling and Testing

Property Tested	AASHTO Test Procedure
Sampling [a]	T 141
Slump	T 119
Air	T 152 or T 196
Curing of Specimens [b]	T 23
Strength:	
Compressive [c]	T 22

Table 701:4
Concrete Sampling and Testing

Property Tested	AASHTO Test Procedure
Flexural [d]	T 97

[a] Sample pumped concrete after it is discharged from the pump.
[b] Maintain the initial curing temperature at 40°F [4°C] or greater. The Resident Engineer will not require a recording thermometer. Maintain the final cure from 40°F to 85°F [4°C to 29°C] until tested.
[c] Base compressive strengths on the average of three test cylinders.
[d] Base flexural strengths on the average of two test beams.

E. Mix Identification

Reference authorized mix identifications on batch tickets, test results, reports, and correspondence.

701.02 PORTLAND CEMENT

A. General

Provide cement that meets the specifications for the following types, as required by the Contract:

- Portland Cement,
- Blended Hydraulic Cement,
- Hydraulic Cement, or
- Rapid Setting Cement (for bridge deck overlays and repairs only).

(1) Portland Cement

Provide portland cement in accordance with AASHTO M 85 except as modified by the following:

Ensure the tricalcium aluminate (C_3A) content in Type I cement does not exceed 15 percent.

Report the amount of portland cement retained on the No. 325 [45 µm] sieve in accordance with AASHTO T 192 on mill test reports.

Ensure the total equivalent alkalis do not exceed 0.95 percent. The Resident Engineer may waive this limit on a per project basis if the proposed concrete mix design meets the expansion limits in Option R of ASTM C 1157 when tested in accordance with ASTM C 1260.

Provide Type IV and Type V cements that meet the optional physical requirements.

Supply supporting data for cement provided under optimum SO_3 requirements as described in footnote [d] of Table 1 of AASHTO M 85quarterly to the Department's Materials Engineer.

(2) Blended Hydraulic Cement

Provide blended hydraulic cement in accordance with AASHTO M 240, except as modified by the following:

Ensure the total equivalent alkalis do not exceed 0.95 percent. The Resident Engineer may waive this limit on a per project basis if the proposed concrete mix design meets the expansion limits in Option R of ASTM C 1157 when tested in accordance with ASTM C 1260.

Ensure the tricalcium aluminate (C_3A) content does not exceed 15 percent.

Record the amount of blended hydraulic cement retained on the No. 325 [45 µm] sieve in accordance with AASHTO T 192. Use the air permeability method in accordance with AASHTO T 153 to determine and record the fineness on mill test reports.

Test silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), and calcium oxide (CaO) in accordance with AASHTO T 105 and report the results on mill reports.

Provide cement substitutions that do not exceed the limits in Subsection 701.01.B, "Cement Substitution."

Supply supporting data for cement provided under optimum SO_3 requirements as described in footnote [a] of Table 1 of AASHTO M 240 quarterly to the Department's Materials Engineer.

(3) Hydraulic Cement

Provide hydraulic cement in accordance with ASTM C 1157 except as modified by the following:

Ensure the total equivalent alkalis do not exceed 0.95 percent. The Resident Engineer may waive this limit on a per project basis if the proposed concrete mix design meets the expansion limits in Option R of ASTM C 1157 when tested in accordance with ASTM C 1260.

Ensure the tricalcium aluminate (C_3A) content does not exceed 15 percent.

Record the amount of hydraulic cement retained on the No. 325 [45 µm] sieve in accordance with AASHTO T 192. Use the air permeability method in accordance with AASHTO T 153 to determine and record the fineness on mill test reports.

Ensure the loss on ignition for hydraulic cements does not exceed 5.0 percent.

Provide cement substitutions that do not exceed the limits in Subsection 701.01.B, "Cement Substitution."

The Department's Materials Engineer may limit substitutes in cement production by type and percentage.

(4) Rapid Setting Cement

Provide rapid setting cement in accordance with Table 701:5:

Table 701:5
Rapid Setting Cement Properties

Material or Property	Cement [a], %
Calcium sulfoaluminate (C_4A_3S)	33
Dicalcium silicate (C_2S)	67

Table 701:5 Rapid Setting Cement Properties	
Material or Property	**Cement [a], %**
Tricalcium aluminate (C_3A)	<5
[a] Approximate percentages by weight [mass]	

B. General Construction Requirements

Table 701:6 specifies the cement for each application. Use these cement types as shown on the Plans.

Table 701:6 Cement Properties	
Cement Type	**Use**
I, II, V, GU, IP(XX), IS(XX)	General construction
I, II, III, HE, GU, IP(XX)	High early strength
II, V, MS, HS	Sulfate mitigation
IV, MH, LH	Low heat of hydration

If required by the Contract, provide white portland cement in accordance with the requirements for Type I cement.

Use the product from one mill for one hydraulic cement brand and type on structures. Provide a storage unit that protects the cement against dampness. The Resident Engineer will reject partially set cement or cement with caked lumps. The Department will not allow salvaged cement. Ensure the cement manufacturer identifies the types and amounts of cement substitutions on each shipping ticket.

Ensure a qualified domestic manufacturer performs the tests. Reimburse the Department for inspection expenses incurred outside the United States and additional expenses incurred by the use of foreign cement.

Use sampling and test methods in accordance with AASHTO M 85, AASHTO M 240, or ASTM C 1157 except as modified by the Department's acceptance policy, "Approval Procedure for Hydraulic Cement." The procedure is available on the following web page:

http://www.okladot.state.ok.us/

701.03 ADMIXTURES

This subsection does not cover specifications for fly ash, ground granulated blast furnace slag, or silica fume. Use admixtures included in the approved mix design. The Department will not allow using admixtures to replace cement or using admixtures containing more than 10,000 ppm of chloride in prestressed or reinforced concrete. Provide admixtures in accordance with the following:

- Accurately measure admixture dosages into each batch.
- Dispense admixtures in liquid form. Provide dispensers large enough to measure the quantity for each batch. Unless liquid admixtures are added to pre-measured water, arrange the discharge to uniformly flow into the water stream.
- Store admixtures to prevent freezing. Agitate admixtures to prevent solids from separating or settling. Do not use air agitation.
- If using more than one liquid admixture, use separate equipment to provide and dispense each admixture. Ensure that admixtures are compatible when used in combination.

A. Air Entraining Admixtures

Provide air entraining admixtures in accordance with AASHTO M 154. The Department may allow an exception if the manufacturer provides certification that the product is neutralized vinsol resin with caustic soda, and contains no other additive. Add air entraining admixture during initial batching. If air content is below the specification minimum, additional air entraining admixture may be added at the jobsite followed by a minimum of 30 revolutions at mixing speed provided the revolution limit of 300 is not exceeded.

B. Chemical Admixtures

Provide chemical admixtures in accordance with AASHTO M 194 for the type of admixture supplied.

When concrete mix designs contain a High Range Water Reducer (HRWR) admixture, Type F or G, define the following:

- The purpose for its use,
- Whether it will be added to the mix at the plant or jobsite, and
- The maximum slump after addition.

Provide a concrete mixture design in accordance with Subsection 701.01, "Mix Design and Proportioning," before adding the admixture.

C. Corrosion-Inhibiting Admixtures

If required by the Contract, provide corrosion-inhibiting admixtures that have the characteristics specified in Table 701:7 when tested in accordance with AASHTO M 194.

Table 701:7
Physical Requirements for Corrosion-Inhibiting Admixture

Characteristic	Value
Calcium nitrite content, percent by weight [mass]	30±2
Time of setting, allowable deviation from control:	
Initial	−1 hr/+3.5 hr
Final	−1 hr/+3.5 hr
Strength, minimum percent of the control (any time):	
Compressive	90
Flexural	90
Length change, maximum shrinkage, percent of the control	135
Relative Durability Factor, minimum	80

Ensure the corrosion inhibitor-protected specimens have an average corrosion current less than 2 µA when tested in accordance with ASTM G 109. Run the test for three cycles in accordance with Section 8, "Period of Testing," after the control specimens fail.

Ensure the protection potentials (Ep) are greater than −280 mV versus SCE when tested in accordance with ASTM G 61. Modify the test medium to contain a 12.5 pH calcium hydroxide ($Ca(OH)_2$) solution and sodium chloride (NaCl) content equal to approximately 5 lb/yd³ [3 kg/m³] of concrete.

After 5 years of testing, ensure the corrosion inhibitor-protected test specimens have a corrosion current in micro amps of less than 10 percent of the control when

tested in accordance with ASTM G 109. Make concrete test specimens with at least 1 in [25 mm] of cover over the reinforcement and ensure a maximum water to cement ratio of 0.40.

Unless otherwise required by the Contract, provide concrete containing 4.0 gal/yd³ [19.8 L/m³] of corrosion inhibiting admixture. Account for possible set acceleration effects from calcium nitrite based admixture. The Department will allow the use of set-retarding admixtures to counter the acceleration effects.

D. Latex Emulsion Admixtures

Provide a water based, homogenous, nontoxic, film forming, polymeric emulsion formulated latex admixture to which all stabilizers were added at the point of manufacture. Provide the latex modifier in accordance with Table 701:8.

Table 701:8
Latex Modifier Properties — Polymer Type Styrene Butadiene Stabilizers

(1) Latex	Nonionic surfactant
(2) Portland cement composition	Poly-dimethyl siloxane
Percent solids	46.0 – 49.0
Mass per unit volume, lb/gal [kg/L] at 77°F [25°C]	8.4 [1.007]
Color	White

Store latex admixture in suitable enclosures and completely cover with insulating blankets to protect from freezing and exposure to temperatures greater than 85°F [29°C]. The Department will not allow storage of latex admixture containers at the project site for more than 10 days.

701.04 WATER

Provide water in accordance with AASHTO M 157, except as modified by the following:

If the water to be used is from an approved ODEQ public water source, the Resident Engineer will not require additional quality testing. If using water from another source, submit test reports from the concrete producer showing compliance with AASHTO M 157 and Table 701:9, “Chemical Limits for Mix Water,” before use.

The Department will allow a blend of concrete wash water and other water sources as mix water if the concrete producer submits certification that the water meets the requirements of AASHTO M 157, Table 701:9, “Chemical Limits for Mix Water,” and Table 701:10, “Acceptance Criteria for Questionable Water Supplies.” Test the blended water weekly for 4 weeks, or provide previous test reports. Test blended water monthly for compliance. Provide water test results when requested by the Resident Engineer.

Table 701:9
Chemical Limits for Mix Water

Contaminant	Test Method	Maximum Concentration, *ppm*
Chloride (Cl)	ASTM D 512	
Prestressed concrete	—	500
Bridge decks and superstructure	—	500
All other concrete	—	1,000

Table 701:9
Chemical Limits for Mix Water

Contaminant	Test Method	Maximum Concentration, *ppm*
Sulfate (SO_4)	ASTM D 516	1,000
Alkalis ($NA_2O + 0.658K_2O$)	ASTM D 4191 and ASTM D 4192	600
Total solids	AASHTO T 26	50,000

Table 701:10
Acceptance Criteria for Questionable Water Supplies

Property	Limits	Test Method
Compressive strength, minimum percent of the control (at 7 days)	90%	AASHTO T 106
Time of set, deviation from control, *hr*	−1/+1.5	AASHTO T 131

701.05 FINE AGGREGATE

A. Materials Covered

This subsection covers fine aggregate quality and size for PCC pavements or bases, highway bridges, and incidental structures.

Provide mortar sand in accordance with AASHTO M 45.

B. General Requirements

Provide fine aggregate that consists of a single-source natural sand in accordance with AASHTO M 6, Class A, except as modified by Subsection 701.05.C, "Gradation."

Alternatively, provide a fine aggregate that consists of a combination of natural sands or a combination of natural and manufactured sands in accordance with AASHTO M 6, Class A, except as modified by the following:

- Mix the two materials under controlled conditions and stockpile as a finished aggregate. Alternatively, the two materials may be combined from separate stockpiles during batching operations at a hydraulic cement concrete plant.
- Ensure the combined fine aggregate meets the gradation requirements of Subsection 701.05.C, "Gradation."
- If a manufactured sand is used in combination with natural sand, ensure the fine aggregate blend has an acid insoluble residue of at least 60 percent by weight when tested in accordance with OHD L-25.
- Obtain crushed fine aggregate (manufactured sand) from a coarse aggregate source on the Materials Division's "Approved Products List" for use in hydraulic cement concrete.

C. Gradation

Provide fine aggregate with a finemess modulus between 2.3 and 3.1, that is well graded from coarse to fine, and when tested in accordance with AASHTO T 27 and AASHTO T 11 meets the requirements of Table 701:11.

Table 701:11 Fine Aggregate Gradation	
Sieve Size	**Percent Passing**
⅜ in [9.5 mm]	100
No. 4 [4.75 mm]	95 – 100
No. 8 [2.36 mm]	80 – 100
No. 16 [1.18 mm]	50 – 85
No. 30 [600 µm]	25 – 60
No. 50 [300 µm]	5 – 30
No. 100 [150 µm]	0 – 10
No. 200 [75 µm]	0.0 – 3.0

The gradation requirements specified in Table 701:11 represent the extreme limits of suitability. Ensure the gradation from one source does not have large changes in percentages of gradation. Use the average fineness modulus to determine the uniformity of the fine aggregate. The average fineness modulus is the average of the last 10 tests by the Resident Engineer and maintained by his office. The Resident Engineer will not accept fine aggregate represented by a test result with a fineness modulus that deviates more than 0.20 from the average. Determine the aggregate fineness modulus by adding the total percentage of sample material that is coarser than each of the following sieve sizes and dividing by 100:

- No. 100 [150 µm],
- No. 50 [300 µm],
- No. 30 [600 µm],
- No. 16 [1.18 mm],
- No. 8 [2.36 mm],
- No. 4 [75 mm], and
- ⅜ in [9.5 mm].

701.06 COARSE AGGREGATE

This subsection covers coarse aggregate quality and size for use in PCC pavements or bases, highway bridges, and incidental structures.

Provide each source of coarse aggregate in accordance with AASHTO M 80, Class A, except as modified by the following:

- Ensure coarse aggregate produces Class A concrete with a durability factor of at least 50. Determine the durability factor after 350 cycles of alternate freezing and thawing in accordance with AASHTO T 161, Procedure A.
- Limit the Los Angeles Abrasion percent wear to a maximum of 40 percent after 500 revolutions when tested in accordance with AASHTO T 96.
- The Resident Engineer will not apply the sodium sulfate soundness requirement.
- Ensure at least 70 percent of the coarse aggregate retained on the No. 4 [4.75 mm] sieve is crushed stone or mechanically crushed gravel with at least two fractured faces.
- Limit the quantity of flat or elongated pieces to 15 percent or less, at a ratio of 1:5, when tested in accordance with ASTM D 4791.
- Provide coarse aggregate graded in accordance with Table 701:12.

Table 701:12 Coarse Aggregate Gradation					
Sieve Size	**Percent Passing per Processed Aggregate Size Number**				
	357	**57**	**67**	**7**	**8**
2½ in [63 mm]	100	—	—	—	—
2 in [50 mm]	95 – 100	—	—	—	—
1½ in [37.5 mm]	—	100	—	—	—
1 in [25 mm]	35 – 70	95 – 100	100	—	—
¾ in [19 mm]	—	—	90 – 100	100	—
½ in [12.5 mm]	10 – 30	25 – 60	—	90 – 100	100
⅜ in [9.5 mm]	—	—	20 – 55	40 – 70	85 – 100
No. 4 [4.75 mm]	0 – 5	0 – 10	0 – 10	0 – 15	10 – 30
No. 8 [2.36 mm]	—	0 – 5	0 – 5	0 – 5	0 – 10
No. 16 [1.18 mm]	—	—	—	—	0 – 5
No. 200 [75 µm]	0 – 1.5	0 – 2.0	0 – 2.0	0 – 2.0	0 – 2.0

More than one approved source of coarse aggregate may be used in a concrete mix design. Provide the specified sizes of coarse aggregate for the following types of concrete:

- No. 57 for Class A and Class AP concrete;
- No. 357 for massive Class A concrete;
- No. 57, No. 67, or No. 357 for Class C concrete;
- No. 7 for thin overlays, details, and thin sections if allowed by the Resident Engineer;
- No. 57 or No. 67 for Class AA or Class P concrete; and
- No. 7 or No. 8 for Class P concrete if the specified 28-day compressive strength is greater than 6,000 psi [41.4 MPa] or the Contract requires permeability limits.

701.07 CURING AGENTS

Provide concrete curing agents consisting of the following:

- Burlap,
- Cotton mats,
- White or red-pigmented membrane curing compound,
- Waterproof paper,
- Polyethylene film,
- Linseed oil emulsion, or
- Water for ponding.

Keep the curing agents free of material that may damage the concrete surface.

A. Burlap

Provide Class 3 burlap cloth in accordance with AASHTO M 182.

Provide new burlap free of starch, filler, or other substances added during the manufacturing process. If the burlap contains these substances, wash it by repeatedly rinsing in clear water. Alternatively, the Department will allow old burlap that has only been used for curing concrete. The Department will not allow the use of worn burlap or burlap with holes. Provide burlap that is at least 2 ft [600 mm] longer than the width of the concrete being covered.

B. Cotton Mats

Provide new cotton mats, or used cotton mats, used only for curing concrete. The Department will not allow the use of worn cotton mats or cotton mats with holes.

C. Liquid Membrane Curing Compounds

Provide liquid membrane curing compounds in accordance with AASHTO M 148, Type 2 or Type 1-D, except as modified by the following:

- Ensure Type 2, white-pigmented compound hiding power has a daylight reflectance of at least 65 percent of magnesium oxide reflectance in accordance with ASTM E 97.
- Color Type 1-D compound with a red fugitive dye so inspection indicates complete coverage. Ensure the color remains for at least 4 hr and then gradually disappears.
- Ensure the curing compound has at least 90 percent water retention when tested in accordance with OHD L-17.

D. Sheet Materials

Provide sheet materials in accordance with AASHTO M 171. The Resident Engineer may approve a sheet material type not specified in AASHTO M 171 if all other requirements of AASHTO M 171 are met. Cut the sheet material into sheets wide enough to completely cover the exposed concrete surface. When joints are needed in the sheets, provide a lap joint of at least 2 ft [650 mm]. The Department will not allow the use of sheet sections that have lost their moisture-retaining qualities.

E. Linseed Oil Emulsion

Provide linseed oil emulsion in accordance with Table 701:13:

Table 701:13
Linseed Oil Emulsion Composition

Composition	Percent by Weight [Mass]
Oil phase (≥50% by volume):	
Boiled linseed oil	96.9 – 97.1
Saturated tallow alcohols	2.9 – 3.1
Total	100
Water phase (≤50% by volume):	
Water	99.5 – 99.7
Sodium hydroxide	0.36 – 0.38
Dipicolinic acid	0.029 – 0.031
Total	100

Ensure the emulsion is stable at the time of application.

Color the linseed oil emulsion with a red fugitive dye to indicate complete coverage for inspection. Ensure the color remains for at least 4 hr and then gradually disappears within 2 weeks.

Ensure the curing compound has at least 90 percent water retention when applied at a coverage rate of 175 ft^2/gal [4.3 m^2/L] and tested in accordance with OHD L-17.

Store and transport linseed oil emulsion in plastic containers marked with the manufacturer's name, contents, lot number, and date of manufacture.

F. Water for Ponding and Material for Dikes

Provide water for ponding in accordance with Subsection 701.04, "Water." Construct dikes from a combination of loam, sand, or clay. Ensure dikes are free of rocks, sticks, or objects that may prevent a watertight dike.

701.08 JOINT FILLERS AND SEALANTS

This subsection covers the requirements for joint fillers and sealants for PCC.

A. Preformed Expansion Joint Filler for Concrete (Bituminous Type)

Provide preformed expansion joint filler in accordance with AASHTO M 33. The Department will not allow this type of expansion joint filler if the Contract requires a sealant.

B. Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction

(1) Non-bituminous Joint Filler

Provide non-bituminous joint filler in accordance with AASHTO M 153.

(2) Bituminous Joint Filler (Non-extruding and Resilient Bituminous Types)

Provide bituminous joint filler in accordance with AASHTO M 213, except the maximum allowable load to compress the test specimen to 50 percent thickness before testing is 1,500 psi [10.34 MPa]. The Resident Engineer will waive compliance with the asphalt content requirement if the material meets all other specified physical requirements.

C. Preformed Elastomeric Compression Joint Sealant

This subsection covers preformed elastomeric compression joint sealants for PCC pavements and concrete bridge floors.

(1) Preformed Joint Seals

Provide joint seals manufactured from an elastomeric material that is resistant to heat, oil, jet fuel, and ozone. Ensure the material is compatible with concrete and is in accordance with AASHTO M 220.

(2) Shape and Dimensions

Make the molded joint seals to the cross-sectional dimensions, lengths, and tolerances as shown on the Plans. Place the sealant in one piece for the full length of transverse joint and in practical lengths to suit field conditions for longitudinal joints.

(3) Inspection

The Resident Engineer will inspect the surface and dimensions of representative sections of each lot to determine visual compliance. Replace preformed elastomeric compression joint sealant that elongates more than 2 percent during placement, at no additional cost to the Department.

(4) Lubrication Adhesive

Provide lubricant adhesive, if necessary, that maintains consistency at the installation temperature and is compatible with the sealant and concrete. Ensure the lubricant remains unaffected by the normal moisture in the concrete. Ensure the lubricant adhesive consists of the same base polymer as the sealant, blended with a volatile solvent.

D. Hot Poured Joint Sealant

Provide hot poured joint sealants that readily bond to concrete surfaces.

(1) Sealant

Provide joint sealants in accordance with AASHTO M 324. Heat the sealant material to the manufacturer recommended temperature range.

(2) Backer Rod

If shown on the Plans, use a backer rod of the size and dimensions required by the Contract. Provide a backer rod that is compatible with the joint sealant and is in accordance with ASTM D 5249.

E. Low Modulus Silicone Joint Sealant (Non-Sag)

This subsection covers non-sag, low modulus silicone joint sealants and expanded polyethylene backer rod for sealing PCC pavement joints. Provide silicone sealant in a one-part silicone formulation. The Department will not allow acetic acid cure sealants.

(1) Silicone Sealant

Provide a silicone sealant in accordance with ASTM D 5893, Type NS.

(2) Backer Rod

Provide a backer rod that is compatible with the joint sealant and does not bond or react with the sealant. Provide a backer rod in accordance with ASTM D 5249.

F. Low Modulus Silicone Joint Sealant (Self-Leveling)

This subsection covers self-leveling, low modulus silicone joint sealants and polyethylene backer rod for sealing PCC pavement joints, PCC to asphalt concrete pavement joints, or both. Provide self-leveling silicone sealant in a one-part silicone formulation. The Department will not allow acetic acid cure sealants.

(1) Silicone Sealant

Provide a silicone sealant in accordance with ASTM D 5893, Type SL.

(2) Backer Rod

Provide a backer rod that is compatible with the joint sealant and does not bond or react with the sealant. Provide a backer rod in accordance with ASTM D 5249.

G. Rapid Cure Joint Sealant and Elastomeric Mortar

This subsection covers rapid cure joint sealant and elastomeric mortar for expansion joints in bridge decks.

(1) Joint Sealant

Provide self-leveling, rapid cure silicone joint sealant that cures to a low modulus rubber when exposed to atmospheric moisture. The Department defines rapid cure as the development of integrity within the silicone in no more than 8 hr, to accommodate highway traffic and bridge movements. Deliver sealing compound to the job site in the manufacturer's original sealed container. Ensure each container is marked with the manufacturer's name, batch or lot number, and has the manufacturer's certification. Ensure petroleum is not deleterious to the sealant. Provide joint sealant in accordance with Table 701:14.

Table 701:14 Joint Sealant Characteristics		
Test Characteristic	**Limit**	**Test Method**
As supplied:		
Extrusion rate	≥200 g/min	MIL S 8802
Specific gravity	1.25 – 1.35	ASTM D 1475
As installed at 77°F [25°C] and 46 – 54% relative humidity:		
Accelerated weathering, 5,000 hr	No cracks, blisters, or bond loss	ASTM C 793
Skin-over time	≤20 min	OHD L-3
Non-volatile content	≥93%	OHD L-4
Joint elongation	≥600%	ASTM D 3583-85
Joint modulus at 100%	3 psi – 12 psi [20.7 kPa – 82.7 kPa]	ASTM D 3583-85 [a]

[a] Modify Section 14 of ASTM D 3583-85 as follows: Clean six 1 in × 1 in × 3 in [25.4 mm × 25.4 mm × 76.2 mm] concrete blocks. Hold them under running tap water and scrub with a brush for 30 sec. Allow blocks to dry for 24 hr at room temperature. Assemble blocks with 1 in × 3 in [25.4 mm × 76.2 mm] surfaces facing with ½ in × ½ in × 1 in [12.7 mm × 12.7 mm × 25.4 mm] Teflon spacers. Use clamps to hold blocks in place. Insert backer rod, closed cell, ½ in diameter by 2 in [12.7 mm diameter by 50.8 mm]; do not touch the surface with fingers. Inject sealant to fill the cavity, with no air entrapment. Allow the sealant to flow to a smooth surface, do not strike off. Allow to cure at 77°F [25°C] and from 46 to 54 percent relative humidity. Cure for 160 hr, remove clamp and Teflon spacers, and pull the test specimens at 2 in/min [50.8 mm/min].

(2) Elastomeric Mortar

Provide binder material consisting of a two-component, rapid curing, liquid polymer that cures to a dense, semi-flexible polymer. Ensure the final product is resistant to chemicals, weather, abrasion, and impact. Provide binder material that the sealant manufacturer determines compatible with the sealant. Cure the binder in the "neat" to form the primer between the elastomeric mortar and the existing surfaces. Mix the binder with aggregate to form the polymer based mortar. Provide aggregate for the elastomeric mortar that the manufacturer determines compatible with the liquid polymer binder material. Ensure the binder material properties are in accordance with Table 701:15.

Table 701:15 Combined Liquid Components		
Property	**Limit**	**Test Method**
Viscosity, 75°F ±2°F [23.9°C ±1.1°C] (Brookfield Model LVT) (Spindle No. 2, 30 RPM)	0.9 – 2.0	ASTM D 2393
Gel time	25 min – 60 min	AASHTO M 200
Elongation	40 – 55%	ASTM D 638 [a]
Tensile strength	≥900 psi [6.21 MPa]	ASTM D 638 [a]
Shore D Hardness, 7 day cure at 77°F [25°C]	45 – 75	ASTM D 2240

[a] Test Method Type 1, Molded Specimens, ¼ in [6.4 mm] thickness; speed of testing shall be 0.2 in ±0.05 in [5.1 mm ±1.3 mm].

Provide elastic mortar that has the properties specified in Table 701:16.

Table 701:16 Elastic Mortar Properties		
Property	**Limit**	**Test Method**
Absorption	≤1.0%	ASTM D 570
Compressive strength, 24 hr Method B	≥2,500 psi [17.24 MPa]	ASTM C 579
Bond shear strength	≥750 psi [5.17 MPa]	ASTM C 882
Abrasion Resistance Wear Index Taber H-22	≤1.5	ASTM C 501
Compressive stress	≥350 psi [2.41 MPa]	OHD L-6
Resilience	≥70%	OHD L-6
Thermal compatibility	Pass	ASTM C 884

(3) General Use Procedure

The manufacturer will recommend mixing and application times. Consult the manufacturer before modifying the elastomeric mortar.

(4) Backer Rod

Provide a backer rod in accordance with ASTM D 5249.

(5) Primer

Apply the primer in accordance with the manufacturer's recommendations before installing the sealant.

(6) Alternative Joint Products

The Department's Bridge Engineer may consider alternative sealants and elastomeric mortar systems as equals to the expansion joint system above if they successfully complete a 3 year trial installation and evaluation in Oklahoma.

701.10 HIGH DENSITY CONCRETE FOR BRIDGE DECK REPAIR AND OVERLAY

This subsection covers the material requirements for high density concrete (HDC) for bridge deck repairs and overlays. Prepare and submit mix designs in accordance with Subsection 701.01.C, "Proportioning."

A. Aggregate

Provide fine aggregate in accordance with Subsection 701.05, "Fine Aggregate," except for the gradation requirements.

Provide coarse aggregate in accordance with Subsection 701.06, "Coarse Aggregate," except for the gradation requirements. Ensure coarse aggregate does not have an absorption greater than 3 percent by mass.

Provide combined aggregate in accordance with Table 701:17.

Table 701:17 Combined Aggregate Gradation	
Sieve Size	**Percent Passing**
¾ in [19.0 mm]	100
½ in [12.5 mm]	75 – 90
⅜ in [9.5 mm]	62 – 80
No. 4 [4.75 mm]	38 – 54
No. 16 [1.18 mm]	16 – 32
No. 30 [600 µm]	10 – 20

Table 701:17 Combined Aggregate Gradation	
Sieve Size	**Percent Passing**
No. 50 [300 µm]	4 – 12
No. 100 [150 µm]	2 – 8
No. 200 [75 µm]	0 – 4

B. Concrete

Provide concrete in accordance with Table 701:18.

Table 701:18 Concrete Properties					
Concrete Class	**Minimum Cement Content,** ***lb/y³ [kg/m³]***	**Air Content [a], %**	**Maximum Water/Cement Ratio [b],** ***lb/lb [kg/kg]***	**Slump [c],** ***in [mm]***	**Minimum Compressive Strength at Road Opening [d],** ***psi [MPa]***
HDC	825 [490]	6.5 ±1.0	0.35	½ – 1 [12 – 25]	4,000 [27.6]

[a] Test air content in accordance with AASHTO T 152 or AASHTO T 196.
[b] Using the weight of each material, calculate the water to cement ratio (W/C) by the following equation:

W/C = Water/ (Cement + Cement Substitutes)

Determine the water actually used by adding the water measured into the batch, the free water on wet aggregate, admixtures, and subtracting water absorbed by dry aggregate.
[c] Test slump in accordance with AASHTO T 119. Ensure the slump reflects a workability appropriate for the application.
[d] Compressive strength is based on the average of three test cylinders tested in accordance with AASHTO T 22. Refer to the contract for Class P concrete compressive strengths.

Use cement in accordance with Subsection 701.02.A(1), "Portland Cement," Subsection 701.02.A(2), "Blended Hydraulic Cement," or Subsection 701.02.A(3), "Hydraulic Cement." The Department will allow the use of water-reducing admixture in accordance with Subsection 701.03, "Admixtures."

C. Grout

Provide grout for bonding HDC to existing concrete that consists of equal parts of cement and fine aggregate by weight [mass]. Mix the cement and aggregate with enough water to form a stiff slurry. Ensure the slurry has a consistency that allows for application with a stiff brush or broom in a thin, even coat that will not run or puddle. Thin the grout to a paint-consistency to seal vertical joints around repairs, between adjacent lanes, and at curbs.

701.11 LATEX MODIFIED CONCRETE FOR BRIDGE DECK OVERLAYS

This subsection covers the material requirements for latex modified concrete (LMC) for bridge deck repairs and overlays. Prepare and submit mix designs in accordance with Subsection 701.01.C, "Proportioning." Use cement in accordance with Subsection 701.02.A(1), "Portland Cement," Subsection 701.02.A(2), "Blended Hydraulic Cement," or Subsection 701.02.A(3), "Hydraulic Cement."

A. Aggregate

Provide fine aggregate in accordance with Subsection 701.05, "Fine Aggregate," except for the gradation requirements.

Provide coarse aggregate in accordance with Subsection 701.06, "Coarse Aggregate," except for the gradation requirements. Ensure the coarse aggregate does not have an absorption greater than 3 percent by weight [mass].

Provide combined aggregate in accordance with Table 701:19.

Table 701:19
Combined Aggregate Gradation

Sieve Size	Percent Passing
¾ in [19.0 mm]	100
½ in [12.5 mm]	90 – 100
⅜ in [9.5 mm]	60 – 95
No. 4 [4.75 mm]	40 – 65
No. 16 [1.18 mm]	20 – 60
No. 30 [600 µm]	10 – 30
No. 50 [300 µm]	4 – 15
No. 100 [150 µm]	2 – 10
No. 200 [75 µm]	0 – 4.0

B. Latex Emulsion Admixture

Provide latex emulsion admixtures in accordance with Subsection 701.03.D, "Latex Emulsion Admixtures."

C. Latex Modified Concrete

Provide latex modified concrete for overlay that contains 3.5 gal [13.25 L] of Latex Emulsion Admixture per bag of cement and is workable with the properties specified in Table 701:20.

Table 701:20
Latex Modified Concrete Properties

Concrete Class	Minimum Cement Content, *lb/y³ [kg/m³]*	Air Content [a], %	Maximum Water/Cement Ratio [b], *lb/lb [kg/kg]*	Slump [c], *in [mm]*	Minimum Compressive Strength at Road Opening [d], *psi [MPa]*
LMC	611 [363]	3.0 – 6.0	0.40	4 – 6 [100 – 150]	4,000 [27.6]

[a] Test air content in accordance with AASHTO T 152 or AASHTO T 196.

[b] Using the weight of each material, calculate the water to cement ratio (W/C) by the following equation:

W/C = Water/ (Cement + Cement Substitutes)

Determine the water actually used by adding the water measured into the batch, the free water on wet aggregate, water in admixtures and subtracting the water absorbed by dry aggregate.

[c] Test slump in accordance with AASHTO T 119. Ensure the slump reflects a workability appropriate for the application. After sampling discharged material, delay the slump test from 4 min to 4½ min.

[d] Base the compressive strength on the average of three test cylinders tested in accordance with AASHTO T 22. Refer to the Contract for Class P concrete compressive strengths.

701.12 PENETRATING WATER REPELLENT FOR TREATMENT OF CONCRETE SURFACES

This subsection covers the material requirements for penetrating water repellents for concrete surfaces.

A. General

Provide penetrating water repellent treatment solution consisting of an organo silicon compound dissolved in a solvent carrier. Provide a solvent carrier that produces a hydrophobic surface covalently bonded to the concrete when applied. Provide one of the following organo silicon compounds:

- Alkyl-alkoxysilane,
- Oligomerous alkyl-alkoxysiloxane.

Ensure the solvent leaves no greater than 1 percent residue by weight [mass] when evaporated. Provide a penetrating water-repellant treatment solution that does not permanently stain, discolor, or darken the concrete. Ensure the solution does not alter the surface texture, form a coating on concrete surfaces, and is compatible with the special surface finish texture coatings specified in Subsection 509.04.G, "Finishing Formed Concrete Surfaces." Ensure the treated concrete surface dries within 30 min of application.

Tint the penetrating water repellent treatment solution with a fugitive dye to make the solution visible on the treated concrete surface for at least 4 hr. Ensure the dye is not conspicuous longer than 7 days after application when exposed to direct sunlight.

B. Testing

If applying a penetrating water repellant treatment solution to a bridge deck or approach slab, test cores in accordance with Table 701:21.

Table 701:21
Core Sample Specifications for Water Repellant Treatment

Test	Method	Limit
Absorption	OHD L-39, 48 hr water immersion	≤1% by weight
Penetration	OHD L-40	≥0.15 in [3.8 mm] deep

701.13 EPOXY RESIN AND OTHER ADHESIVES FOR GENERAL USE WITH CONCRETE

This subsection covers epoxy-resin and related bonding systems for PCC.

A. General

If the epoxy-resin type, grade, and class are shown on the Plans, provide an epoxy-resin system in accordance with AASHTO M 235. If the epoxy-resin system is not specified, provide the appropriate type, with the approval of the Resident Engineer, for the intended purpose as follows:

Type A. An epoxy-resin for bonding hardened concrete to hardened concrete.

Type B. An epoxy-resin for bonding fresh concrete to hardened concrete.

Type C. An epoxy-resin for bonding traffic markers to hardened concrete and to asphalt concrete.

Type D. A fluid epoxy for crack injection in old structures repair.

Type E. An epoxy for repairing spalled areas on vertical concrete structures without forms.

Type F. An epoxy for repairing spalled areas on concrete structures with forms.

Type G. An epoxy for filling small holes in concrete.

Type H. An epoxy for installing rebar and anchor bolts in hardened concrete except when exposed to suspended or sustained tension loads.

Type J. An epoxy for post-tensioning anchorage protection systems.

Type K. High Molecular Weight Methacrylate (HMWM): A monomer which, when polymerized, can structurally re-bond cracks and act as a film forming sealant against chloride ions on concrete surfaces.

Type L. Epoxy Penetrant: A two part, low viscosity, epoxy resin penetrating sealant that re-bonds cracks and acts as a film forming sealant against chloride ions on concrete surfaces.

Type M. An epoxy for sealing cracks before an epoxy bridge deck overlay.

Type N. An epoxy or epoxy-urethane for multiple layer polymer concrete bridge deck overlays.

B. Specification Requirements for Epoxy-Resin and Related Bonding Systems

(1) Type A

Provide Type A epoxy in accordance with AASHTO M 235 for Type IV, Grade 2.

(2) Type B

Provide Type B epoxy in accordance with AASHTO M 235 for Type V, Grade 2.

(3) Type C

Provide Type C epoxy in accordance with AASHTO M 237 for Type IV.

(4) Type D

Provide Type D epoxy in accordance with AASHTO M 235 for Type IV Grade 1 with a maximum viscosity of 600 cP [0.6 Pa•s] at 77°F [25°C].

(5) Type E

Provide Type E epoxy in accordance with AASHTO M 235 for Type IV Grade 3, except with an elongation in tension of at least 10 percent. Mix no greater than 2.25 parts sand to 1 part epoxy by volume. Match to the color of No. 36622 in Federal Standard No. 595a.

(6) Type F

Provide Type F epoxy in accordance with AASHTO M 235 for Type IV Grade 1 or Grade 2 with an elongation in tension of at least 10 percent. Mix no greater than

2.25 parts sand to 1 part epoxy by volume. Match to the color of No. 36622 in Federal Standard No. 595a.

(7)Type G

Provide Type G epoxy in accordance with AASHTO M 235 for Type II Grade 1, Grade 2, or Grade 3 at hole location as shown on the Plans.

(8)Type H

Provide Type H epoxy in accordance with AASHTO M 235 for Type IV Grade 3.

(9)Type J

Provide Type J epoxy that will produce a low exothermic reaction and have characteristics for machine base plate applications. Extend the material with the aggregate supplied by the manufacturer. Use all the aggregate supplied.

Provide factory pre-portioned epoxy compound with aggregate. Deliver epoxy and aggregate in the original containers, labeled with manufacturer's name, date of manufacture, product identification, and batch numbers. Store, condition, and use the product in accordance with the manufacturer's recommendations.

Provide epoxy grout and aggregate mix for Type J epoxy in accordance with Table 701:22.

Table 701:22
Epoxy Grout and Aggregate Mix Properties

Property	Test Value	Test Method
Compressive strength cubes 7 day cure at 77°F [25°C]	≥10,000 psi [68.9 MPa]	ASTM C 579B
Tensile strength at 7 day	≥2,100 psi [14.5 MPa]	ASTM C 307
Flexural strength 7 day cure at 77°F [25°C]	≥3,600 psi [24.8 MPa]	ASTM C 580
Modulus of Elasticity 7 day cure at 77°F [25°C]	<2,100,000 psi [14.5 GPa]	ASTM C 580
Coefficient of thermal expansion from 74°F to 210°F [23°C to 99°C]	$<20\times10^{-6}$ in/in/°F [11.1×10^{-6} mm/mm/°C]	ASTM C 531
Peak Exotherm, specimen 12 in × 12 in × 3 in [305 mm × 305 mm × 76 mm]	<150°F [66°C]	ASTM D 2471
Slant shear at 7 day (bond strength to concrete)	>3,000 psi [20.7 MPa]	ASTM C 882
Thermal compatibility	5 cycles passed	ASTM C 884
Linear shrinkage at 7 day	≤0.025%	ASTM C 531
Flowability and bearing area	90% Contact area	ASTM C 1339
Gel time, specimen 12 in × 12 in × 3 in [305 mm × 305 mm × 76 mm]	<4 hr	ASTM D 2471

(10)Type K — Monomer Materials for HMWM

Provide a low viscosity, low odor, HMWM monomer system in accordance with Table 701:23. Ensure standard Methyl Methacrylate (MMA) resins are not used due to volatility. Provide a compatible promoter/initiator system that has a deck surface cure time from 40 min to 6 hr at the surface application temperature. Formulate the promoter/initiator system to allow for adjustment of the gel time to compensate for the temperature changes during treatment application. Submit to the Resident Engineer a table showing correct promoter and initiator proportions to be added to the monomer to achieve the cure time requirements based on the surface temperature. Ship materials within 6 months of the date of manufacture.

The Resident Engineer will accept two component materials if the material requirements of Table 701:23 are met.

Table 701:23
HMWM Properties

Property	Requirement	ASTM Test Method
Viscosity (Brookfield) [a]	10 cP – 25 cP	D 1824
Density (Pensky Martens CC), at 77°F	>8.4 lb/gal	D 2849
Flash point	>200°F	D 93
Vapor pressure, at 77°F	<1.0 mm Hg	D 323
Shelf life	≥1 year	—
Gel time, 100 g mass to a thin film	>40 min	D 2471
Tensile elongation	≥30%	D 638
Cure time at deck temperature:		
Bulk	40 min – 150 min	—
Surface	40 min – 360 min	—
Bond strength	>750 psi	D 882
Percent volatiles	≤30%	D 2369

[a] Brookfield viscometer, Model RVT with a UL adaptor or Model LVF, No. 1 spindle and UL adaptor at 77°F.

(11)Type L - Materials for Epoxy-Resin

Supply a two part epoxy-resin in accordance with Table 701:24, "Epoxy-Mixed System Properties." Add a fluorescent tracer dye to provide evidence of crack penetration.

Table 701:24
Epoxy-Mixed System Properties

Property	Requirement	Standard
Mixing ratio	1:1	—
Viscosity (Brookfield)	≤50 cP	ASTM C 881
Bond strength (14 day cure)	≥1,500 psi	ASTM C 882
Water adsorption (24 hr)	≤1.0%	ASTM D 570
Tensile strength (10 mil thickness)	≥2,500 psi	ASTM D 638
Elongation	≥2%	ASTM D 638
Gel time in mass at 72°F	≥30 min	AASHTO M 235
Percent volatile	≤30%	ASTM D 2369

(12)Type M — Hairline Cracks and Encapsulating Steel Grid

Provide Type M epoxy, as a two component, hybrid polymer system, free of fillers and volatile solvents that can provide a simple volumetric ratio. Formulate Type M epoxy so that it has an extremely low viscosity and surface tension, and an affinity for concrete and steel.

Mix component A and component B in the appropriate ratio so the cured resin is in accordance with Table 701:25.

Table 701:25 Physical Properties of the Cured System		
Property	**Value**	**Standard**
Strength:		
Compressive (7 days)	5,500 psi – 7,500 psi	AASHTO T 106
Tensile	3,000 psi – 4,000 psi	ASTM D 638
Tensile elongation	30 – 40%	ASTM D 638
Water absorption	≤0.1%wt.	ASTM D 570
Shore D Hardness, 77°F [25°C]	65 – 75	ASTM D 2240
Gel time	40 min – 60 min	Gel Time Procedure [a]
Adhesion to concrete, percent failure in concrete	100	ASTM C 1583
Surface tension	26 Dynes/cc – 32 Dynes/cc	ASTM D 971
Percent solids	100	ASTM D 2369
[a] Measure a 6 oz sample of the epoxy into an unwaxed paper cup, in recommended proportions at 77°F [25°C]. Record the time and mix immediately for the specified duration. Pour 100 g of the mixture into a new 6 oz unwaxed paper cup and place on a wooden surface. Starting 20 min from the recorded time, probe the mixture every 2 min with a small stick until a small ball forms in the center of the container. Gel Time is the total time from pouring the mix to ball formation. Perform the test in an enclosed area with a temperature of 77°F ±3.6°F [25°C ±2°C] and a relative humidity of 50 ±5 percent.		

(13)Type N — Physical Requirements of Epoxy or Epoxy-Urethane Copolymer Overlay System

Provide a two component epoxy or epoxy-urethane system in accordance with Table 701:26.

Table 701:26 Physical Properties of the Cured System		
Property	**Value**	**Standard**
Compressive strength with aggregate:		
At 5 hr	≥1,000 psi	ASTM C 579 [a]
At 2 days	≥5,000 psi	ASTM C 579 [a]
Tensile strength (7 day)	1,800 psi – 5,000 psi	ASTM D 638
Elongation (neat)(7 day)	25 – 100%	ASTM D 638
Absorption (neat) (1 day)	≤1.0%	ASTM D 570
Shore D Hardness, 77°F [25°C]	≥60	ASTM D 2240
Gel time	15 min – 45 min	ASTM C 881
Adhesion to concrete, percent failure in concrete	100	ASTM C 1583
Viscosity	7 P – 70 P	Brookfield RVT, spindle No. 3 at 20 rpm.
Thermal compatibility	No delamination of overlay	ASTM C 884
[a] Modified with plastic inserts.		

701.14 WHITE CONCRETE

This subsection covers the requirements for providing white PCC for median barriers specified in Section 627, “Concrete Longitudinal Barrier.”

A. Materials

If white PCC is shown on the Plans, use the following requirements to supplement the general provision for PCC.

(1) Cement

Provide white portland cement in accordance with AASHTO M 85 for Type 1 portland cement. Ensure the portland cement contains no more than 0.50 percent of ferric oxide (Fe_2O_3) by mass.

(2) Fine Aggregate

Provide light colored fine aggregate in accordance with Subsection 701.05, "Fine Aggregate."

(3) Coarse Aggregate

Provide light colored coarse aggregate. Use No. 57 or No. 67 coarse aggregate in accordance with Subsection 701.06, "Coarse Aggregate."

(4) Water

Use mixing water in accordance with Subsection 701.04, "Water," that is free of impurities that may cause staining.

B. Proportioning

Proportion white concrete mixes in accordance with ACI 211.1. For barrier construction, ensure the white concrete mix contains 660 lb/yd³ [392 kg/m³] of white Type 1 cement with an air content of 6 percent ±1 percentage point, and a slump of 3 in ±1 in [75 mm ±25 mm]. Ensure a maximum water to cement ratio of 0.53, and a minimum compression strength of 3,000 psi [20.68 MPa] at 28 days.

C. Batching and Mixing

Provide clean mixing and batching equipment to prevent white concrete contamination and discoloration. Use cement bins, truck mixer drums, and weigh hoppers that are free of loose, gray portland cement.

D. Surface Finish

Use form oil that will not stain the surface to construct white concrete median barriers in metal forms. Treat the surface with a penetrating water repellent solution at the rate recommended by the manufacturer in accordance with Section 515, "Penetrating Water Repellent Treatment."

E. Acceptance

Ensure the white concrete barrier or parapet is at least as white as 10Y91 in accordance with the *Munsell Book of Color*. Before white concrete barrier or parapet production, submit to the Resident Engineer a 1 ft² [0.09 m²] test panel of material for the construction. Use the test panel as a standard as approved by the Resident Engineer.

701.15 FIBER REINFORCEMENT FOR PCC

A. General Requirements

This subsection covers fiber reinforcement added to PCC. Provide polypropylene fibers or steel fibers in accordance with the Subsection 701.15.A(1) and Subsection 701.15.A(2).

(1) Polypropylene Fibers

Use synthetic fibers that are 100 percent polypropylene, collated, fibrillated fibers manufactured to graduated lengths of equal proportions for secondary reinforcement. Provide fibers in accordance with ASTM C 1116 for Type III.

(2) Steel Fibers

Use steel fiber in accordance with ASTM A 820, for Type II, cut-sheet steel. Provide steel fibers with an aspect ratio of 30:60 and from 1⅛ in [30 mm] to 2 in [50 mm] long.

B. Application

Add the fibers to the PCC at a rate specified by the manufacturer. Mix the concrete to uniformly distribute the fiber.

701.16 DOWEL BAR RETROFIT MORTAR

Provide a mortar for retrofitting portland cement concrete pavements with dowel bars in accordance with Table 701:27. Combine the mortar mix with an aggregate extender in accordance with Subsection 701.06, "Coarse Aggregate" size No. 8, to form a concrete.

Table 701:27
Grout Properties

Property	Test Value	ASSHTO / ASTM Test Method
Compressive strength @ 3 hours without aggregate extender	≥4,000 psi [27.6 MPa]	T22
Compressive strength @ 7 days without aggregate extender	≥6,000 psi [41.4 MPa]	T22
Compressive strength @ 3 hours with aggregate extender	≥3,000 psi [20.7 MPa]	T22
Compressive strength @ 7 days with aggregate extender	≥5,000 psi [34.5 MPa]	T22
Freeze-thaw Durability Factor with and without aggregate extender @ 300 cycles	≥90.0%	T161, procedure B
Bond Strength by Slant Shear with and without aggregate extender @ 7 days	≥1,400 psi [9.7 MPa], or	C 882
	≥2,200 psi [20.7 MPa]	C 882 [a]
Linear Shrinkage with and without aggregate extender @ 7 days	≤0.180%	C 531

[a] Referenced from ASTM C 928.

701.17 TEMPORARY CONCRETE MIX DESIGN AND PROPORATIONING

This subsection covers the material for use in the construction of temporary concrete. Temporary concrete is any concrete that is to be installed and removed during the project and will not become part of any permanent structure or pavement. Temporary concrete will be known as Class T concrete.

Provide Class T concrete in accordance with Subsection 701.01, "Mix Design and Proportioning," Class AP concrete, except for the following:

- The Department does not require air entrainment or any other concrete admixtures.
- The Department waives the AASHTO T 161, Procedure A, freeze-thaw testing for all aggregates.
- The Department waives the fractured face requirement for all aggregates.
- Ensure aggregate material larger than the No 4 sieve has an AASHTO T 96, Los Angeles Abrasion percent wear of no greater than 60.
- Provide fine and coarse aggregates manufactured from virgin rock or stone, reclaimed rock or stone, or recycled crushed concrete.
- Provide fine and coarse aggregates in accordance with the gradation requirements in Subsection 701.05, "Fine Aggregate," and Subsection 701.06, "Coarse Aggregate," or provide combined aggregates in accordance with Table 703:3, "Combined Aggregate Gradation."

Provide all materials used in Class T concrete from sources on the Materials Divisions "Approved Products List" except for the aggregate sources which are to be approved by the Resident Engineer. Maintain temporary concrete at the no additional cost to the Department.

701.18 POST-TENSIONING GROUT

This subsection covers grouts for protecting post-tensioning steel. The Department differentiates grout applications into horizontal, vertical, and repair. The Department will not allow the use of grouts that contain aluminum powder or components that produce hydrogen, carbon dioxide, or oxygen gas.

A. Certification

Submit to the Resident Engineer a Type A certification for each grout shipment, in accordance with Subsection 106.04, "Materials Certifications," indicating compliance with Subsection 701.18.B, "Test Procedures." Prepackage grouts in moisture proof containers. Label containers with the manufacture date, lot number, shipment date, and mixing instructions.

B. Test Procedures

(1) Laboratory Tests

Provide grout tested from 65°F to 78°F [18°C to 25°C] in accordance with Table 701:27. Conduct the tests using a grout mix with the minimum efflux time. Adjust the water content to produce the minimum and maximum efflux time.

Table 701:28
Grout Properties

Property	Test Value	ASTM Test Method
Total chloride ions by weight of cementitious material	≤0.08%	C 1152
Fine aggregate passing the No. 50 [300 µm] sieve (if used)	99%	C 136 [a]
Hardened height change at 24 hr and 28 days	0.0 – 0.2%	C 1090 [b]
Expansion	≤2.0% for up to 3 hr	C 940
Wet density:		
Lab	Report maximum and minimum test value in lb/ft³ [kg/L]	C 185
Field	Report maximum and minimum test value in lb/ft³ [kg/L]	C 138
Compressive strength 28 day (average of 3 cubes)	≥7,000 psi [48.3 MPa]	C 942
Initial set of grout	3 hr – 12 hr	C 953
Time of efflux [c]:		
Immediately after mixing	20 sec – 30 sec	C 939
	9 sec – 20 sec	C 939 [d]
30 min after mixing with remixing for 30 sec	≤30 sec	C 939
	≤30 sec	C 939 [d]
Bleeding at 3 hr	≤0.0%	C 940 [e]
Permeability at 28 days	≤2,500 coulombs at 30 V for 6 hr	C 1202

[a] Modify ASTM C 117 procedure and use a No. 50 sieve. Determine the percent passing after washing the sieve.
[b] Modify ASTM C 1090 to include verification at 24 hr and 28 days.
[c] Adjust flow rates in accordance with the manufacturer's recommendations. The Department defines the efflux time as the time to fill a 1 L container under the flow cone.
[d] Modify ASTM C 939 procedure by filling the cone to the top instead of to the standard level.
[e] Modify ASTM C 940 in accordance with the wick induced bleed test in Subsection 701.18.B(2), "Laboratory Wick Induced Bleed Test."

(2)Laboratory Wick Induced Bleed Test

Modify the ASTM C 940 test method as specified in Table 701:27, "Grout Properties," in accordance with the wick induced bleed test as follows:

- Use a 20 in [0.5 m] long wick of seven-wire ½ in [12.7 mm] diameter strand in accordance with ASTM A 416. Before cutting, wrap the strand ends at each end with 2 in [50 mm] wide duct or electrical tape to prevent the wires from splaying. Use acetone or hexane solvent to degrease the strand. With a wire brush, remove surface rust before temperature conditioning.
- Condition the dry ingredients, mixing water, prestressing strand, and test apparatus overnight from 65°F to 75°F [18°C to 24°C].
- Mix the conditioned dry ingredients with the conditioned mixing water and place 800 mL of the grout into the 1,000 mL graduate cylinder. Measure and record the grout level.
- Insert the strand into the graduated cylinder. Center and fasten the strand so it is parallel to the cylinder vertical axis. Measure and record the grout level.
- Store the mixed grout at temperatures from 65°F to 75°F [18°C to 24°C].

- Measure the level of the bleed water every 15 min for 1 hr and hourly for the next two readings.
- Calculate the bleed water at the end of the 3 hr test period and the expansion per the ASTM C 940 procedures. Express the bleed water quantity as a percent of the initial grout volume. Record if the bleed water remains above or below the top of the original grout height. Specify if bleed water is absorbed into the specimen during the test.

(3)Simulated Field High Temperature Fluidity Test

Perform a conditioned laboratory high temperature grout fluidity test using the mixing and storage tanks of production grouting equipment. Ensure the grouts are in accordance with Table 701:27, "Grout Properties." For the test to be successful, ensure the grout has an efflux time no greater than 30 s at the end of the 1 hr test period. Determine the efflux time using ASTM C 939 or the following modifications:

- Before the test, condition the room, grout, water, duct, pump, mixer, and other equipment to 90°F [32.5°C] for at least 12 hr.
- Use from 390 ft [119 m] to 410 ft [125 m] of duct for the test. Use duct with an inside diameter of 1 in [25 mm].
- Mix the grout to the water content in accordance with Subsection 701.18, "Post-Tensioning Grout." Pump the grout through the duct until it discharges from the duct outlet end and is returned to the pump.
- Start the 1 hr test period after the duct is completely full of grout. Record the time to circulate the grout through the duct. Constantly re-circulate the grout into the commercial grout mixer storage tank.
- Pump and re-circulate the grout for at least 1 hr.
- Record the pumping pressure at the inlet, grout temperature, and fluidity at the discharge outlet every 15 min during the test period.

(4)Accelerated Corrosion Test Method

Perform the Accelerated Corrosion Test Method (ACTM) as specified in Appendix B of the Post-Tensioning Institute *Specification for Grouting of Post-Tensioning Structures*. Report the time to corrosion for the test grout and control sample using a neat grout with a 0.45 water to cement ratio. The Department defines satisfactory grout as grout with an average time to corrosion longer than the control sample and a time to corrosion exceeding 1,000 hr.

(5)Variation in Testing for Specific Applications

(a)*Horizontal*

Horizontal applications include grouting superstructure and transverse substructure tendons in caps and struts. Provide grouts for horizontal applications in accordance with Subsection 701.18.B, "Test Procedures."

(b)*Vertical*

Vertical applications include grouting substructure column tendons. Provide grouts for vertical applications in accordance with Subsection 701.18.B, "Test Procedures." Perform the "Schupack Pressure Bleed Test Procedure for Cement Grouts for Post-Tensioned Structures" in accordance with Appendix C of the Post-Tensioning Institute *Specification for Grouting of Post-Tensioned*

Structures. Test grout at 100 psi [689 kPa] and report the percent bleed. The Resident Engineer will only accept grout without bleed water (0.0%).

(c) ***Repair***

Use repair applications to augment grouting operations that do not fill the duct or anchorage. For new construction, the Department will allow repairs with the same grout for the tendon if the void is no greater than 0.5 gal [2 L]. In other cases, use a non-sanded grout in accordance with Subsection 701.18.B(1), "Laboratory Tests," and Subsection 701.18.B(4), "Accelerated Corrosion Test Method," with a modified maximum permeability of 2,800 coulombs tested in accordance with ASTM C 1202 at 30 V. Provide non-sanded grouts with 95 percent passing No. 100 sieve and 90 percent passing No. 170 sieve in accordance with ASTM C 33. Wash and dry each sieve before weighing in accordance with ASTM C 117 as modified for sieve size.

701.19 CONTROLLED LOW-STRENGTH MATERIAL

A. General

Controlled Low-Strength Material (CLSM). A low strength grout backfill material consisting of portland cement, fly ash, fine aggregate, and water.

The Department will allow the use of an air entraining agent.

B. Mix Design

Design the mix using absolute volumes. Use at least 20 lb/yd³ [12 kg/m³] of portland cement in the mix design. Submit the proposed mix design with trial batch testing data before use. Include the weight [mass], specific gravity, material source, and material requirements for each ingredient. Include the flowability results, unit weight [mass], and trial batch strength tests. The Department will allow the submittal of previously used and successful mix designs without retesting if material sources have not changed. Provide materials in accordance with the following sections and subsections for CLSM:

Material:	Section or Subsection:
Portland Cement	701.02
Fly Ash	702
Fine Aggregate	701.05
Water	701.04
Air Entraining Agents	701.03

C. Sampling and Testing

Test CLSM in accordance with the following methods:

- Conduct the flow test in accordance with ASTM D 6103. Provide a CLSM spread diameter of 8 in [200 mm] or greater.
- Conduct the unit weight [mass] tests in accordance with ASTM D 6023. The Resident Engineer will reject batches with a unit weight [mass] that deviates 5 percent or more from the mix design value.
- Conduct the compressive strength tests in accordance with ASTM D 4832. Provide a CLSM compressive strength at 28 days from 100 psi to 800 psi [700 kPa to 5,500 kPa]. Earlier strength tests may be performed to confirm that the material reaches the minimum strength, but are not required by the Contract.

701.20 EARLY STRENGTH CONCRETE FOR BRIDGE DECK PATCHING AND OVERLAYS

This subsection covers Very Early Strength Type I (VES I), Very Early Strength Type III (VES III), and Rapid Setting Latex-Modified Concrete (RSLMC) for bridge deck patching and overlays. Prepare and submit mix designs in accordance with Subsection 701.01.C, "Proportioning."

A. Materials

Provide materials in accordance with the following subsections for early strength concretes:

Material:	Subsection:
Portland Cement	701.02
Fine Aggregate	701.05
Coarse Aggregate	701.06
Water	701.04
Concrete Admixtures	701.03
Concrete Fibers	701.15

B. Classes of Early Strength Concrete

Table 701:29
Early Strength Concrete Properties

Concrete Class	Minimum Cement Content, *lb/yd³ [kg/m³]*	Air Content [a], *%*	Maximum Water/Cement Ratio [b], *lb/lb [kg/kg]*	Slump [c], *in [mm]*	Minimum Compressive Strength at Road Opening [d], *psi [MPa]*
VES I	900 [535]	6 ±1.5	0.30	1 – 8 [25 – 203]	3,000 [20.7]
VES III	600 [423]	6 ±1.5	0.35	1 – 8 [25 – 203]	3,000 [20.7]
RSLMC	658 [391]	1.5 ±1.5	0.47	6 ±2 [150 ±50]	3,000 [20.7]

[a] Test air content in accordance with AASHTO T 152 or AASHTO T 196.

[b] Using the weight of each material, calculate the water to cement ratio (W/C) by the following equation:

W/C = Water/(Cement + Cement Substitutes)

The water used is determined by the water measured into the batch plus the free water on wet aggregate minus the water absorbed by dry aggregate plus water in admixture solutions not to exceed the limit required by the Contract.

[c] Test slump in accordance with AASHTO T 119. Ensure the slump reflects a workability appropriate for the application.

[d] Compressive strength is based on the average of three test cylinders tested in accordance with AASHTO T 22. Refer to the Contract for the Class P concrete compressive strengths.

(1) Very Early Strength Type I (VES I)

Ensure the VES I mix reaches 3,000 psi [20.7 MPa] at 6 hr. Use a Type I cement for this concrete. Provide No. 67 size coarse aggregate. Use a high range water-reducing admixture to obtain slump. Add no more than 7.5 gal/yd³ [37 L/m³] calcium nitrite as a liquid admixture. Use an air entraining admixture to obtain the air content in accordance with Table 701:29, "Early Strength Concrete Properties."

The Department will not allow fly ash substitution. To improve mix durability, add concrete fibers as directed by the Resident Engineer.

(2) Very Early Strength Type III (VES III)

Ensure the VES III mix reaches 3,000 psi [20.7 MPa] at 6 hr. Use a Type III cement for this concrete. Provide No. 67 size coarse aggregate. Use a high range water-reducing admixture to obtain slump. Add at least 6.0 gal/yd³ [30 L/m³] calcium nitrite as a liquid admixture. Use an air entraining admixture to obtain the air content in accordance with Table 701:29, "Early Strength Concrete Properties." The Department will not allow fly ash substitution. To improve mix durability, add concrete fibers as directed by the Resident Engineer.

(3) Rapid Setting Latex Modified Concrete (RSLMC)

Ensure the RSLMC mix reaches 3,000 psi [20.7 MPa] at 4 hr. Provide a rapid setting cement for RSLMC in accordance with Subsection 701.02.A.4, "Rapid Setting Cement." Provide No. 67 size coarse aggregate. Use a latex emulsion admixture at 24.5 gal/yd³ [121 L/m³]. The Department will not allow an air entraining admixture or fly ash substitution. Add Food-Grade citric acid to delay the set time at a rate no greater than 2 lb/yd³ [1.2 kg/m³]. Dissolve the citric acid in water before adding to the mix in accordance with the manufacturer recommendations. To improve mix durability, add concrete fibers as directed by the Resident Engineer.

701.21 MAGNESIUM AMMONIUM PHOSPHATE CONCRETE FOR CONCRETE REPAIR

This subsection covers magnesium ammonium phosphate concrete (MAPC) for repairing block-outs, holes, and defects in post-tensioned boxes and girders. Follow the manufacturer's recommendations for preparing surfaces, mixing, placing, and curing concrete.

Provide MAPC in accordance with Table 701:30.

Table 701:30
Physical Properties

Requirement	Test Value	Test Method
Strength at 28 day (air curing instead of moist curing):		
Compressive	≥8,500 psi [58.6 MPa]	ASTM C 109
Flexural	≥600 psi [4.1 MPa]	ASTM C 348
Slant shear bond at 14 day (air curing instead of moist curing)	≥2,500 psi [17.2 MPa]	ASTM C 882
Time of setting, initial set (at least 95°F [35°C])	≥15 min	ASTM C 266
Scaling resistance	No scaling	ASTM C 672
Maximum length change:		
Wet cure at 28 days	0.03%	ASTM C 157
Dry cure at 28 days	0.03%	ASTM C 596
Sulfate resistance after 52 weeks of immersion	0.1%	ASTM C 1012
Maximum chloride absorption at 21 days (use cubes meeting ASTM C 109)	1.5%	NCHRP T-244

SECTION 702
SUPPLEMENTARY CEMENTITIOUS MATERIALS

702.01 FLY ASH

A. General

Fly ash. A very fine, fluid material with pozzolanic properties and possibly some cementitious properties that is a by-product gathered by dust collection systems during the coal burning process at coal fired power plants.

The Department will allow the substitution of a portion of the cement in portland cement concrete (PCC) with fly ash in accordance with Subsection 701.01, "Mix Design and Proportioning." The Department will also allow the use of fly ash to stabilize or modify soils in accordance with OHD L-50 and OHD L-51. Provide fly ash for PCC from one source (power plant) and soil stabilization or modification fly ash from one source.

Protect fly ash from contamination and dampness. The Resident Engineer will not accept lumpy, contaminated, or partially set fly ash.

B. Requirements for Portland Cement Concrete Use

Provide fly ash for PCC in accordance with AASHTO M 295, Class C or Class F.

C. Requirements for Soil Use

Provide fly ash for soil stabilization or modification in accordance with AASHTO M 295, Class C.

702.02 GROUND GRANULATED BLAST FURNACE SLAG

A. General

Ground granulated blast furnace slag (GGBFS). A glassy granular, non-metallic by-product of iron production that is ground to various degrees of fineness and consists of silicates and aluminosilicates of calcium and other bases.

The Department will allow the substitution of a portion of the cement in PCC with GGBFS in accordance with Subsection 701.01, "Mix Design and Proportioning." Provide GGBFS from one source (plant).

Protect GGBFS from contamination and dampness. The Resident Engineer will not accept lumpy, contaminated, or partially set GGBFS.

B. Requirements

Provide GGBFS in accordance with AASHTO M 302, Grade 100 or Grade 120.

702.03 CEMENT KILN DUST

A. General

Cement kiln dust (CKD). A very fine by-product of portland cement manufacturing, with particle sizes between 6 microns and 100 microns, that is gathered by kiln dust collection systems during the cement clinker manufacturing process and consists of a particulate mixture of partially calcined

gathered by kiln dust collection systems during the cement clinker manufacturing process and consists of a particulate mixture of partially calcined and untreated raw feed, clinker dust, and fuel ash, enriched with alkali sulfates, halides, and other volatiles.

The Department will allow the use of CKD to stabilize or modify soils in accordance with OHD L-50 or OHD L-51. Provide CKD from one source (plant).

Protect CKD from contamination and dampness. The Resident Engineer will not accept lumpy, contaminated, or partially set CKD.

B. Requirements

Test CKD in accordance with AASHTO T 105 to determine the total calcium oxide (CaO), the alkali equivalent $\{(0.658\times K_2O)+(Na_2O)\}$, the total sulfates ($SO_3$), and the loss on ignition. Refer to Table 702:1 for the chemical content limits based on average values of samples from the plant the month before shipment.

Table 702:1
Chemical Content of CKD

Property	Limits, %
Total calcium oxide	≥35
Alkali equivalent	≤8
Total sulfates	≤10
Loss on ignition	≤30

702.04 SILICA FUME

A. General

Silica fume. A very fine pozzolanic by-product of the production of elemental silicon and ferrosilicon alloys, composed mostly of amorphous silica produced by electric arc furnaces; also know as condensed silica fume and microsilica.

The Department will allow the substitution of a portion of the cement in PCC with silica fume in accordance with Subsection 701.01, “Mix Design and Proportioning.” Provide silica from one source (plant).

Protect silica fume from contamination and dampness. If storing in a liquid state, continually mix during storage. The Resident Engineer will not accept lumpy, contaminated, or partially set silica fume.

B. Requirements

Provide silica fume in accordance with of ASTM C 1240.

SECTION 703
BASES AND MISCELLANEOUS AGGREGATES

703.01 AGGREGATE FOR AGGREGATE BASE

A. General Requirements

Provide aggregate base course material consisting of a mixture of coarse and fine graded aggregate that is free of vegetation and other deleterious materials.

Coarse aggregate is the material retained on a No. 10 [2.00 mm] sieve. Provide coarse aggregate consisting of the following durable particles or fragments:

- Gravel,
- Stone,
- Disintegrated granite,
- Crushed concrete, or

Provide fine aggregate made of sand, stone dust, or other inert, finely-divided mineral.

Ensure at least 40 percent of the completed Type A or Type B mixture retained on the No. 4 [4.75 mm] sieve contains uniformly graded, mechanically crushed particles with at least one fractured face.

Ensure 100 percent of the completed Type C or Type D mixture retained on the No. 4 [4.75 mm] sieve contains uniformly graded, mechanically crushed particles with at least two fractured faces. Ensure the completed Type C mixture contains no more than 15 percent natural sand.

B. Physical Properties

Ensure the coarse aggregate retained on the ⅜ in [9.5 mm] sieve of the completed mixture has no more than 50 percent wear in accordance with the Los Angeles Abrasion Test in accordance with AASHTO T 96. Ensure the aggregate has an Aggregate Durability Index of at least 40 in accordance with AASHTO T 210.

C. Gradation and Other Requirements

Sample the uniform mixture from the project site before compacting. Ensure samples are in accordance with Table 703:1 for Gradation, Plasticity Index, and Liquid Limit for the provided aggregate base type.

Table 703:1

Aggregate Base Gradation				
Sieve Size	Percent Passing per Type			
	Type A	Type B	Type C	Type D
3 in [75 mm]	—	100	—	—
2 in [50 mm]	—	—	100	—
1½ in [37.5 mm]	100	40 – 100	90 – 100	100
1 in [25.4 mm]	—	—	80 – 100	95 – 100
¾ in [19.0 mm]	40 – 100	30 – 75	—	—
½ in [12.5 mm]	—	—	60 – 80	25 – 60
⅜ in [9.5 mm]	30 – 75	25 – 60	—	—
No. 4 [4.75 mm]	25 – 60	20 – 50	40 – 60	0 – 10

Table 703:1
Aggregate Base Gradation

Sieve Size	Percent Passing per Type			
	Type A	Type B	Type C	Type D
No. 8 [2.36 mm]	—	—	—	0 – 5
No. 10 [2.0 mm]	20 – 43	15 – 35	25 – 45	—
No. 40 [425 µm]	8 – 26	7 – 22	15 – 30	—
No. 200 [75 µm] [a]	4.0 – 12.0	3.0 – 10.0	0 – 5.0	0 – 2.0
Other Requirements:				
Plasticity Index [b]	≤6	≤6	≤6	—
Liquid Limit [b]	≤25	≤25	≤25	—

[a] Ensure the material passing the No. 200 [75 µm] sieve comprises no greater than two-thirds of the quantity of material passing the No. 40 [425 µm] sieve.
[b] The Department will allow blending of separate aggregates to produce an aggregate mixture if no individual aggregate has a plasticity index higher than 8.

D. Sampling and Testing

Test aggregate in accordance with Table 703:2.

Table 703:2
Aggregate Testing Methods

Test Item	Test Method
Los Angeles Abrasion, wear	AASHTO T 96
Sieve analysis	AASHTO T 27
Sampling	AASHTO T 2
Determining plastic limit & plasticity Index	AASHTO T 90
Fractured faces	OHD L-18
Method of preparation of samples	AASHTO T 87
Determining liquid limit	AASHTO T 89
Maximum density	AASHTO T 180, Method D
Aggregate durability index	AASHTO T 210
Material passing No.200 [75µm] sieve	AASHTO T 11
Soft particles	OHD L-38

703.02 AGGREGATES FOR ECONOCRETE BASE AND CEMENT TREATED BASE

A. General

Provide aggregates for Econocrete Base and Cement Treated Base that meet the following requirements:

- Consists of a mixture of coarse and fine graded aggregate,
- Free of vegetation and other deleterious materials, and
- Meets the gradation requirements of Subsection 703.02.C(1), “Option One,” or Subsection 703.02.C(2), “Option Two.”

Coarse aggregate is the material retained on a No. 10 [2.00 mm] sieve. Provide coarse aggregate consisting of the following durable particles or fragments:

- Crushed gravel,
- Crushed stone,
- Crushed concrete, or
- A combination of these.

Provide fine aggregate made of natural sand, manufactured sand, or stone dust.

B. Physical Properties

Ensure at least 40 percent of the combined mixture retained on the No. 4 [4.75 mm] sieve contains mechanically crushed particles with at least one fractured face, tested in accordance with OHD L-18.

Ensure the coarse aggregate retained on the ⅜ in [9.5 mm] sieve of the completed mixture has no more than 50 percent wear, tested in accordance with the Los Angeles Abrasion Test, AASHTO T 96.

Ensure the aggregate has an Aggregate Durability Index of at least 40, tested in accordance with AASHTO T 210.

Provide combined aggregate with at least a 45 sand equivalent, tested in accordance with AASHTO T 176.

C. Gradations

Sample and test the aggregate gradation in accordance with AASHTO T 2, T 11, and T 27.

Provide aggregates that meet the gradation requirements of Subsection 703.02.C(1), "Option One," or Subsection 703.02.C(2), "Option Two."

Notify the Engineer of the gradation option being used.

(1) Option One

Provide aggregate composed of 40 to 60 percent fine aggregate meeting the gradation requirements of Subsection 701.05, "Fine Aggregate."

Provide coarse aggregate meeting the gradation requirements of No. 57 coarse aggregate in Subsection 701.06, "Coarse Aggregate."

(2) Option Two

Provide aggregate with a combined aggregate gradation in accordance with Table 703:3.

Table 703:3
Combined Aggregate Gradation

Sieve Size	Percent Passing
1½ in [37.5 mm]	100
1 in [25.0 mm]	70 – 100
½ in [12.5 mm]	55 – 85
No. 4 [4.75 mm]	30 – 60
No. 40 [425 µm]	10 – 30
No. 200 [75 µm]	1 – 15

703.03 AGGREGATE FOR OPEN GRADED PORTLAND CEMENT CONCRETE BASE

Provide aggregate for open graded portland cement base in accordance with AASHTO M 80, Class A, consisting of crushed gravel or stone, or a combination of crushed gravel or stone, except as modified by the following:

- Limit the Los Angeles Abrasion percent wear to a maximum of 40 percent after 500 revolutions, tested in accordance with AASHTO T 96.

- Ensure at least 70 percent of the coarse aggregate retained on the No. 4 [4.75 mm] sieve is crushed stone or mechanically crushed gravel with at least two fractured faces, tested in accordance with OHD L-18.
- Ensure the aggregate has an Aggregate Durability Index of at least 40 in accordance with AASHTO T 210.
- Limit the quantity of flat or elongated pieces to 15 percent or less, at a ratio of 1:5, tested in accordance with ASTM D 4791.
- The Engineer will not apply the sodium sulfate soundness requirements.
- Provide an aggregate gradation meeting Table 703:4, sampled and tested in accordance with AASHTO T 2, T 11, and T 27.

Table 703:4
Aggregate Gradation

Sieve Size	Percent Passing
1½ in [37.5 mm]	100
1 in [25.0 mm]	95 – 100
½ in [12.5 mm]	25 – 60
No. 4 [4.75 mm]	0 – 10
No. 8 [2.36 mm]	0 – 5
No. 200 [75 µm]	0 – 2

703.04 COVER AGGREGATES FOR BITUMINOUS SURFACE TREATMENTS

A. General Requirements

Provide cover aggregate consisting of clean, sound, durable particles of mineral aggregates or manufactured lightweight cover aggregates (LWCA). Use the same source of cover aggregate throughout the project, unless otherwise approved, in writing, by the Resident Engineer.

(1) Mineral Aggregates

Provide uniform mineral aggregate consisting of crushed gravel or crushed stone that is substantially free of organic material.

Place substantially dry mineral aggregate on the bituminous binder, unless using cationic emulsified asphalt.

(2) Lightweight Cover Aggregates

Provide uniform LWCA consisting of ceramic lightweight aggregate manufactured from kiln-produced expanded clay and shale that is substantially free of organic material. Ensure that absorbed moisture does not affect the quality of the aggregate.

B. Physical Properties

Provide cover aggregate with physical properties in accordance with Table 703:6.

Table 703:6
Physical Properties of Cover Aggregates

Property	Test Method	Limits
Sampling	AASHTO T 2	—
Lost Angeles Abrasion, wear	AASHTO T 96	≤40%
Durability, Dc Factor	AASHTO T 210	≥40
Flat and elongated pieces [a]	ASTM D 4791	≤10%

Table 703:6 Physical Properties of Cover Aggregates		
Property	**Test Method**	**Limits**
Clay lumps and friable particles	ASTM C 142	≤3%
Fractured faces, two faces [b]	OHD L-18	≥60%
LWCA dry loose bulk density (pcf) [c]	AASHTO T 19	35 – 60
Dust coating	OHD L-48	0 – 1.0%

[a] A flat and elongated piece has a length greater than five times the average thickness.
[b] Expanded clay and expanded shale aggregates contain angular particles with a rough micro surface texture and perform similarly to a mechanically crushed particle. Such angular particles may be considered as crushed.
[c] AASHTO T 19 shoveling procedure.

C. Gradation

Provide cover aggregates with gradations in accordance with Table 703:7.

Table 703:7 Cover Aggregate Gradations				
Sieve Size	**Percent Passing per Cover Aggregate Size Number**			
	No.1	**No.2**	**No.3**	**No.3C**
¾ in [19.0 mm]	100	—	—	—
⅝ in [16.0 mm]	—	—	100	100
½ in [12.5 mm]	25 – 60	100	90 – 100	70 – 100
⅜ in [9.5 mm]	0 – 15	90 – 100	40 – 75	20 – 55
No. 4 [4.75 mm]	0 – 5	0 – 25	0 – 15	0 – 15
No. 8 [2.36 mm]	—	0 – 5	0 – 5	0 – 5
No. 200 [75µm]	0.0 – 2.0	0.0 – 2.0	0.0 – 2.0	0.0 – 2.0
Other Gradation Requirement:				
Dust coating (OHD L-48)	0.0 – 1.0	0.0 – 1.0	0.0 – 1.0	0.0 – 1.0

D. Precoated Cover Aggregates

If the Contract requires precoated cover aggregates, provide cover aggregate material in accordance with Subsection 703.04.A, “General Requirements,” Subsection 703.04.B, "Physical Properties," and Subsection 703.04.C, "Gradation," covered with bituminous material in accordance with Subsection 708.03, “Asphalt Materials.” Apply bituminous material within 0.30 to 1.75 percent by weight [mass] of the untreated aggregate, depending on the type and grade of bituminous material. Apply enough bituminous material for surface absorption, dust dissipation, and film coating (durable and free of scales and blisters) of the aggregate. Provide bituminous material that, when applied to the road, has no excess binder or moisture that may hinder handling, spreading, or rolling operations. Before starting production, submit to the Resident Engineer the type, grade, and amount of asphalt treatment proposed.

Ensure the producer consistently checks the aggregate to prevent surface or absorbed moisture that may interfere with binder absorption and adhesion, or cause blisters or subsequent scaling of the treatment. If it will facilitate uniform coating of the aggregate with the bituminous material, the Department will allow the producer to add water at the pugmill, no more than 2 percent by weight [mass] of the aggregate. When heating is used, ensure the producer keeps the temperature of the bituminous

material below the flash point and temperatures that may affect the quality of the material. Ensure the asphalt material temperature remains within the mixing range for the type and grade in accordance with Table 708:4, "Temperature Ranges for Use of Asphalt Materials," while applying asphalt material to the aggregate.

Ensure the treated aggregate flows so that it can be spread with mechanical spreading devices approved by the Resident Engineer.

Determine the percent of asphalt for pre-coating the aggregate based on the type and grade of bituminous material and aggregate used.

703.05 AGGREGATES FOR TRAFFIC-BOUND SURFACE COURSE

Ensure the traffic-bound surface course material provides a bonded traffic surface consisting of a mixture of coarse and fine graded aggregate that is free of vegetation and other deleterious material. The Department defines coarse aggregate as material retained on a No. 10 [2.00 mm] sieve. Provide coarse aggregate consisting of durable particles or fragments of crushed gravel, stone, disintegrated granite, recycled crushed concrete, or a combination of these. Provide fine aggregate consisting of sand, stone dust, or other inert, finely divided mineral material.

A. Physical Properties

Ensure coarse aggregate retained on the ⅜ in [9.5 mm] sieve of the finished mixture for Type A, Type B, Type C, Type D, or Type E has a percent wear no greater than 50 when tested in accordance with the Los Angeles Abrasion Test.

B. Gradation and Other Requirements

Select and use one of the six gradations or types of surface course. If the Contract does not require the surface course type, select the gradation or type before construction. Ensure the gradation, plasticity index, and liquid limit of the produced or processed material is in accordance with Table 703:8 for the type used. Use the same type of material throughout the project, unless otherwise approved, in writing, by the Resident Engineer.

Crush oversized particles or conglomerate materials delivered to the job site and incorporate them into the surfacing material.

Table 703:8
Aggregate Gradation

Sieve Size	Percent Passing per Type of Aggregate					
	Type A	Type B [a]	Type C	Type D	Type E [b]	Type F [c]
1½ in [37.5 mm]	—	—	—	100	100	100
1 in [25.4 mm]	100	100	100	90 – 100	—	—
¾ in [19.0 mm]	95 – 100	95 – 100	—	—	40 – 100	—
½ in [12.5 mm]	—	—	—	25 – 60	—	—
⅜ in [9.5 mm]	—	—	—	—	30 – 75	—
No. 4 [4.75 mm]	5 – 75	0 – 85	40 – 75	0 – 5	25 – 60	35 – 80
No. 10 [2.5 mm]	—	—	—	—	20 – 43	—
No. 20 [850 µm]	0 – 30	—	—	—	—	—
No. 40 [425 µm]	—	—	20 – 40	—	8 – 26	—
No. 200 [75 µm]	0 – 10	0 – 20	8 – 25	—	4 – 12	0 – 20
Other Requirements:						
Plasticity Index	—	—	8 – 18	—	≤6	—

Table 703:8
Aggregate Gradation

Sieve Size	Percent Passing per Type of Aggregate					
	Type A	Type B [a]	Type C	Type D	Type E [b]	Type F [c]
Liquid Limit	—	—	≤35	—	≤25	—

[a] Type B material consists of disintegrated granite with natural binder.
[b] Type E material meets the requirements for Aggregate Base Type A in accordance with Subsection 703.01, "Aggregate for Aggregate Base."
[c] Type F material only temporarily, in light traffic situations. The Los Angeles Abrasion Test requirement does not apply to this material.

703.06 COVER MATERIAL FOR PIPE UNDERDRAINS

Provide cover material for pipe underdrains consisting of coarse cover aggregate and filter sand. Ensure the coarse cover aggregate consists of gravel or crushed stone, and the filter sand is free of deleterious materials.

A. Physical Properties

Provide coarse cover aggregate with a Los Angeles Abrasion test percent wear of no greater than 50 and an Aggregate Durability Index of at least 40.

B. Gradation

(1) Coarse Cover Aggregate

Provide course cover aggregate in accordance with Table 703:9.

Table 703:9
Coarse Cover Aggregate Gradation

Sieve Size	Percent Passing
½ in [12.5 mm]	100
⅜ in [9.5 mm]	90 – 100
No. 4 [4.75 mm]	20 – 55
No. 8 [2.36 mm]	0 – 25
No. 16 [1.18 mm]	0 – 10
No. 50 [300 µm]	0 – 5

(2) Filter Sand

Provide filter sand in accordance with Table 703:10.

Table 703:10
Filter Sand Gradation

Sieve Size	Percent Passing
⅜ in [9.5 mm]	100
No. 4 [4.75 mm]	95 – 100
No. 16 [1.18 mm]	50 – 85
No. 50 [300 µm]	15 – 33
No. 100 [150 µm]	0 – 10

C. Sampling and Testing

Sample and test in accordance with Subsection 703.01.D, "Sampling and Testing."

703.07 GRANULAR BACKFILL

A. Physical Properties

Provide granular backfill material for structure excavation that is free of deleterious materials, shale, or soft, low durability particles.

B. Gradation and Other Requirements

Provide granular backfill material with a non-plastic plasticity index and with a gradation in accordance with Table 703:11. Ensure the granular backfill has an Aggregate Durability Index of at least 30.

Table 703:11
Granular Backfill Gradation

Sieve Size	Percent Passing
3 in [75 mm]	100
1 in [25.0 mm]	90 – 100
No. 40 [425 µm]	0 – 45
No. 200 [75 µm]	0 – 10

C. Sampling and Testing

Sample and test in accordance with Subsection 703.01.D, "Sampling and Testing."

703.08 STANDARD BEDDING MATERIAL

Provide standard bedding material as required by the Contract for the following classes of bedding material:

A. Class A Bedding Material

Provide Class A bedding material consisting of a continuous encasement of Controlled Low Strength Material (CLSM) in accordance with Subsection 701.19, "Controlled Low-Strength Material," or Class A Concrete in accordance with Subsection 701.01, "Mix Design and Proportioning."

B. Class B Bedding Material

Provide Class B bedding material consisting of crushed rock or stone in accordance with Subsection 703.06.B(1), "Coarse Cover Aggregate," or Subsection 701.06, "Coarse Aggregate," size No. 8.

C. Class C Bedding Material

Provide Class C bedding material consisting of sand, stone, rock, screenings, or select sandy soil. Ensure the bedding material is free of organic material, frozen lumps, or moisture that may prevent the Contract required compaction. Ensure the Class C bedding material gradation is in accordance with Table 703:12.

Table 703:12
Class C Bedding Material Gradation

Sieve Size	Percent Passing
⅜ in [9.5 mm]	100
No. 200 [75 µm]	0 – 10

D. Class D Bedding Material

Provide Class D bedding material consisting of native material with particles no larger than 3 in [62.5 mm] in greatest dimension, no frozen lumps, or excess moisture that may prevent the Contract required compaction.

703.09 CALICHE BASE

A. General

Provide Caliche Base coarse material consisting of a mixture of coarse and fine graded aggregates intimately mixed with a calcareous binder that is free of vegetation and other deleterious materials.

Provide caliche base material with the material retained on a No. 4 [4.75 mm] sieve consisting of the following durable particles:

- Crushed gravel,
- Crushed stone,
- Caliche type material, or
- A combination of these.

The base material passing a No 4 [4.75 mm] sieve may contain fine aggregate made of natural sand, manufactured sand, stone dust, or other finely divided fragments, provided at least 50 percent of this material is a caliche type material.

B. Physical Properties

Ensure at least 25 percent of the combined mixture retained on the No 4 [4.75 mm] sieve contains mechanically crushed particles with at least one fractured face, tested in accordance with OHD L-18.

Ensure the caliche base material has a Liquid Limit no greater than 35 percent, tested in accordance with AASHTO T 89.

Ensure the caliche base material has a Plasticity Index no greater than 10 percent, tested in accordance with AASHTO T 90.

C. Gradation

Sample the caliche base material from uniformly blended windrows, and test in accordance with AASHTO T 2 and OHD L-20.

Provide a combined base material that meets the gradation requirements of Table 703:13.

Table 703:13
Caliche Base Gradation

Sieve Size	Percent Passing
2 in [50.0 mm]	100
No. 4 [4.75 mm]	0 – 60
No. 40 [425 µm]	0 – 40

SECTION 705
SELECT BORROW

705.01 MATERIALS

Provide select borrow in accordance with Table 705:1.

Table 705:1
Select Borrow Requirements

Group Classification [a]	Group Index (Maximum Value)
A-1	(0)
A-2-4	(0)
A-3	(0)

[a] Classify select borrow material in accordance with AASHTO M 145.

Provide select borrow that passes a 3 in [75 mm] sieve and remove material from the right-of-way that does not reduce to a size 3 in [75 mm] or less. Ensure select borrow produced from rocks has a Slake Durability Index of at least 80.

If the Contractor encounters a lens, layer, or stratum of unacceptable material in a borrow pit or roadway cut, the Department will allow the Contractor to combine the unacceptable material with acceptable material as long as the resulting uniform mixture meets the Contract requirements.

Provide select borrow that is uniform in gradation and plastic properties.

Unless otherwise required by the Contract, provide all materials for select borrow. Make preliminary investigations to locate and verify the proposed material source.

Test select borrow in accordance with Table 705:2.

Table 705:2
Select Borrow Testing Methods

Test Item	Method
Sieve analysis	AASHTO T 88 [a]
Preparing samples	AASHTO T 87
Liquid limit	AASHTO T 89
Plastic limit and plasticity index	AASHTO T 90
Slake durability	ASTM D 4644

[a] Omit the Hydrometer Test

SECTION 706
LIME

706.01 HYDRATED LIME

Provide hydrated lime in accordance with AASHTO M 216, except, ensure the Available Lime Index, expressed as $Ca(OH)_2$, is at least 90.0 percent in accordance with ASTM C 25.

The Department will not allow by-product lime.

706.02 QUICK LIME

Provide quick lime in accordance with AASHTO M 216, except, ensure the Available Lime Index, expressed as CaO, is at least 90.0 percent in accordance with ASTM C 25.

The Department will not allow by-product lime.

706.03 AGRICULTURAL LIMESTONE

Provide high calcitic or dolomitic limestone for agricultural limestone that is free of toxic salts and other harmful matter. Test limestone in accordance with ASTM C 602. Ensure the Calcium Carbonate Equivalent is at least 80.0 percent. Ensure the gradation is in accordance with Table 706:01.

Table 706:1
Agricultural Limestone Gradation

Sieve Size	Percent Passing
No. 4 [4.75 mm]	100
No. 8 [2.36 mm]	90 – 100
No. 60 [250 µm]	30 – 100

The Department will not allow by-product lime.

SECTION 707
THIN SURFACE COURSES

707.01 MATERIALS

A. Approval of Materials

Prepare the mix design as required by the Contract and at the Contractor designated lab. Establish a job mix formula (JMF) which includes target gradations and specifies a percentage of residual asphalt for the mixture. Submit the mix design to the Department's Materials Division, with applicable worksheets and data, for approval. The Department will allow the use of previous mix designs reviewed and approved in the current calendar year.

To substantiate the design, produce and test trial mixtures before placement using the proposed project materials and equipment. The Resident Engineer may waive trial mixtures if the design was previously proven to conform with these specifications.

If changing material sources, establish a new mix design before using the new material. The Resident Engineer may request a new mix design if unsatisfactory results or other conditions make it necessary.

The Resident Engineer will conditionally approve the following:

- Aggregate stockpiled at the plant,
- Asphalt at the source, and
- The mixture after mixing, pending the results of final acceptance tests.

B. Mineral Aggregate

Provide mineral aggregate that is 100 percent crushed, clean, durable, and composed of rhyolite, granite, sandstone, or other approved aggregates in accordance with Table 707:1.

Table 707:1
Physical Properties of Aggregates

Property	Micro Surfacing Limit	UTBWC Limit
Los Angeles Abrasion [a], *% wear*	≤40	≤35
Micro-deval, *% loss*	—	18
Sand equivalent, *%*	65	≥45
Un-compacted void content, *%*	—	≥40
Mechanically fractured faces [a,e], *%*	≥100/100	≥100/85
Aggregate durability index	≥40	—
Insoluble residue, *%*	≥65	≥65
Flat and elongated pieces [b], *%*	≤15 [c]	≤22 [d]
Natural sand and gravel, *%*	0	0
Clay balls and friable particles [b], *%*	0	0
Soft particles, *%*	≤5	≤5

Table 707:1
Physical Properties of Aggregates

Property	Micro Surfacing Limit	UTBWC Limit
Sticks or roots, %	0	0

[a] Applies to each source.
[b] Applies to combined aggregate.
[c] For micro surfacing, a flat and elongated piece is longer than five times the thickness.
[d] For UTBWC, flat, elongated pieces are longer than three times the thickness.
[e] In the mechanically fractured faces requirement format "xx/yy", "xx" is the minimum percentage of coarse aggregate requiring one fractured face, and "yy" is the minimum percentage requiring two fractured faces.

C. Emulsified Asphalt

For micro surfacing, provide a polymer modified PMCSS-1h (cationic) emulsified asphalt in accordance with Table 708:3, "Requirements for Polymer Modified Cationic Emulsified Asphalt."

Provide asphalt used in UTBWC for the Polymer Modified Emulsion Membrane in accordance with PMCRS-1s in Table 708:3, "Requirements for Polymer Modified Cationic Emulsified Asphalt."

D. Performance Graded Binder

Provide performance graded binder in accordance with Section 708, "Plant Mix Bituminous Bases and Surfaces," for PG 70-28 OK or PG 76-28 OK, as shown on the Plans.

E. Mineral Filler

Provide mineral filler for micro surfacing that is a recognized brand of portland cement free of lumps in accordance with AASHTO M 85. The Resident Engineer may visually inspect and approve mineral filler. Use acceptable mineral fillers such as rock dust, hydrated lime, fly ash, and Type 1 portland cement for UTBWC if needed to meet the gradation requirements. Ensure the mineral fillers for UTBWC have 100 percent passing the No. 30 [600 µm] sieve and at least 75 percent passing the No. 200 [75 µm] sieve.

F. Water

Provide potable water free of harmful soluble salts. The Contractor may add water in accordance with the emulsion manufacturer recommendations.

G. Other Additives

Optionally, use additives supplied and approved by the emulsion manufacturer in the emulsion mix to control the material in the field.

707.02 COMPOSITION OF MIXTURES

In order to allow traffic on the mat without causing damage, formulate the micro surfacing mixture to ensure the placed mat will cure sufficiently within 1 hr of mixing under the job site conditions (including time for transporting, placement, rolling, and finishing). The Resident Engineer will determine if additional curing is necessary at driveways, intersections, or other areas where sharp turns, accelerations, or decelerations

occur. Refer to Table 707:2 for the composition of micro surfacing and Table 707:3 for the composition of UTBWC.

Table 707:2
Micro Surfacing Aggregate Gradations and Composition Requirements

Sieve Size	Percent Passing per Type		
	Type I	Type II	Type III
⅜ in [9.5 mm]	100	99 – 100	98 – 100
No. 4 [4.75 mm]	98 – 100	80 – 94	70 – 90
No. 8 [2.36 mm]	71 – 88	45 – 65	45 – 70
No. 16 [1.18 mm]	44 – 63	25 – 45	28 – 50
No. 30 [600 µm]	27 – 46	15 – 34	19 – 34
No. 50 [300 µm]	15 – 33	9 – 25	12 – 25
No. 100 [150 µm]	8 – 23	7 – 19	7 – 18
No. 200 [75 µm]	5 – 15	5 – 15	5 – 15
Composition Requirements:	**Value**		
Residual asphalt, % by dry weight [mass] of aggregate	6 – 9		
Mineral filler, % by dry weight [mass] of aggregate	1 – 3		
Water	as required to provide the specified properties.		
Additives	as required to provide the specified properties.		

Table 707:3
UTBWC Aggregate Gradations and Composition Requirements

Sieve Size	Percent Passing per Type		
	No. 4 - Type A	⅜ in - Type B	½ in - Type C
¾ in [19.0 mm]	—	—	100
½ in [12.5 mm]	—	100	75 – 100
⅜ in [9.5 mm]	100	75 – 100	50 – 80
No. 4 [4.75 mm]	40 – 55	25 – 38	25 – 38
No. 8 [2.36 mm]	22 – 32	19 – 27	19 – 27
No. 16 [1.18 mm]	15 – 25	15 – 23	15 – 23
No. 30 [600 µm]	10 – 18	10 – 18	10 – 18
No. 50 [300 µm]	8 – 13	8 – 13	8 – 13
No. 100 [150 µm]	6 – 10	6 – 10	6 – 10
No. 200 [75 µm]	4.0 – 5.5	4.0 – 5.5	4.0 – 5.5
Composition Requirement:			
Asphalt content, %	5.0 – 5.8	4.8 – 5.6	4.6 – 5.6

Note: Mix at 325°F [163°C]. Compact at 300°F [149°C].
Determine the percent drain-down in accordance with AASHTO T 305. Test the drain down at the optimum AC content plus 0.5 percent at a temperature of 352°F [178°C]. Allow a maximum of 0.10 percent.
Determine stripping susceptibility in accordance with AASHTO T 283. Ensure the tensile strength ratio is at least 0.8.
The Department will not allow reclaimed asphalt pavement (RAP) in UTBWC.

707.03 TOLERANCES

Provide micro-surfacing material in accordance with Subsection 707.02, "Composition of Mixtures," except the Department will not allow the mixture residual asphalt content to vary by no more than 0.5 percent from the job-mix formula when measured by the tank-strap method.

The Department will allow the additional tolerances for UTBWC specified in Table 707:4 to modify the ranges specified in Table 707:3, "UTBWC Aggregate Gradations and Composition Requirements." These tolerances may extend outside the broad range in Table 707:3.

Table 707:4
Additional UTBWC Tolerances

Sieve Size	Percent Passing per Type		
	No. 4 – Type A	⅛ in – Type B	½ in – Type C
¾ in [19.0 mm]	—	—	—
½ in [12.5 mm]	—	—	±5
⅜ in [9.5 mm]	—	±5	—
No. 4 [4.75 mm]	±5	±4	±4
No. 8 [2.36 mm]	±4	±4	±4
No. 16 [1.18 mm]	±4	—	—
No. 30 [600 µm]	—	—	—
No. 50 [300 µm]	—	—	—
No. 100 [150 µm]	—	—	—
No. 200 [75 µm]	±1.0	±1.0	±1.0
Composition Requirement:			
Asphalt content, %	±0.3	±0.3	±0.3

707.04 SAMPLING AND TESTING

Sample and test in accordance with Table 707:5.

Table 707:5
Sampling and Testing

Property	Test Method
Sampling and Testing Aggregates:	
Sampling	AASHTO T 2
Material passing No. 200 [75 µm] sieve	AASHTO T 11
Sieve analysis	AASHTO T 27
Los Angeles Abrasion	AASHTO T 96
Sand equivalent	AASHTO T 176
Aggregate durability index	AASHTO T 210
Un-compacted void content of fine aggregate	AASHTO T 304, Method A
Aggregate degradation by micro-deval	AASHTO T 327
Flat and elongated particles in coarse aggregate	ASTM D 4791
Mud, clay balls, sand clusters, sticks, and roots retained on No. 4 [4.75 mm] sieve	OHD L-9
Fractured faces	OHD L-18
Insoluble residue	OHD L-25
Soft particles	OHD L-38
Testing asphalt materials:	
Solubility of bituminous materials	AASHTO T 44
Penetration of bituminous materials	AASHTO T 49
Ductility of bituminous materials	AASHTO T 51
Softening point of bitumen (ring-and-ball apparatus)	AASHTO T 53
Standard test methods for emulsified asphalts	AASHTO T 59
Saybolt viscosity	AASHTO T 72

Table 707:5 Sampling and Testing	
Property	**Test Method**
Distillation of cutback asphaltic (bituminous) products	AASHTO T 78
Viscosity of asphalts by vacuum capillary viscometer	AASHTO T 202
Specific gravity of semi-solid bituminous materials	AASHTO T 228
Specific gravity by hydrometer	ASTM D 3142
Elastic recovery test by means of ductilometer [a]	ASTM D 6084
Elastic recovery test by means of ductilometer [b]	OHD L-42
[a] Use ASTM D 6084 for PG binders only. [b] Use OHD L-42 for polymer modified emulsions only.	

SECTION 708
PLANT MIX BITUMINOUS BASES AND SURFACES

708.01 APPROVAL OF MATERIALS

The Department's Materials Engineer must approve aggregate sources and blend percentages on a project basis before use.

Stockpile the aggregate in accordance with Subsection 106.08. The Resident Engineer may accept aggregates in stockpiles and plant mixed materials after blending and mixing at the plant. Obtain asphalt from an approved source in accordance with Subsection 708.06.B.

708.02 MINERAL AGGREGATE

Provide mineral aggregate composed of coarse aggregate, fine aggregate, and mineral filler in accordance with these specifications. If crushing natural gravel for mixes, the Resident Engineer may require a washing operation to separate fines from the gravel. The Department will not allow blending different materials in the same storage or feeder. Provide aggregates in accordance with Table 708:1.

Table 708:1
Physical Properties of Aggregates

Test	Aggregates to be used in:						
	Superpave		Stone Matrix Asphalt	Permeable Friction Course	Rich Bottom Layer	Open Graded Friction Course	Open Graded Bituminous Base
L.A. Abrasion [a], % wear	≤40		≤30	≤30	≤40	≤30	≤40
Micro-Deval [a], % wear	≤25[l]		≤25	≤25	—	≤25[l]	—
Sand equivalent [b], per traffic ESALs [k]							
<3 M	≥40		—	—	≥40	—	—
3 M – <30 M	≥45		—	—	≥40	—	—
≥30 M	≥50		—	—	≥40	—	—
Mechanically fractured faces [b,c,i] per traffic ESALs [k], %							
Depth from surface [j], in [mm]	≤4 [100]	>4 [100]					
<3 M	≥75/75	≥65/65	≥100/95	≥100/95	≥75/75	≥100/95	≥75/75
3 M – <10 M	≥85/80	≥75/75	≥100/95	≥100/95	≥75/75	≥100/95	≥75/75
10 M – <30 M	≥95/90	≥80/75	≥100/95	≥100/95	≥75/75	≥100/95	≥75/75
30 M – <100 M	≥100/100	≥95/90	≥100/95	≥100/95	≥75/75	≥100/95	≥75/75
≥100 M	≥100/100	≥100/100	≥100/95	≥100/95	≥75/75	≥100/95	≥75/75
Aggregate durability index [a]	≥40		≥40	≥40	≥40	≥40	≥40
Insoluble residue [d,e], %, per traffic ESALs [k]							
<3 M	≥30		≥40	≥40	—	≥30	—
≥3 M	≥40		≥40	≥40	—	≥40	—
Flat and elongated pieces [b,c,f], %	≤10		≤10	≤10	≤15	≤15	≤15
Natural sand and gravel [b], %, per traffic ESALs [k]							
<0.3 M	≤25		0	0	≤15	0	0
≥0.3 M	≤15		0	0	≤15	0	0
Clay balls and friable particles [g], %	≤1.0		0	0	≤1.0	0	0
Soft particles [a], %	≤5		≤5	≤5	≤5	≤5	≤5
Sticks or roots [a], %	≤0.5		0	0	≤0.5	0	0
Uncompacted void content of fine aggregate [b,h], %, per traffic ESALs [k]							
Depth from surface, [j] in [mm]	≤4 [100]	>4 [100]					
<0.3 M	—	—	—	—	—	—	—
0.3 M – <3 M	≥40	≥40	—	—	—	—	—
3 M – <30 M	≥45	≥40	—	—	—	—	—
≥30 M	≥45	≥45	—	—	—	—	—

Table 708:1
Physical Properties of Aggregates

Test	Aggregates to be used in:					
	Superpave	Stone Matrix Asphalt	Permeable Friction Course	Rich Bottom Layer	Open Graded Friction Course	Open Graded Bituminous Base

Note: For the purpose of this table, "million" is abbreviated as "M".
[a] Applies to each source.
[b] Applies to the combined aggregate.
[c] Applies to the aggregate retained on the No. 4 [4.75 mm] sieve.
[d] Applies to the combined coarse aggregate.
[e] Applies to the coarse aggregate in the surface course. Does not apply to shoulders, driveways, and temporary detours.
[f] A flat and elongated piece has a length greater than five times the thickness.
[g] Applies to combined aggregate. If the maximum for the combined aggregate is not exceeded, the Department will allow 1.5% for one source.
[h] Applies to the aggregate passing the No.8 [2.36 mm] sieve.
[i] In the mechanically fractured faces requirement format “xx/yy,” “xx” is the minimum percentage of coarse aggregate requiring one fractured face, and “yy” is the percentage requiring two fractured faces.
[j] If less than 25% of a layer is within 4 in [100 mm] of the surface, the layer may be considered to be below 4 in [100 mm] for mixture design purposes.
[k] Regardless of the actual design life of the roadway, the design ESALs are based on 20 years.
[l] Applies to projects with 30 million or more design ESALs.

Ensure a crusher run or similarly graded aggregate is not the only source of crushed coarse aggregate in asphalt concrete.

A. Coarse Aggregate

Coarse aggregate is defined as that part of the aggregate retained on the No. 8 [2.36 mm] sieve. Provide coarse aggregate consisting of clean, tough, durable particles that are free of soft and disintegrated pieces, shale, clay, organic, or other deleterious material.

The Department will not allow the use of natural gravel as a source of insoluble material unless it is crushed so that at least 75 percent of the material retained on the No. 4 [4.75 mm] sieve has at least two mechanically fractured faces.

B. Fine Aggregate

Fine aggregate is defined as that part of the aggregate that passes the No. 8 [2.36 mm] sieve and consists of hard, durable natural sand grains, crushed stone, stone dust, crushed gravel, mine chat, jig-sand, or any combination of these. Produce crushed materials from a source that meets the requirements for coarse aggregate in Table 708:1.

C. Mineral Filler

If required by the Contract, provide mineral filler in accordance with AASHTO M 17.

708.03 ASPHALT MATERIALS

Provide asphalt cement in accordance with AASHTO M 320 and Table 708:2 for the grade required by the Contract.

Table 708:2
Additional Requirements to AASHTO M 320 for Asphalt Cement

Test	PG 64-22 OK	PG 70-28 OK	PG 76-28 OK
Elastic recovery at 77°F [25°C], *%*	—	≥65	≥75
Separation [a], *%*	—	≤10	≤10
Original DSR G*/sin(δ), *kPa*	≤2.50	≤2.50	≤2.50
RTFO DSR G*/sin(δ), *kPa*	≤5.50	≤5.50	≤5.50
PAV DSR change in testing temperature, *°F [°C]*	—	77 [25]	77 [25]
Spot test [b]	Negative	—	—
Flash point, *°F [°C]*	≥500 [260]	≥500 [260]	≥500 [260]
Solubility in trichloroethylene, *%*	≥99	≥99	≥99

Note: Asphalt binder suppliers will provide handling requirements and recommended field mixing and compaction temperatures for their product to the hot-mix producer.
[a] Separation test samples are prepared in accordance with ASTM D 5976, but are reported as the difference in G* between the top and bottom samples.
[b] Spot test using solvent blend of 65 percent heptane and 35 percent xylene by volume.

Provide medium-curing cutback asphalt in accordance with AASHTO M 82 for the asphalt type and grade required by the Contract. The spot test is required using a solvent blend of 65 percent heptane and 35 percent xylene by volume. Residue may also be obtained by evaporation.

Provide emulsified asphalt in accordance with AASHTO M 140 for the asphalt type and grade required by the Contract, with the following exception:

- The minimum Saybolt Furol Viscosity for RS-2 at 122 °F [50 °C] is 150.

Residue may also be obtained by evaporation.

Provide cationic emulsified asphalt in accordance with AASHTO M 208 for the asphalt type and grade required by the Contract, with the following exception:

- The minimum Saybolt Furol Viscosity for CRS-2 at 122 °F [50 °C] is 150.

Perform the demulsibilty test within 30 days of shipment. If the particle charge test is inconclusive, the Department's Materials Division will approve material with a maximum pH of 6.7. Residue may also be obtained by evaporation.

Provide polymer modified cationic emulsified asphalt in accordance with Table 708:3 for the asphalt type and grade required by the Contract.

Table 708:3
Requirements for Polymer Modified Cationic Emulsified Asphalt

Test	Rapid-Setting PMCRS-1s	Rapid-Setting PMCRS-2s [a]	Slow-Setting PMCSS-1h
Test on emulsions			
Viscosity, Saybolt Furol, 77 °F [25 °C], s	—	—	20 – 100
Viscosity, Saybolt Furol, 122 °F [50 °C], s	25 – 125	125 – 400	—
Storage stability test 24 hr, %	≤1	—	≤1
Settlement test [b], 5 day, %	—	≤5%	—
Particle charge test	—	positive	positive
Sieve test, %	≤0.05	≤0.10	≤0.10
Demulsibility, %	≥60	≥60	—
Distillation [e]			
Oil distillate, by volume of emulsion, %	≤2	≤2	≤0.5
Residue, %	≥63	≥65	≥62
Tests on residue from distillation test [c,d]			
Penetration, 77 °F, [25 °C], 100 g, 5 s	90 – 150	100 – 200	40 – 90
Ductility, 77 °F, [25 °C], 5cm/min, cm	—	—	≥70
Ductility, 40 °F, [4 °C], 5 cm/min, cm	—	≥30	—
Softening point, ring, and ball, °F[°C]	—	≥112 [44]	≥135 [57]
Elastic recovery, 50 °F [10 °C], %	≥60	≥58	—
Tensile stress at 800% elongation, 40 °F [4 °C], 50 cm/min, kPa	—	≥196	—
Solubility in trichloroethylene [f], %	≥97.5	—	≥97
Ash content, %	—	≤1.0	—

[a] Provide a Type B certification for each polymer modified asphalt lot in accordance with Subsection 106.04.
[b] After the test cylinder stands undisturbed for 5 days, ensure that there is no milky colored substance and there is a homogenous brown color throughout the cylinder.
[c] Modify the distillation procedure as follows:
Maintain a temperature from 345 °F [174 °C] to 355 °F [180 °C] on the lower thermometer for the last 20 min of the test.
Maintain a test duration from 50 min to 70 min from the first application of heat.
[d] Ensure the distillation residue of the modified emulsion contains at least 3 percent polymer solids by asphalt mass as determined by an analytical method approved by the Department.
[e] Residue may also be obtained by evaporation.
[f] An organic solvent may be used.

A. Handling

Handle, load, haul, and transfer bituminous materials in accordance with OHD L-11. The Resident Engineer will reject further shipments if materials fail to produce the results required by the Contract. The Resident Engineer will not accept further work until the Department is satisfied that the material has been corrected so that it produces the results required by the Contract.

B. Application Temperature

Heat asphalt materials in accordance with Table 708:4 unless otherwise required by the Contract.

Table 708:4
Temperature Ranges for Use of Asphalt Materials

Type or Grade	Mixture, *°F [°C]*	For Mixing, *°F [°C]*	For Spraying, *°F [°C]*
PG76	≤350 [177]	275 – 350 [135 – 177]	285 – 350 [141 – 177]
PG70	≤350 [177]	275 – 350 [135 – 177]	285 – 350 [141 – 177]
PG64	≤350 [177]	275 – 350 [135 – 177]	285 – 350 [141 – 177]
MC-30	—	50 – 120 [10 – 49]	50 – 120 [10 – 49]
MC-70	—	80 – 150 [27 – 66]	80 – 150 [27 – 66]
MC-250	≤200 [93]	100 – 200 [38 – 93]	100 – 200 [38 – 93]
MC-800	≤210 [99]	160 – 210 [71 – 99]	185 – 260 [85 – 127]
MC-3000	≤250 [121]	200 – 250 [93 – 121]	225 – 275 [107 – 135]
All emulsions	—	70 – 185 [21 – 85]	70 – 185 [21 – 85]

708.04 COMPOSITION OF MIXTURES

A. Asphalt Mix Design and Initial Job-Mix Formula

Prepare asphalt mix designs in general accordance with AASHTO R 35 except where modified by these specifications. The asphalt mix design and initial job-mix formula (JMF) are the responsibility of the Contractor. Submit the asphalt mix design and initial JMF to the Department's Materials Engineer for review.

The Department's Materials Engineer will determine if the mix design meets the design criteria. Provide one mix design for each asphalt concrete mixture required by the Contract. Prepare the mix in a Department approved laboratory. The Department will approve the laboratory based on the Materials Division Policy for Asphalt Design Laboratories.

Ensure the initial JMF is in accordance with Table 708:6 and Table 708:8 or Table 708:7 and Table 708:10 for the type of mix required by the Contract. Prepare a trial mixture in accordance with Subsection 411.04.C. Propose changes to the JMF if the trial, prepared at the initial JMF proportions, fails to meet the requirements of Tables 708:6, 708:9, and 708:12 or Tables 708:7, 708:11, and 708:12. If the changes do not produce a mix design in accordance with these tables, the Resident Engineer will require a new mix design. If the changes do produce a mix design in accordance

with these tables, the Department's Materials Engineer will approve the changes for adjustment of the JMF.

Ensure the JMF establishes a percentage of aggregate passing each required sieve, a percentage of asphalt contained in the mixture, and a mixture temperature at the point of discharge from the plant.

The JMF with the allowable tolerances shown in Table 708:12, establish the specification limits for each mixture. These limits may be outside the range in Table 708:6 or Table 708:7 except for the following conditions:

- The absolute maximum sieve size,
- PFC and Open Graded Friction Surface Course, where the JMF with allowable tolerances must be within the broad range in accordance with Table 708:7.
- When no tolerances are shown in Table 708:12, the broad ranges given in Table 708:7 are the specification limits.

B. Plant Produced Mixtures

Provide a uniform, plant produced mixture of the combined aggregate and asphalt in accordance with Tables 708:6 and 708:9 or Tables 708:7 and 708:11 within the specification limits established by the JMF with allowable tolerances.

After the plant is in operation, propose any necessary adjustments to the JMF in accordance with Table 708:6 or Table 708:7. If test results indicate the adjustments are in accordance with Table 708:9 or Table 708:11, adjust the JMF accordingly.

If a source of materials changes, the Resident Engineer will require a new mix design before the use of the new materials. If unsatisfactory results or other conditions make it necessary, the Resident Engineer will require a new mix design.

The Department defines the asphalt JMF as the target value. Attempt to incorporate that asphalt amount regardless of the allowable tolerances.

C. Reclaimed Asphalt Pavement

Unless otherwise shown on the Plans, Superpave mixtures containing reclaimed asphalt pavement (RAP) will be accepted in accordance with Table 708:5, if the mixture is not used in the surface layer and meets the Contract requirements for the type or grade.

Table 708:5
Reclaimed Asphalt Pavements

Superpave with Binder Type	Maximum RAP, %
PG 64-22 OK	25
PG 70-28 OK	15
PG 76-28 OK	15

Regardless of the layer or binder type, the Department's Materials Engineer will accept superpave mixtures with no greater than 25 percent RAP for shoulders, driveways, layers serving as a bond breaker under PCC pavements, and on roadways with less than 0.3 million ESALs if the mixture meets the Contract requirements for the type or grade. Superpave mixtures containing up to 35 percent RAP will be accepted in temporary detours if the mixture meets the Contract requirements for the type or grade, and if the mixture can be produced meeting air quality standards set forth by the Oklahoma Department of Environmental Quality. Temporary is defined

as any material that will not become part of any permanent pavement. Temporary material must be removed before the end of the project.

Process RAP by fractionating it into at least two stockpiles: a coarse stockpile and a fine stockpile. Crush, screen, or size the coarse stockpile so that 100 percent passes through a 1.5 in [37.5 mm] sieve. Crush, screen, or size the fine stockpile so that 100 percent passes through either a ⅝ in [16.5 mm], ½ in [12.5 mm], or ⅜ in [9.5 mm] sieve. If RAP comes from an unknown source and documentation is unavailable, the Department will consider the insoluble residue content to be zero. The Department will reduce the amount of natural sand and gravel allowed in the combined aggregate by the amount of natural sand and gravel contained in the RAP. The Department will not allow the use of RAP in Stone Matrix Asphalt (SMA), Permeable Friction Course (PFC), Rich Bottom Layer (RBL),Open-Graded Friction Surface Course (OGFSC), or Open-Graded Bituminous Base (OGBB) mixes.

Table 708:6
Mixtures for Superpave

Sieve Size [a]	Percent Passing per Superpave Mixture Type				
	S2	S3	S4	S5	S6
1½ in [37.5 mm]	100	—	—	—	—
1 in [25.0 mm]	90 – 100	100	—	—	—
¾ in [19.0 mm]	≤90	90 – 100	100	—	—
1/2 in [12.5 mm]	—	≤90	90 – 100	100	—
⅜ in [9.5 mm]	—	—	≤90	90 – 100	100
No. 4 [4.75 mm]	≥40	—	—	≤90	80 – 100
No. 8 [2.36 mm]	29 – 45	31 – 49	34 – 58	37 – 67	54 – 90
No. 16 [1.18 mm]	—	—	—	—	—
No. 30 [0.600 mm]	—	—	—	—	—
No. 50 [0.300 mm]	—	—	—	—	—
No. 100 [0.150 mm]	—	—	—	—	—
No. 200 [0.075 mm]	1.0 – 7.0 [b]	2.0 – 8.0 [b]	2.0 – 10.0 [b]	2.0 – 10.0 [b]	5.0 – 15.0
Other Mixture Requirements					
NMS [c]	1 in [25 mm]	¾ in [19 mm]	½ in [12.5 mm]	⅜ in [9.5 mm]	No. 4 [4.75 mm]
Asphalt Cement [d], % of mix mass	≥3.7	≥4.1	≥4.6	≥5.1	≥5.6
Performance grade asphalt cement	e	e	e	e	e

[a] Table 708:6 reflects the sieve size boundaries for design and JMF purposes. After the design is established, the JMF will designate combined aggregate sieve requirements with tolerances in Table 708:12.
[b] Ensure the ratio of the percent passing the No. 200 [75 µm] sieve to the percent effective asphalt cement is from 0.6 to 1.6.
[c] Nominal Maximum Size (NMS) is defined as one size larger than the first sieve to retain more than 10 percent.
[d] The Department's Materials Engineer may adjust the lower limit if the effective specific gravity of the combined aggregates is greater than 2.65. The Department's Materials Engineer may allow adjustments if a theoretical lab molded specimen at the JMF asphalt content meets the VMA requirement at 4% air voids.
[e] The Contractor may substitute a higher grade of asphalt than that shown on the Plans at no additional cost to the Department.

Table 708:7
Mixture for Hot Mix – Hot Lay, Non-Superpave

Sieve Size [a]	Percent Passing per Asphalt Concrete Mixture Type				
	SMA	PFC [b]	RBL	OGFSC [b, c]	OGBB
1 ½ in [37.5 mm]	—	—	—	—	100
1 in [25.0 mm]	—	—	—	—	95 – 100
¾ in [19.0 mm]	100	100	100	—	—
½ in [12.5 mm]	90 – 100	80 – 100	90 – 100	100	25 – 60
⅜ in [9.5 mm]	65 – 80	35 – 60	72 – 90	90 – 100	—
No. 4 [4.75 mm]	22 – 30	1 – 20	53 – 70	25 – 45	≤10
No. 8 [2.36 mm]	16 – 24	1 – 10	34 – 58	≤10	≤5
No. 16 [1.18 mm]	—	—	—	—	—
No. 30 [0.600 mm]	—	—	—	—	—
No. 50 [0.300 mm]	—	—	—	—	—
No. 100 [0.150 mm]	—	—	—	—	—
No. 200 [0.075 mm]	9.0 – 12.0	1.0 – 4.0	2.0 – 10.0	≤5.0	≤3.0
Other Mixture Requirements					
NMS [d]	½ in [12.5 mm]	½ in [12.5 mm]	½ in [12.5 mm]	⅜ in [9.5 mm]	1 in [25 mm]
Cellulose Fiber, % of mix mass	0.3 – 0.4	0.2 – 0.5	—	—	—
Asphalt Cement [e], % of mix mass	≥6.0	6.0 – 7.0	≥5.2	≥5.1 [f]	2.5 [g]
Performance grade asphalt cement	PG 76-28 OK	PG 76-28 OK	[h]	[h]	[h]

[a] Table 708:7 reflects the sieve size boundaries for design and JMF purposes. After the design is established, the JMF will designate the combined aggregate sieve requirements with tolerances set in Table 708:12.

[b] Use an approved anti-stripping agent at the rate of 5 gal/1,000 gal [5 L/1,000L] of asphalt cement.

[c] Retain at least 55 percent of the aggregate between the ⅜ in [9.5 mm] and the No. 4 [4.75 mm].

[d] Nominal Maximum Size (NMS) is defined as one size larger than the first sieve to retain more than 10 percent.

[e] The Department's Materials Engineer may allow the lower limit to be adjusted if the effective specific gravity of the combined aggregates is greater than 2.65. The Department's Materials Engineer may allow adjustments if a theoretical lab molded specimen at the JMF asphalt content meets the VMA requirement at 4 percent air voids.

[f] Calculate the JMF for percent AC in the open graded friction course with the following equation:

$$\% \text{ AC} = (16.5) / (\text{Effective Specific Gravity } (G_{se}) + 0.165).$$

[g] The Department's Material Engineer may allow the amount of asphalt binder to be adjusted if the effective specific gravity of the combined aggregate is greater than 2.833 or less than 2.495.

[h] The Contractor may substitute a higher grade of asphalt than that shown on the Plans, at no additional cost to the Department.

Table 708:8
Mix Design Properties of Laboratory Molded Superpave Specimens

Property	Design ESALs [a]				
	<0.3 M	**0.3 M – <3 M**	**3 M – <10 M**	**10 M – <30 M**	**≥30 M**
Compaction Level [b]	4	3	2	2	1
Number of SGC Gyration					
N_{ini}	6	7	8	8	9
N_{des}	50	75	100	100	125
N_{max}	75	115	160	160	205
Required Density, *% of* G_{mm}					
N_{ini}	85.5 – 91.5	85.5 – 90.5	85.5 – 89.0	85.5 – 89.0	85.5 – 89.0
N_{des}	96.0	96.0	96.0	96.0	96.0
N_{max}	≤98.0	≤98.0	≤98.0	≤98.0	≤98.0
VMA [c] Superpave mix type, *%*					
S2	≥12.0	≥12.0	≥12.0	≥12.0	≥12.0
S3	≥13.0	≥13.0	≥13.0	≥13.0	≥13.0
S4	≥14.0	≥14.0	≥14.0	≥14.0	≥14.0
S5	≥15.0	≥15.0	≥15.0	≥15.0	≥15.0
S6	≥16.0	≥16.0	≥16.0	≥16.0	≥16.0
VFA, [d] *%*	70 [e] – 80	65 – 78	65 – 75 [f, g]	65 – 75 [f, g]	65 – 75 [f, g]
APA rut depth, *mm*	≤8	≤6	≤5	≤4	≤3
Lab Permeability, *cm/s* × 10^{-5}	≤12.5	≤12.5	≤12.5	≤12.5	≤12.5
Tensile strength ratio	0.80	0.80	0.80	0.80	0.80

Note: For the purpose of this table, "million" is abbreviated "M."

[a] Regardless of the actual design life of the roadway, the design ESALs are based on 20 years.

[b] Mix designs for shoulders may be designed at one compaction level less than the 20 year Flex ESAL level used for mainline construction. Design lifts below PCC pavements at the 20 year flex ESAL level or a lower compaction level. Mix designs for temporary construction, such as crossovers and detours, may be designed within two compaction levels of the designated 20 year Flex ESAL level. Design S2 mixtures at compaction level 3 unless the compaction levels of the designated 20 year Flex ESAL level is less than 0.3 million, in which case S2 mixtures shall be designed at compaction level 4.

[c] VMA is based on the bulk specific gravity of the aggregates.

[d] VFA is defined as the percentage of VMA containing asphalt binder.

[e] For Mix Type S2, the lower limit for 20 year Flex ESAL levels, <0.3 million, is 67%.

[f] For Mix Type S5, the limits for 20 year Flex ESAL levels ≥3 million are 73% to 76%

[g] For Mix Type S6, the limits for 20 year Flex ESAL levels ≥3 million are 75% to 78%.

Table 708:9
Field Sample Properties of Laboratory Molded Superpave Specimens

Property	Design ESALs [a]				
	<0.3 M	0.3 M – <3 M	3 M – <10 M	10 M – <30 M	≥30 M
Compaction Level	4	3	2	2	1
Number of SGC gyrations:					
N_{ini}	6	7	8	8	9
N_{des}	50	75	100	100	125
N_{max}	75	115	160	160	205
Required Density, *% of* G_{mm}:					
N_{ini}	85.5 – 91.5	85.5 – 90.5	85.5 – 89.0	85.5 – 89.0	85.5 – 89.0
N_{des}	94.5 – 97.4	94.5 – 97.4	94.5 – 97.4	94.5 – 97.4	94.5 – 97.4
N_{max}	—	—	—	—	—
VMA [b] superpave mix type, *%*:					
S2	≥11.5	≥11.5	≥11.5	≥11.5	≥11.5
S3	≥12.5	≥12.5	≥12.5	≥12.5	≥12.5
S4	≥13.5	≥13.5	≥13.5	≥13.5	≥13.5
S5	≥14.5	≥14.5	≥14.5	≥14.5	≥14.5
S6	≥15.5	≥15.5	≥15.5	≥15.5	≥15.5
VFA, *%*	—	—	—	—	—
APA rut depth, *mm*	—	—	—	—	—
Lab Permeability, $cm/s \times 10^{-5}$	—	—	—	—	—
Tensile strength ratio	0.75	0.75	0.75	0.75	0.75

Note: For the purpose of this table, "million" is abbreviated "M."
[a] Regardless of the actual design life of the roadway, the design ESALs are based on 20 years.
[b] VMA is based on the bulk specific gravity of the aggregates. Compute a new bulk specific gravity from each AASHTO T 209 test. Calculate the value by multiplying the aggregate Effective Specific Gravity (G_{se}) calculated from the latest AASHTO T 209 test by the aggregate Bulk Specific Gravity (G_{sb}) from the design. Afterwards, divide the product by the aggregate G_{se} from the design.

Table 708:10
Mix Design Properties of Laboratory Molded Non-Superpave Specimens

Property	Mix Type		
	SMA	PFC	RBL
Number of SGC Gyrations	50	50	50
Required Density, *% of* G_{mm}	96.0	≤82.0	98.0
VMA [a], *%*	≥17.0	—	≥14.0
TSR minimum	0.80	—	0.80
Draindown, *%*	≤0.20	≤0.20	—
Permeability, $cm/s \times 10^{-5}$	≤12.5	—	≤12.5

Table 708:10
Mix Design Properties of Laboratory Molded Non-Superpave Specimens

Property	Mix Type		
	SMA	PFC	RBL
APA rut depth, *mm*	≤3	—	≤10

[a] VMA is based on the bulk specific gravity of the aggregates.

Table 708:11
Field Sample Properties of Laboratory Molded Non-Superpave Specimens

Property	Mix Type		
	SMA	PFC	RBL
Number of SGC Gyrations	50	50	50
Required Density, *% of* G_{mm}	94.5 – 97.4	≤82.0	96.5 – 99.4
VMA [a], *%*	≥16.5	—	≥13.5
TSR	≥0.75	—	≥0.75
Draindown, *%*	—	—	—
Permeability, *cm/s* × 10^{-5}	—	—	—
APA rut depth, *mm*	—	—	—

[a] VMA is based on the bulk specific gravity of the aggregates. Compute a new bulk specific gravity from each AASHTO T 209 test. Calculate the value by multiplying the aggregate Effective Specific Gravity (G_{se}) calculated from the latest AASHTO T 209 test by the aggregate Bulk Specific Gravity (G_{sb}) from the design. Afterwards, divide the product by the aggregate G_{se} from the design.

D. Acceptance of Combined Cold Feed Aggregate Gradation

The Resident Engineer may use combined aggregate samples taken before asphalt coating for mixture gradation acceptance. Obtain the sample by an approved sampling device and perform a sieve analysis in accordance with Subsection 708.06, AASHTO T 27, and AASHTO T 11. This method may be allowed if the asphalt mixture does not contain reclaimed bituminous materials and the aggregate does not appreciably degrade during the drying and mixing process.

The Resident Engineer may accept bituminous plant mix gradation results based on specified cold feed combined aggregate samples under the following conditions:

- If the aggregate gradation test on extracted aggregates in accordance with AASHTO T 30 compares favorably with the results of cold feed aggregate gradation results.
- If the Independent Assurance Samples test results of extracted gradation analysis compares favorably with acceptance samples.

If test results do not compare favorably, the Resident Engineer will base acceptance gradation tests performed in accordance with AASHTO T 30, on aggregate from extraction or ignition oven testing.

E. Acceptance of Bitumen Content

Determine the bitumen content of plant produced mixtures in accordance with OHD L-26 method of test. Determine the bitumen content of open-graded plant

produced mixtures (PFC, OGFSC, OGBB) using the tank strap method or a digital printout from the asphalt plant of the quantity used.

708.05 TOLERANCES

Apply the tolerances shown in Table 708:12 to the JMF in accordance with Subsection 708.04.

Table 708:12
JMF Tolerances Per Mixture

Sieve Size	Superpave	Stone Matrix Asphalt	Permeable Friction Course	Rich Bottom Layer	Open Graded Friction Course	Open Graded Bituminous Base
	Percent Passing					
≥No. 4 [4.75 mm]	±7	±7	±7	±7	±7	—
No. 8 [2.36 mm]	±5	±5	±5	±5	±5	—
No. 16 [1.18 mm]	±4	±4	—	±4	—	—
No. 30 [0.600 mm]	±4	±4	—	±4	—	—
No. 50 [0.300 mm]	±4	±4	—	±4	—	—
No. 100 [0.150 mm]	±3	±3	—	±3	—	—
No. 200 [0.075 mm]	±2	±2	±2	±2	±2	—
Other Mixture Tolerances:						
Asphalt cement, % of mix mass	±0.4	±0.4	±0.3	±0.4	±0.3	±0.3
Mix temperature as discharged from mixer, *°F [°C]*	±20 [±10]	±20 [±10]	±20 [±10]	±20 [±10]	±20 [±10]	±20 [±10]

708.06 SAMPLING AND TESTING

A. Testing Methods

Sample and test in accordance with Table 708:13.

Table 708:13
Sampling and Testing of Aggregates, Bituminous Mixtures, and Asphalt Materials

Materials	Testing Method
Aggregates	
Sampling	AASHTO T 2
Sieve analysis	AASHTO T 27
Material passing No. 200 [75 µm] sieve	AASHTO T 11
Specific gravity and absorption of fine aggregate	AASHTO T 84
Specific gravity and absorption of coarse aggregate	AASHTO T 85
Los Angeles abrasion	AASHTO T 96
Sand equivalent	AASHTO T 176
Aggregate durability index	AASHTO T 210
Uncompacted void content of fine aggregate	AASHTO T 304, Method A
Aggregate degradation by Micro-Deval apparatus	AASHTO T 327
Flat and elongated particles in coarse aggregate	ASTM D4791
Mud, clay balls, sand clusters, sticks and roots retained on No. 4 [4.75 mm] sieve	OHD L-9
Fractured faces	OHD L-18
Insoluble residue	OHD L-25
Soft particles	OHD L-38
Bituminous Mixtures	
Mechanical analysis of extracted aggregate	AASHTO T 30
Sampling bituminous mixtures	AASHTO T 168
Maximum specific gravity of bituminous paving mixtures	AASHTO T 209
Bulk specific gravity using paraffin-coating specimens	AASHTO T 275
Resistance to moisture damage [a, g]	AASHTO T 283
Draindown characteristics of uncompacted asphalt samples	AASHTO T 305
Preparing specimens by superpave gyratory compactor[b]	AASHTO T 312
Reducing samples of HMA to testing size	AASHTO T 328
Superpave volumetric mix design	AASHTO M 323
Mixture conditioning of hot-mix asphalt	AASHTO R 30
Superpave volumetric design for HMA[c]	AASHTO R 35
Bulk impregnated specific gravity of aggregates[d]	OHD L-7
Specific gravity and unit weight of compressed bituminous mixtures	OHD L-14
Bitumen content	OHD L-26
Rutting susceptibility using the asphalt pavement analyzer	OHD L-43
Water permeability of compacted paving mixtures	OHD L-44
Specific gravity and unit weight using the CoreLok™	OHD L-45
Asphalt Materials	
Samping bituminous materials	AASHTO T 40
Solubility of bituminous materials	AASHTO T 44
Flash and fire points by Cleveland Open Cup	AASHTO T 48
Penetration of bituminous materials	AASHTO T 49
Ductility of bituminous materials	AASHTO T 51
Softening point of bitumen (ring-and-ball apparatus)	AASHTO T 53
Water in bituminous materials by distillation	AASHTO T 55
Standard test methods for emulsified asphalts	AASHTO T 59
Coating and retention testing for mixing grade emulsions	AASHTO T 59 Modified
Saybolt viscosity	AASHTO T 72
Distillation of cutback asphaltic (bituminous) products	AASHTO T 78
Flash points with tag open-cup apparatus	AASHTO T 79

Table 708:13
Sampling and Testing of Aggregates, Bituminous Mixtures, and Asphalt Materials

Materials	Testing Method
Spot test of asphaltic materials	AASHTO T 102
Inorganic matter or ash in bituminous material	AASHTO T 111
pH of aqueous solutions with the glass electrode	AASHTO T 200
Kinematic viscosity of asphalts (bitumens)	AASHTO T 201
Viscosity of asphalts by vacuum capillary viscometer	AASHTO T 202
Specific gravity of semi-solid bituminous materials	AASHTO T 228
Rolling thin film oven test	AASHTO T 240
Flexural creep stiffness using the bending beam rheometer	AASHTO T 313
Rheologial properties using a dynamic shear rheometer	AASHTO T 315
Viscosity determination using rotational viscometer	AASHTO T 316
Performance-graded asphalt binder	AASHTO M 320
Accelerated aging using a pressurized aging vessel	AASHTO R 28
Grading or verifying the performance guide	AASHTO R 29
Specific gravity by hydrometer	ASTM D 3142
Separation (Type 1 Polymer Modified)	ASTM D 5976
Elastic recovery test by means of ductilometer [e]	ASTM D 6084
Elastic recovery test by means of ductilometer [f]	OHD L-42

[a] Run AASHTO T 283 on 6 in [150 mm] diameter specimens compacted by the Superpave Gyratory Compactor to an approximate height of 3.75 in [95 mm].
[b] Mix design mixtures at 325 °F [163 °C] and age at 300 °F [149 °C] from 2 hr to 4 hr. Compact design mixtures at 300 °F [149 °C]. No minimum aging period is required for field samples. Heat field samples uniformly to 300 °F [149 °C] for no greater than 4 hr.
[c] Compact lab-molded specimens to N_{des} gyrations to determine the density at N_{des}, percent of G_{mm}. Back-calculate the density at N_{ini}, percent of G_{mm}, from these specimens. Compact lab-molded specimens to N_{max} gyrations to determine the density at N_{max}, percent of G_{mm} for mix designs and JMF changes only. Ensure reported values are the average of two specimens.
[d] Use OHD L-7 for OGFSC only.
[e] Use ASTM D 6084 for PG binders only.
[f] Use OHD L-42 for polymer modified emulsions only.
[g] Use AASHTO R 30 for aging instead of the procedure outlined in AASHTO T 283.

B. Method and Procedure for Sampling Bituminous Materials

Sample bituminous materials in accordance with AASHTO T 40. Sample bituminous materials at the project site or mixing plant in accordance with OHD L-5.

The Department may modify the sampling methods, testing, and acceptance for the bituminous materials. Obtain copies of the procedure at the office of the Department's Materials Engineer.

Sample at the point of manufacture if the quantity shipped warrants testing. Alternatively, take samples at the point of destination. Use bituminous materials only after the Department's Materials Division conditionally approves them at the source.

SECTION 709
ELECTRICAL CONDUIT

709.01 GENERAL

Ensure all conduits and fitting are liquid-tight. Ensure outlet boxes, fittings, entrance caps, and other accessories comply with current industry standards and are compatible with the conduit material used.

709.02 METALLIC CONDUITS

A. Rigid

Provide a UL-rated, rigid, galvanized steel conduit, intermediate metallic conduit, electrical metallic tubing, or rigid aluminum conduit.

B. Flexible

Provide a liquid-tight, flexible steel conduit in accordance with UL-360.

709.03 NON-METALLIC CONDUITS

A. Rigid

Provide rigid PVC, schedule 40 conduit in accordance with UL-651. For solvent cement to join conduit, refer to ASTM D 2564.

B. Flexible

Provide a smooth-wall, coilable, UL-rated, flexible plastic conduit in accordance with NEMA TC7.

C. Cable-in-Duct

Provide UL-rated, factory-assembled cable-in-duct conduit. Ensure the duct is high density polyethylene. Identify the conductor by color-coding the insulation with a continuous longitudinal stripe, or provide colored insulation in addition to standard conductor markings.

SECTION 710
DELINEATORS

710.01 REFLECTORS

A. General

Provide circular reflectors mounted on posts to form delineators with a mounting hole through the center. Ensure the reflector can accommodate a $^{3}/_{16}$ in [4.76 mm] nominal diameter blind rivet expanded to 0.196 in [4.98 mm] without fracturing. Alternatively, make the center mount reflectors with an aluminum housing.

B. Definitions

Incidence angle. The angle between the direction of light incident on the reflector and the direction of the reflector's axis.

Divergence angle. The angle between the observer's line of sight and the direction of light incident on the reflector.

Specific intensity. The intensity, in candelas, that a reflector returns at the chosen divergence angle for each footcandle [lux] of illumination at the reflector.

Lens. Reflective area of a reflector.

C. Delineators

For delineators on roadway shoulders and guard rail posts, mount reflectors on galvanized steel posts. For delineators on bridges, mount reflectors on galvanized steel posts and brackets.

D. Acrylic Plastic Reflector

Provide an acrylic plastic methyl methacrylate reflector in accordance with Federal Specifications L-M-5002, Type 1, Class 3.

Provide reflectors with the following characteristics:

- A colorless crystal, amber, or red transparent plastic face with a diameter of at least 3.0 in [76.2 mm];
- A lens of at least 7.0 in² [4,516 mm²];
- A heat sealable acrylic plastic or heat sealable metal foil back fused around the lens perimeter under heat and pressure; and
- A central mounting hole sealed against water and water vapor.

Provide embossed aluminum housing with a thickness from 0.02 in ±0.002 in [0.51 mm ±0.051 mm]. Back center mount reflectors without aluminum housing with a vapor-tight, hermetically-sealed plastic backing.

Provide a lens with a smooth front surface free of projections or indentations, except for the central mounting hole and identification, with a rear surface bearing a prismatic configuration that will affect the total internal reflection of light. Mold the manufacturer's name or trade mark into the lens face.

E. Specific Intensity

Use reflectors as delineators or markers in accordance with Table 710:1, regardless of reflector orientation.

Table 710:1 Minimum Specific Intensity for Reflectors				
Light Angles, °		**Specific Intensity, *cd/lx***		
Divergence	**Incidence**	**Crystal**	**Amber**	**Red**
$^{1}/_{10}$	0	11.1	6.6	2.7
$^{1}/_{10}$	20	4.4	2.6	1.0
⅓	0	1.9	1.1	0.46
⅓	20	0.7	0.46	0.19

F. Specific Intensity Test

The Department will determine the specific intensity in accordance with Federal Test Method 370.

The Resident Engineer will not accept reflectors that fail to meet the minimum specific intensity. The Resident Engineer will not accept a lot or shipment if more than 4 percent of the reflectors fail, or if the lot or shipment consists of 25 or fewer reflectors, if more than one reflector fails.

G. Seal Test

The Department will use the following test to determine if a reflector is sealed against dust and water:

- Submerge the samples in water at room temperature,
- Subject the submerged samples to a vacuum of 2.45 psi [16.9 kPa] for 5 min,
- Restore atmospheric pressure and leave the samples submerged for 5 min, and
- Examine the samples for water intake. The intake of any water by the sample constitutes failure.

The Resident Engineer will not accept reflectors if tests show a failure rate of more than 4 percent.

710.02 POSTS

A. Galvanized Steel Delineator Posts

Cut, drill, punch, fabricate, and galvanize a finished channel-type or hat-type delineator post as shown on the Plans and in accordance with the following:

Make the galvanized channel-type post from a 1½ in × ½ in × ⅛ in [38 mm × 12 mm × 3 mm] steel bar channel. Drill, punch, and cut to the length required by the Contract. Ensure the post is compatible with the delineator type required by the Contract.

Optionally, use an alternative galvanized steel hat section post rolled from sheet steel to the dimensions shown on the Plans. Ensure the alternative steel post before galvanizing has a weight [mass] of 1.12 lb [1.67 kg] per linear foot [meter] with a tolerance of ±3.5 percent.

Provide the correct size fasteners for the type of post. Cut, drill, and punch before galvanizing. Coat the posts with at least 2.0 oz/ft² [610 g/m²] of zinc coating in accordance with AASHTO M 111.

B. Flexible Delineator Posts

For a flexible delineator post, use Type III retroreflective sheeting material.

The Department will allow the sides of the post facing traffic to be flat or curved. Ensure the sides have at least 3.0 in [76.2 mm] of wide, flat surface to which the reflective sheeting can adhere. Provide posts at least 62 in [1,575 mm] long. Ensure the lower end of the post facilitates installation and replacement.

Attach reflective sheeting material to the post. Ensure sheeting is 9.0 in × 3.0 in [229 mm × 76 mm] with 1.0 in [25 mm] gaps (beginning 1.0 in [25 mm] below the top of the post) and is white, yellow, or red as shown on the Plans. The Department defines mono-directional delineator posts as posts with reflective sheeting material on one side, and bi-directional delineator posts as posts with reflective sheeting material on both sides or with one to three reflective sheeting strips applied around the post.

(1) Materials

Provide posts manufactured from any combination of thermosetting resins, plasticizers, coloring pigments, and inert fillers.

Provide Type III retroreflective sheeting material in accordance with AASHTO M 268.

(2) Performance

Ensure the posts are capable of remaining upright and in service at temperatures from 0°F to 100°F [−17°C to 37°C] and after ten vehicle impacts by mid-sized sedan traveling at 55 mph [88 km/h].

(3) Additional Testing

(a) Temperature Resistance

Place a post inside a conditioning chamber for at least 2 hr at a temperature from 0°F to 140°F [−17°C to 60°C]. Secure a segment of post 36 in [914.4 mm] long, bend 90°, and release. Perform the procedure three more times. The Resident Engineer will not accept posts that crack, are permanently deformed, or do not straighten out within 60 sec after testing.

(b) Weathering

Ensure posts do not change in color, flexibility, or integrity after exposure for 300 hr in an Atlas-Sunshine Weather-o-Meter fitted with a 19-102 cyclic gear.

SECTION 711
TRAFFIC STRIPE

711.01 MATERIAL FOR HOT-APPLIED THERMOPLASTIC COMPOUNDS

Provide hot-applied thermoplastic compound in accordance with AASHTO M 249. Provide binder component made of hydrocarbon based material.

711.02 PERMANENT PAVEMENT MARKING TAPE

Provide plastic striping tape free of cracks with straight and unbroken edges. Provide material in rolls with no greater than three splices per 150 ft [45.7 m].

Conform preformed words and symbols to the applicable shapes and sizes in accordance with the MUTCD. Package plastic striping tape in standard commercial containers to prevent damage during shipment and storage. Ensure the plastic striping retains the properties required by the Contract when stored at temperatures no greater than 100 °F [38 °C] and for no longer than 1 year. Provide plastic striping tape in accordance with Subsection 711.02.A, "Composition," through Subsection 711.02.L, "Effective Performance Life."

A. Composition

Uniformly distribute and firmly bond plastic materials, pigments, and glass beads on the top surface of retroreflective, preformed pavement marking film. Provide pre-coat preformed plastic film with a pressure-sensitive adhesive that is compatible with bituminous concrete and portland cement concrete road surfaces.

B. Skid Resistance

Ensure the retroreflective preformed film surface provides skid resistance value of at least 35 British Pendulum Number when tested in accordance with ASTM E 303.

C. Thickness

Provide a thickness from 0.06 in to 0.09 in [1.52 mm to 2.29 mm] for preformed plastic film, without adhesive, for lane and edge lines.

D. Tensile Strength and Elongation

Provide film with a tensile strength of at least 40 psi [275.8 kPa] of cross section when tested in accordance with ASTM D 638, except, test a 6 in × 1 in [152.4 mm × 25.4 mm] sample from 70 °F to 80 °F [21.1 °C to 26.7 °C] using a jaw speed from 10 in to 12 in [254 mm to 304.8 mm] per minute. Provide the sample with an elongation of at least 75 percent at break when tested by this method.

E. Conformability

Provide preformed film that conforms to pavement contours, breaks, and faults at normal pavement temperatures. Provide preformed plastic film that fuses with itself and previously applied marking film of the same composition.

F. Removability

Provide plastic striping tape that cannot be easily removed after application.

G. Adhesive

Provide plastic striping tape for longitudinal and transverse markings with pressure-sensitive backing without liner. Provide word and symbol tape with pressure-sensitive backing and protective liner.

H. Application Properties

Ensure the material adheres to asphalt concrete and portland cement concrete (PCC) surfaces when applied according to manufacturer's recommendations at surface temperature of at least 65 °F [18.3 °C]. If applying the markings when the surface temperature is from 50 °F to 65 °F [10 °C to 18.3 °C], apply in accordance with the manufacturer's recommendations, other special instructions, or both.

I. Glass Beads

Ensure the manufacturer incorporates glass beads for immediate and continuing retroreflection. Ensure the size, quality, and refractive index of the glass beads are such that the beads perform in accordance with Subsection 711.02.K, "Reflectance." Provide bead adhesion so beads are not easily removed when scratching the material surface with a thumbnail.

J. Pigmentation

Thoroughly blend color pigments to provide a pavement marking film that maintains uniform color under day and night lighting conditions throughout the expected life of the film. Provide white pavement marking film similar to Federal Standard Color No. 595-17886. Provide yellow pavement marking film similar to Federal Standard Color No. 595-13538.

K. Reflectance

Provide white and yellow films with an initial reflectance value at observation angles of 0.5° and 0.2°, and an 86° entrance angle, measured in accordance with the Federal Test Method 370. Ensure the specific luminance is measured in millicandelas per square foot per foot-candle (mcd/ft²/fc) [millicandelas per square meter per lux (mcd/m²/lx)]. Perform the test on a 24 in × 30 in [610 mm ×762 mm] sample from 50 ft [15.2 m] away.

Ensure the angular aperture of the photoreceptor and light projector is 6 min of arc. Ensure the reference center is the geometric center of the sample and is taken perpendicular to the test sample.

Table 711:1
White and Yellow Film Reflective Properties

Property	White		Yellow	
Observation angle, °	0.2	0.5	0.2	0.5
Specific luminance, *mcd/ft²/fc [mcd/m²/lux]*	550 [550]	380 [380]	410 [410]	250 [250]

L. Effective Performance Life

Provide a film that leaves a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Ensure the Department, another state DOT, or the National Transportation Product Evaluation Program (NTPEP) qualifies the tape using a performance test of at least 12 months. Provide a pliant polymer that supplies a cushioned, resilient substrate that reduces bead crushing

and loss. Provide weather resistant film that does not fade, lift, tear, roll back, or shrink throughout the marking life.

711.03 NON-REMOVABLE TEMPORARY PAVEMENT MARKING TAPE

A. General

Provide traffic striping material with a white or yellow weather and traffic resistant reflective film on a conformable backing pre-coated with a pressure-sensitive adhesive. Ensure the Department, or another state department of transportation, qualifies the material through a performance test of at least 12 months.

Provide white or yellow retroreflective striping tape as required by the Contract. Ensure the tape reflects white or yellow respectively and is visible with automobile headlights at night.

Provide striping tape with a pre-coated, pressure-sensitive adhesive that does not require activation procedures or a liner to protect from contamination, pre-adhesion, and blocking.

Ensure the material adheres to asphalt concrete and PCC surfaces if applied in accordance with the manufacturer recommendations at surface temperatures of at least 35 °F [1.7 °C], and does not require protective devices.

B. Conformability

Provide thin, flexible, and formable striping material that conforms to the texture of the pavement surface after application.

Ensure the average thickness of the material, taken using five micrometer readings, is from 15 mil to 45 mil [381 µm to 1,143 µm].

C. Durability and Wear Resistance

Provide weather resistant striping material that will not fade, lift, or shrink.

D. Packaging

Provide striping material packaged in standard commercial containers to prevent damage during shipment and storage.

E. Storage

Provide striping material that will not deteriorate when stored for 1 year in temperatures no greater than 100 °F [37.8 °C].

F. Certification

Submit to the Resident Engineer a Type D certification for the non-removable temporary pavement marking tape in accordance with Subsection 106.04, “Materials Certifications.”

711.04 REMOVABLE PAVEMENT MARKING TAPE

A. General

Provide removable pavement marking tape with a white or yellow all-weather, traffic-resistant film on a reinforced, conformable backing.

B. Adhesive

Provide removable, preformed pavement marking film pre-coated with a pressure-sensitive adhesive that is immediately ready for traffic after application. Ensure the film adheres to asphalt concrete and PCC surfaces without heat, solvents, additional adhesives, or activators. Provide adhesives that bond to pavement surfaces if applied at temperatures of at least 50 °F [10 °C] without pickup or distortion by vehicular traffic.

C. Color

Provide removable pavement marking tape in white or yellow that conforms to the standard highway color requirements of MUTCD as required by the Contract.

D. Glass Beads

Provide colorless glass beads with refraction index of at least 1.50 if tested using the liquid immersion method. Provide beads in the size and quantity that maintains retroreflectivity of the film as it wears through the surface course. Ensure the glass beads are uniformly distributed throughout the film for retroreflectivity.

E. Removability

Provide preformed pavement marking film that can be removed, intact or in large strips, from asphalt concrete and PCC surfaces. Ensure removal of the film is possible manually or with a mechanical roll-up device at temperatures above 50 °F [10 °C], and without heat, solvents, grinding, or sandblasting.

F. Durability

Provide film that leaves a neat, durable marking that will not flow or distort due to temperature. Ensure the Department, or another state department of transportation, qualifies the material through a performance test of at least 6 months. Ensure the tape meets the removability requirements through the performance test in accordance with Subsection 711.04.E, "Removability." Provide weather resistant film that will not fade, lift, or shrink.

G. Certification

Submit to the Resident Engineer a Type D certification for the removable pavement marking tape in accordance with Subsection 106.04, “Materials Certifications.”

711.05 GLASS BEADS FOR TRAFFIC PAINT

A. Traffic Paint

Provide glass beads for traffic stripe paint in accordance with AASHTO M 247, Type I. Supply beads with a moisture-resistant coating.

B. Glass Beads For Thermoplastic

Provide drop-on glass beads in accordance with the following:

(1) Appearance

Provide colorless, clean and transparent glass traffic beads that are free of milkiness, excessive air bubbles, skins, and foreign material.

(2) Moisture

Provide glass traffic beads with no greater than 25 percent moisture by weight [mass].

(3) Refractive Index

Provide glass traffic beads with a refractive index of at least 1.5 when tested by the liquid immersion method at 77 °F [25 °C].

(4) Shape

Provide spherically shaped glass traffic beads free of sharp, angular edges. Ensure the beads are free of scars and scratches.

(5) Static Charge

Provide glass traffic beads that do not create static electricity when flowing through a regular traffic bead dispenser.

(6) Gradation

Provide Oklahoma DOT Standard Glass Beads for Thermoplastic with a gradation in accordance with AASHTO M 247, Type I.

Provide Oklahoma DOT Large Glass Beads for Thermoplastic with a gradation in accordance with Table 711:2.

Table 711:2
Large Glass Beads

Open U.S. Standard Sieves	Percent Retained
No. 10	0
No. 12	0 – 5
No. 14	5 – 20
No. 16	40 – 80
No. 18	10 – 40
No. 20	0 – 5
Pan	0 – 2

(7) Roundness

Provide standard gradation glass beads that have at least 80 percent true spheres if tested in accordance with ASTM D 1155. Provide large gradation beads that have at least 80 percent true spheres. The manufacturer will provide a Type A certification for roundness with each shipment of large beads.

(8) Coatings

Provide standard and large glass beads with an adhesion coating to promote adhesion in thermoplastic pavement marking material. Supply standard glass beads in accordance with AASHTO M 247, Type I with a moisture-resistant coating to prevent clumping.

711.06 TRAFFIC STRIPE PAINT – ACRYLIC WATERBORNE

Directly apply waterborne white and yellow traffic paint on asphalt concrete or PCC surfaces or existing traffic stripe composed of solvent based paint, waterborne paint, or thermoplastic compounds. Apply with spray equipment at application temperatures from 50 °F to 150 °F [10 °C to 66 °C]. Provide paint that receives and holds glass beads to produce reflectorized traffic markings.

A. Materials

Provide paint free of lead and chromium with a limited quantity of volatile organic compounds (VOC).

B. General

Provide finished paint formulated and manufactured from first-grade material listed in the Standard Formula. The Resident Engineer must approve alternative materials before manufacture. Ensure the proposed materials equal the quality, composition, and the physical and chemical behavior of the materials on the Standard Formula after aging in the finished product.

C. Pigment

(1) Titanium Dioxide

Provide titanium dioxide in accordance with ASTM D 476, Type II, Rutile. Ensure the hiding power of the titanium dioxide is at least equal to the standard sample if tested in the standard formula.

(2) Pigment Yellow 65

Provide Yellow 65 pigment from Hoechst Celanese, Engelhard, Sun Chemical, or an equivalent approved by the Resident Engineer.

(3) Calcium Carbonate

Provide calcium carbonate in accordance with the ASTM D 1199, Type GC, Grade I, with at least 95 percent calcium carbonate and Type PC with at least 98 percent calcium carbonate.

D. Vehicle

(1) Acrylic Emulsion Polymer

Provide Rohm and Haas E-3427 acrylic emulsion polymer, or an equivalent approved by the Resident Engineer. Ensure the nonvolatile portion of the vehicle is composed of a 100 percent acrylic polymer and is at least 44 percent by weight [mass].

(2) Methyl Alcohol

Provide methyl alcohol in accordance with ASTM D 1152 Specific Gravity, 20/20 °C, from 0.791 to 0.794.

(3) Water

Provide potable water.

(4) Miscellaneous Materials

Provide the miscellaneous materials in accordance with Table 711:3.

Table 711:3
Miscellaneous Materials

Material	Type
Dispersant	Tamol 850
	Colloids 226-35
Surfactant	Triton CF-10
	Colloids CTA 639
Defoamer	Foamaster 111
	Drew 493

Table 711:3 Miscellaneous Materials	
Material	**Type**
Defoamer	Colloids 654
Hydroxy ethyl cellulose	Natrasol 250 HBR
	Bermocoll E431FQ
Coalescent	Texanol
Preservative	Troy 192
	Dowicil 75
	Nuosept 101

E. Manufacture

Deliver ingredient materials in the original containers.

The manufacturer will provide the exact batch formula to manufacture the paint. The Department will not allow changes to the formula without Resident Engineer approval. The Resident Engineer will not approve changes that adversely affect the quality or serviceability of the paint.

The Department will use the standard formulas as specified in Table 711:4 as the basis for the paint. The Department will not allow variations from the standard formula, except for the replacement of volatiles lost in processing or variations reviewed by the Department's Materials Engineer and approved by the Resident Engineer.

Table 711:4 Standard Paint Formulas		
Material	**White, *lb [kg]***	**Yellow, *lb [kg]***
C.I. pigment, yellow 65 (Engelhard 1244)	—	32 [14.5]
Titanium dioxide, rutile, Type II (Kerr McGee CR800)	100 [45.4]	21 [9.5]
Calcium carbonate Type PC (Miss.M-60)	150 [68.0]	150 [68.0]
Calcium carbonate, Type GC (Hubercarb Q6)	430 [195.0]	465 [210.9]
Hydroxy ethyl cellulose (Natrasol 250HBR) [a]	0.5 [0.2]	0.5 [0.2]
Acrylic emulsion, 50% solids (E2706)	541 [245.4]	535 [242.7]
Texanol (Eastman)	24 [10.9]	23 [10.4]
Defoamer (Colloids 654)	5 [2.3]	5 [2.3]
Dispersant (Tamol 850)	8 [3.6]	9 [4.1]
Surfactant (Triton CF10)	2 [0.9]	2 [0.9]
Methyl alcohol	29 [13.2]	28 [12.7]
Preservative (Troy 192)	1.5 [0.7]	1.5 [0.7]
Water	10 [4.5]	10 [4.5]
Total	**1,301 [590.1]**	**1,282 [581.8]**

[a] The Department will allow the amount of hydroxy ethyl cellulose to vary up to 0.1 lb [0.05 kg] to adjust viscosity to desired range.

F. Mixed Paint

If the Resident Engineer allows variations in materials, ensure the mixed paint equals the test results on a standard prepared from the standard formula and tested by the manufacturer under parallel conditions for the listed requirements.

Before filling, strain the paint with a screen no coarser than No. 40 mesh [425 µm] or a sieve meeting the Resident Engineer’s approval.

Provide finished paint with no greater than 1.25 lb [150 g] of VOC per gallon [liter] of total non-volatile paint, in accordance with ASTM D 3960.

Provide paint in accordance with Subsection 711.06.F(1), "Pigment Composition," through Subsection 711.06.F(15), "Dry Through Time."

(1) Pigment Composition

Analyze the extracted pigment in accordance with Table 711:5.

Table 711:5
Pigment Composition

Material	White	Yellow
Organic yellow (65%) [a]	—	≥4.8
Titanium dioxide	≥13.4%	≥2.6%
Calcium carbonate	≤86%	≤93%

[a] To be determined by x-ray florescence, color spectrophotometry, or any other method the Department may choose. This may be sent to an outside agency or organic pigment manufacturer. It also may include audit of the manufacturer's invoices, batch tickets, inventory or other means determined by the Department.

(2) Physical Properties

Table 711:6
Mixed Paint Physical Properties

Property	Value
Total solids by weight [mass]	≥73%
Volume solids	≥58%
Pigment by weight [mass]	49 – 54%
Vehicle by weight [mass]	46 – 51%
Non-volatile in vehicle by weight [mass]	≥44%
Weight [mass] per unit volume, from theoretical	±0.3 lb/gal [±36 g/L]
Viscosity at 77 °F [25 °C]	83 KU – 98 KU
Grind (Hegman Gauge)	≥3
Laboratory dry time, ASTM D 711	≤10 min
Dry through time	≤15 min of Standard Formula

(3) Color

Provide white paint that dries to a flat white color, is free of tint, and has opacity and visibility in both day and artificial light.

Provide yellow paint that matches Color Chip 33538 of Federal Standard 595 and is within 6 percent of the PR 1 chart central color when read over the black portion of a 2A Leneta Chart.

(4) Flexibility

Provide paint that is flexible and will not crack or flake if tested in accordance with Federal Specification TT-P-1952B.

(5) Water Resistance

Provide water resistant paint in accordance with Federal Specification TT-P-1952B. Ensure the paint does not blister, lose adhesion, soften, or deteriorate after the examination.

(6)Freeze-Thaw Stability

Provide freeze-thaw stable paint that does not coagulate, discolor, or change in viscosity greater than 10 KU if tested in accordance with Federal Specification TT-P-1952B.

(7)Heat Stability

Provide heat stable paint that does not coagulate, discolor, or change in viscosity greater than 10 KU if tested in accordance with Federal Specification TT-P-1952B.

(8)Dilution Test

Provide paint that can be diluted with water without curdling or precipitation so that wet paint can be cleaned with water.

(9)Storage Stability

Provide paint that will not cake, skin, liver, curdle, or hard settle after 30 days in a closed container filled three-quarter full. Ensure the paint can be remixed to a smooth, homogeneous state. Ensure the viscosity does not differ from the original sample by greater than 5 KU.

Ensure the pigment will not settle or cake. Provide paint that will not skin, thicken, spoil, or change in consistency after nine months in storage from the packaging date.

Provide paint that can be re-dispersed with a paddle to a smooth, homogeneous condition.

(10)Contrast Ratio

Provide paint with a black/white contrast ratio of at least 0.98 if applied at a wet film thickness of 15 mil [381 μm] on a 2A Leneta Chart, or equivalent, and air dried for 24 hr. The Department defines the contrast ratio as black over white.

(11)Reflectance

Ensure the daylight directional reflectance is at least 84 percent for white paint and at least 50 percent for yellow paint of a 15 mil [381 μm] wet film applied to a 2A Leneta Chart or an equivalent. After drying for 24 hr, use a Colorimeter and ASTM E 97 to measure the reflectance of the paint over the black portion of the chart.

(12)Bleeding

Provide paint with a bleeding ratio of at least 0.97 if tested in accordance with Federal Specifications TT-P-1952B. Provide asphalt-saturated felt in accordance with ASTM D 226, Type I.

(13)Abrasion Resistance

Provide at least 50 gal [190 L] of sand to remove paint film if tested in accordance with Federal Specification TT-P-1952B.

(14)No-Tracking Time Field Test

Dry the paint to a non-tracking condition in no greater than 3 min if applied at 17 mil ±1 mil [432 μm ±25 μm] wet film thickness plus 45 lb/ft³ [719 kg/m³] of glass beads at the specified application temperature. The Department defines “no tracking” as the period when the line dries so a vehicle can run over the line at

40 mph [64 km/h] without tracking the reflectorized line when viewed from 50 ft [15 m] away.

(15)Dry Through Time

Apply the paint to a non-absorbent substrate at a wet film thickness from 17 mil ±1 mil [432 µm ±25 µm]. Place the paint in a humidity chamber controlled 90 ±5 percent relative humidity and from 72.5 °F ±2.5 °F [22.5 °C ±1.4 °C].

Determine the dry-through time in accordance with ASTM D 1640, except that the pressure exerted is the minimum amount to maintain contact with the thumb and film.

SECTION 712
CONSTRUCTION FABRICS

712.01 FABRIC REINFORCEMENT FOR ASPHALT CONCRETE PAVEMENT

A. General

This subsection covers fabrics for hot mix asphalt pavement reinforcement.

B. Requirements

Provide fabric in accordance with AASHTO M 288, meeting the paving fabric requirements.

C. Packaging and Storing

Obtain fabric rolls of standard width and length from the manufacturer. Ensure the manufacturer uniformly winds the fabric on cylinders or cores for mechanical laydown equipment. Ensure the rolls provide full pavement coverage with minimal joint splices.

Protect the fabric from sunlight and moisture by wrapping the rolls. If stored outdoors, elevate the rolls and cover.

712.02 GEOTEXTILES FOR EROSION CONTROL

A. General

This subsection covers pervious fabric under riprap for slope protection, and gabions for separation.

B. Requirements

Provide fabric for erosion control in accordance with AASHTO M 288, “Permanent Erosion Control Geotextile Requirements.”

712.03 GEOTEXTILES FOR SUBSURFACE DRAINAGE PURPOSES

A. General

This subsection covers geotextiles for pipe underdrain and drainage systems.

B. Requirements

Provide fabric for subsurface drainage in accordance with AASHTO M 288, Subsurface Drainage Geotextile Requirements. In addition, use AASHTO M 288, Table 2, with from 15 to 50 percent of in-situ soil passing the No. 200 [75 µm] sieve.

712.04 GEOTEXTILES FOR SUBGRADE REINFORCEMENT

A. General

This subsection covers fabric for subgrade reinforcement under pavement structures.

B. Requirements

Provide fabric for subgrade reinforcement in accordance with AASHTO M 288, "Stabilization Geotextile Property Requirements."

712.05 GEOTEXTILES FOR BASES

A. General

This subsection covers a pervious fabric under base courses for separation.

B. Requirements

Provide a non-woven fabric for base course separation in accordance with AASHTO M 288, "Separation Geotextile Property Requirements" with a Class 2 Degree of Survivability.

712.06 FILTER FABRIC FOR SILT FENCE

A. General

This subsection covers fabric for soil removal from water.

B. Requirements

Provide fabric for temporary silt fence in accordance with AASHTO M 288, "Temporary Silt Fence Property Requirements" for unsupported silt fence with less than 50 percent elongation.

712.07 GEOGRID SUBGRADE REINFORCEMENT OF PAVEMENT STRUCTURES

A. General

This subsection covers geogrid properties for subgrade reinforcement.

B. Requirements

Provide long-chain synthetic polymers for geogrids. Form the polymers into a network so the ribs, filaments, or yarns retain dimensional stability relative to each other and selvages.

Provide the type of geogrid for subgrade reinforcement, as required in the Contract, in accordance with Table 712:1, "Type 1 Geogrid – Property Requirements," or Table 712:2, "Type 2 Geogrid – Property Requirements." A geogrid consists of a regular network of integrally connected tensile elements with apertures that allow

interlocking with surrounding soil, rock, or earth, forming a biaxial polymeric grid. The Department will not allow polyester geogrid.

Table 712:1
Type 1 Geogrid – Property Requirements

Property	Test Method	Value [a]
Reinforcement properties:		
2% and 5% tensile modulus	ASTM D6637 [b]	≥14,000 lb/ft
Junction strength, per junction	GRI GG2	≥50 lb
Aperture size	Direct measure	1.0 in – 2.0 in
Rib thickness	Direct measure	≥0.03 in
Percent open area	COE CW-02215	≥70%
Aperture stability	COE Method	2.56 kg-cm/deg
Survivability index values:		
Ultimate tensile strength	ASTM D6637 [b]	850 lb/ft
Junction efficiency	GRI GG2	89%
Flexural stiffness	ASTM D1388	250,000 mg-cm

[a] Values, except Ultraviolet Stability, Aperture Size, and Coefs are MARVs.
[b] Modified test method for geogrids.

Table 712:2
Type 2 Geogrid – Property Requirements

Property	Test Method	Value [a]
Reinforcement properties:		
2% and 5% tensile modulus	ASTM D6637 [b]	≥20,000 lb/ft
Junction strength, per junction	GRI GG2	≥75 lb
Aperture size	Direct measure	1.0 in – 2.0 in
Rib thickness	Direct measure	≥0.05 in
Percent open area	COE CW-02215	≥70%
Aperture stability	COE Method	3.7 kg-cm/deg
Survivability index values:		
Ultimate tensile strength	ASTM D6637 [b]	1,300 lb/ft
Junction efficiency	GRI GG2	89%
Flexural stiffness	ASTM D 1388	750,000 mg-cm

[a] Values, except Ultraviolet Stability, Aperture Size, and Coefs are MARVs.
[b] Test method for geogrids.

C. Packing, Shipment, and Storage

Label, ship, and store geogrids in accordance with ASTM D4873. Label the product with the manufacturer or supplier name, style name, and roll number.

712.08 FABRIC FOR TURBIDITY CURTAIN

A. General

Provide fabric for Turbidity Curtain that meets the following requirements:

- Sew or heat-bond hemmed pockets for flotation devices and bottom weights.
- Place metal grommets through reinforced hems on panel ends.
- Tie connections between panels with synthetic or wire rope to prevent flow through the joint.

B. Requirements

Provide fabric in accordance with Table 712:3. If the provided fabric is polymer impregnated, negate the permittivity and opening size requirements.

Table 712:3
Property Requirements

Property	ASTM Test Method	Value [a]
Grab tensile strength	D4632	≥270 lb [1.2 kN]
Trapezoidal tear strength	D4533	≥100 lb [445 N]
Puncture strength	D4833	≥100 lb [445 N]
Mullen burst strength [b]	D3786	400 psi [2,760 kPa]
Permittivity	D4491	≤0.06 per second
Apparent opening size [c]	D4751	400 psi [2,760 kPa]

[a] Minimum average roll value.
[b] ASTM D3786-87. The fluid displacement rate for the Mullen burst test equipment must be from 165 mL/min to 175 mL/min. Subtract tare strength from the ultimate burst strength in accordance with ASTM.
[c] The Department will allow filtration opening size (FOS, Canadian General Standards Board, Method 148.1 No. 10) as an alternative test method to ASTM D4751 for non-woven geotextiles.

712.09 WATERPROOF MEMBRANE FOR ASPHALT OVERLAY

A. General

This subsection covers the polymer type, geotextile fabric backed, waterproof membrane properties for use when placing an asphalt concrete overlay on a concrete bridge deck.

B. Requirements

Provide a non-woven polypropylene backing fabric with rubberized asphalt as the waterproofing agent and meeting the requirements of Table 712:4. Ensure the membrane can withstand the temperatures obtained during the application of "super pave" asphalt concrete which can briefly reach 350 ºF.

Table 712:4
Waterproof Membrane for Concrete Bridge Deck Overlays

Property	Test Method	Value
Thickness	ASTM D1000	65 mil [1.65 mm]
Tensile strength, average of machine and cross machine directions	ASTM D882 (Method A)	≥50 lb/in [8.8 kN/m] of width
Puncture resistance	ASTM E154	≥200 lb [890 N]
Permeance, perms	ASTM E96 (Method B)	≤0.1
Softening point of waterproofing compound	ASTM D36	≥205 ºF [96 ºC]
Pliability at −15 ºF [−26 ºC] using a ¼ in [6.35 mm] mandrel and 180º bend	ASTM D146 (Modified)	No cracks in fabric or rubberized asphalt

SECTION 713
EROSION CONTROL STONE

713.01 RIPRAP STONE

Determine the bulk specific gravity and absorption in accordance with ASTM D 6473. Ensure the bulk specific gravity is at least 2.25, and the maximum absorption is 6.0 percent. Ensure the loss of soundness after 20 cycles is no greater than 15 percent when tested in accordance with the U.S. Army Corps of Engineers test method CRD-C 144. Provide riprap pieces with a width and thickness at least one-third the length. If placed on the embankment, distribute smaller stones throughout the mass. Provide the stone sizes specified in Table 713:1, Table 713:2, and Table 713:3:

Table 713:1
Stone for Plain Riprap (Type I)

Riprap Thickness, *in [mm]*	Sizes, *lb [kg]*		
	Maximum	**Average**	**More than 80% of the riprap stone**
12 [300]	150 [70]	30 – 50 [13 – 23]	≥20 [9]
18 [450]	300 [150]	70 – 125 [30 – 60]	≥30 [14]
24 [600]	1,000 [450]	225 – 400 [100 – 180]	≥40 [18]
30 [750]	1,000 [450]	225 – 400 [100 – 180]	≥40 [18]
36 [900]	2,000 [900]	450 – 800 [200 – 360]	≥80 [36]

Table 713:2
Stone for Special Plain Riprap (Type II)

Percent of Total Volume	Volume of each stone, *ft³ [m³]*
40 – 60	5 – 12 [0.142 – 0.340]
20 – 30	2 – <5 [0.057 – <0.142]
10 – 20	0.25 – <2 [0.007 – <0.057]
5 – 15	<0.25 [0.007]

Table 713:3
Stone for Laid up (Type III) or Grouted Riprap (Type IV)

Riprap Thickness, *in [mm]*	Sizes, *lb [kg]*	
	Range	**60% or more of the riprap stone**
12 [300]	50 – 250 [23 – 113]	>100 [45]
18 [450]	50 – 250 [23 – 113]	>150 [68]
Note: The Department will not allow slabs or slivers. Use well graded, appropriately sized spalls.		

713.02 FILTER BLANKET MATERIAL

Provide material for a filter blanket consisting of sand, gravel, or crushed stone, that has been processed, blended, or naturally combined. Limit deleterious materials to no greater than 3 percent. Provide filter blanket material containing 20 percent or less flat or

elongated particles at a ratio of 1:5 if tested in accordance with ASTM D 4791. Provide filter blanket within the gradation limits specified in Table 713:4 or Table 713:5:

Table 713:4
Single Course Filter Blanket Gradation

Sieve Size	Percent Passing
4 in [100 mm]	100
2 in [50 mm]	60 – 90
1 in [25 mm]	40 – 70
⅜ in [9.5 mm]	15 – 40
No. 4 [4.75 mm]	0 – 15

Table 713:5
Two Course Filter Blanket Gradation

Sieve Size	Percent Passing	
	Lower Course	Upper Course
6 in [150 mm]	—	100
4 in [100 mm]	—	90 – 100
2 in [50 mm]	—	65 – 85
1 in [25 mm]	—	40 – 70
⅜ in [9.5 mm]	100	15 – 35
No. 4 [4.75 mm]	95 – 100	0 – 10
No. 8 [2.36 mm]	80 – 90	—
No. 16 [1.18 mm]	55 – 75	—
No. 30 [600 µm]	30 – 60	—
No. 50 [300 µm]	12 – 30	—
No. 100 [150 µm]	0 – 10	—

713.03 GABIONS, REVETMENT MATTRESSES, AND ROCK FILTER DAMS

Provide stone fill for gabions, revetment mattresses, and rock filter dams that is rough-fractured, cubical, and has the following characteristics:

- A soundness loss of no greater than 15 percent after 20 cycles when tested in accordance with the U.S. Army Corps of Engineers test method CRD-C 144.
- A bulk specific gravity of at least 2.5 in accordance with ASTM D 6473.
- Dimensions in accordance with Table 713:6:

Table 713:6
Stone Dimensions

Structure Type	Dimension
Gabions [a] / rock filter dam	4 in – 8 in [100 mm – 200 mm]
Revetment mattresses [b]	3 in – 5 in [75 mm – 125 mm]

[a] If the gabion height exceeds 18 in [450 mm], the Department will allow 5 percent of the stone to have a maximum dimension of 10 in [250 mm].
[b] For 12 in [300 mm] revetment mattresses, the Department will allow the stone to have a maximum dimension of 6 in [150 mm].

SECTION 714
MASONRY BRICK

714.01 MASONRY BRICK MADE FROM CLAY OR SHALE

Unless otherwise shown on the Plans, provide Grade MW or SW masonry brick made from clay or shale in accordance with AASHTO M 114, except, the requirements for "Maximum Water Absorption by Five-Hour Boiling" and "Maximum Saturation Coefficient" do not apply.

Use Grade MM or Grade MS bricks for manhole brick, in accordance with AASHTO M 91.

714.02 CONCRETE BUILDING BRICK

Provide normal weight concrete building brick in accordance with ASTM C 55, except, the requirements for "Water Absorption," "Moisture Content," and "Linear Shrinkage" do not apply.

SECTION 719
SIGNS

719.01 PANELS

A. Aluminum

(1) Sheet Aluminum

Provide sheet aluminum signs in accordance with ASTM B 209, alloy 6061-T6 or alloy 5052-H38 with mill finish. Use the dimensions, hole sizes, and hole locations shown on the Plans. Ensure panels are flat and straight within commercial tolerances. Treat sheet aluminum signs with a chromate type chemical conversion coating in accordance with ASTM B 449, Class II.

(2) Extruded Aluminum

Provide extruded aluminum panel signs in accordance with ASTM B 221, alloy 6063-T6 with the dimensions, hole sizes, and hole locations shown on the Plans. Keep panels flat and straight within commercial tolerances. Ensure extruded aluminum is free of corrosion, white rust, and dirt.

Provide aluminum edge strip in accordance with ASTM B 221, alloy 6063-T6. Place aluminum sheet metal screws with slotted pan heads on centers no greater than 24 in [609.6 mm] to secure the edge strips to the sign panels. On signs less than 36 in [914.4 mm] wide, use at least three screws.

B. Sign Faces

Make sign faces in accordance with the drawings in the latest revision of the MUTCD, and as shown on the Plans.

719.02 SUPPORT ARMS AND FITTINGS

A. Materials

For sign supports for sheet signs, use structural steel in accordance with AASHTO M 270, Grade 36, or aluminum alloy in accordance with ASTM B 221, alloy 6063-T6.

B. Fabrication

Provide pre-fabricated sign supports, bracket arms, and fittings that are cut to the shapes and dimensions shown on the Plans before degreasing, etching, and applying reflective sheeting. Ensure parts are free of buckles, warp, dents, cockles, burrs, and defects.

719.03 SHEET AND EXTRUDED ALUMINUM SIGN FASTENERS

For bolts for fastening sheet aluminum signs to sign bracket arms, use aluminum fasteners and collars sized as shown on the Plans.

For panel bolts, hex nuts, post clip bolts, stop nuts, and flat washers, use aluminum ASTM B 209, alloy 2024-T4. Attach extruded aluminum signs to posts on each side with post clips, post clip bolts, and nuts and flat washers, as shown on the Plans. Use flat washers under nuts to prevent gouging.

719.04 RETROREFLECTIVE SHEETING

A. Description

Use retroreflective sheeting to make reflectorized sign faces as shown on the Plans. Provide Type II retroreflective sheeting, unless otherwise required by the Contract.

B. Requirements

Provide materials for retroreflective sheeting in accordance with ASTM D 4956, and the supplementary specifications of S3. Provide sheeting with a Class 1 adhesive backing. Perform outdoor weathering on an AASHTO, National Transportation Product Evaluation Program test deck.

The Resident Engineer will inspect completed signs, and will not accept sign faces with faults or blemishes that impair serviceability or mismatched colors visible from a distance of 25 ft [7.6 m] under day or night light conditions.

719.05 SIGN COPY (SCREEN COPY)

A. Direct Screening Process

The Department will allow the direct screening process for applying a non-reflectorized copy on reflectorized or non-reflectorized backgrounds. This process normally applies to black copy.

B. Reverse Screening Process

Use the reverse screening process to provide reflectorized messages on colored backgrounds with transparent color stencil paste applied to a silver white sheeting background. This process normally applies to white copy, for example, the “STOP” sign.

C. Material and Application

For the silk screen method, apply a top quality, exterior baking screen enamel or stencil paste designed for roadway signs and compatible with the type of background material. Apply and cure the screened copy in accordance with the manufacturer's recommendations for the background material.

Use durable colors in accordance with the FHWA Standards Colors Charts for Signs. Ensure the colors appear uniform in hue when viewed in daylight and under normal headlights at night.

D. Final Finish

Treat signs after completion in accordance with Subsection 850.04.C, "Finishing Signs."

E. Tests

Ensure screening enamel, stencil pastes, and process inks do not discolor, crack, craze, blister, or lift when applied and exposed to accelerated weathering for 1,000 hr in accordance with Federal Test Method 141/6151.

719.06 RETROREFLECTIVE AND NON-RETROREFLECTIVE CUTOUT LETTERS, NUMERALS, ARROWS, SYMBOLS, AND BORDERS

Design letters in accordance with the 1966 FHWA standard alphabets (as revised). For retroreflective cutout letters, use Type III or Type IV retroreflective sheeting in accordance with Subsection 719.04, "Retroreflective Sheeting."

SECTION 720
OVERHEAD SIGN STRUCTURES

720.01 ALUMINUM

A. Aluminum Alloy Extruded Tube

Provide aluminum alloy extruded tube in accordance with ASTM B 221, alloy 6061 T6.

B. Aluminum Alloy Permanent Mold Castings

Provide aluminum alloy permanent mold castings in accordance with ASTM B 108, alloy SC 70A, F or T 71.

C. Aluminum Alloy Sand Castings

Provide aluminum alloy sand castings in accordance with ASTM B 26, alloy SC 70A, F or T7.

D. Aluminum Alloy Plate

Provide aluminum alloy plate in accordance with ASTM B 209, alloy 6061 T6.

E. Aluminum Alloy Bolts

Provide aluminum alloy bolts consisting of rod in accordance with ASTM B 211, alloy 2024 T4. Provide bolt heads in accordance with American Standard Regular Hexagon, ASA B18.2. Ensure the threads are in accordance with Class 2 or Class 2A. Give the finished bolt an anodic coating in accordance with a No. 204 aluminite finish.

As an alternative, the Department will allow the use of stainless steel bolts in accordance with ASTM F 593.

F. Nuts

Provide self-locking nuts in accordance with the Air Force-Navy Aeronautical "Nuts, Self-Locking, AN-N-5b," or an equivalent approved by the Resident Engineer.

AS an alternative, the Department will allow the use of stainless steel nuts in accordance with ASTM F 594.

G. Aluminum Alloy Washers

Provide aluminum alloy washers made from sheet in accordance with ASTM B 209, alloy 2024 T4.

As an alternative, the Department will allow stainless steel washers in accordance with ASTM F 594.

H. Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes

Provide filler wire for welding in accordance with AWS A5.10.

I. Aluminum Extruded Shapes

Provide aluminum extruded structural shapes in accordance with ASTM B 221, alloy 6061 T6.

J. Aluminum Alloy Pipe

Provide aluminum alloy pipe for handrail in accordance with ASTM B 241, schedule 40, alloy 6063 T6.

K. Anchor Bolts, Nuts, and Washers

Provide anchor bolts, nuts, and washers in accordance with ASTM A 307 for steel machine bolts, nuts, and tap bolts. Ensure the exposed portion plus 6 in [152 mm] of steel anchor bolts, nuts, and washers are zinc-plated.

As an alternative, the Department will allow stainless steel bolts, nuts, and washers in accordance with ASTM F 593 and ASTM F 594.

720.02 STEEL

A. Tube or Pipe Members

Provide round tube or pipe members in accordance with ASTM A 53, Grade B. Galvanize both horizontal truss units and the vertical end support units in accordance with AASHTO M 111, after welding, and punching or drilling holes.

B. Bolts, Nuts, and Plain Washers

Provide bolts, nuts, and plain washers of the size required by the Contract in accordance AASHTO M 164. Galvanize bolts, nuts, and plain washers in accordance with AASHTO M 232.

720.03 WELDING REQUIREMENT

A. Welding Requirements for Aluminum

Provide welding aluminum alloys for sign structures, bridge rails, and lamp posts. Ensure welding terms are interpreted in accordance with the definitions in AWS Definitions-Welding and Cutting (AWS A3.0).

The welding symbols shown on the Plans are shown in the Standard Welding Symbols (AWS A2.1). Explain special conditions in added notes or details.

Weld in accordance with ANSI/AWS D1.2.

(1) Qualification of Procedures, Welders, and Welding Operators

Before beginning welding operations, ensure joint welding procedures, welders, and welding operators are qualified by tests in accordance with ANSI/AWS D1.2 Aluminum Structural Welding Code. The Resident Engineer may accept evidence of previous qualification of the joint welding procedures, welders, and welding operators. Use the same process and equipment required by the Contract for the work to qualify welders and welding operators.

(2) Identification Marks

Use low-stress stencils to make identification marks. Ensure the Fabricator's mark is adjacent to the item number on each structure.

Ensure the welder's identification is placed with low-stress steel dyes. Ensure the figures on the tags are at least ½ in [12.5 mm] high. Place the area adjacent to primary member welds. Highlight the area to facilitate inspection.

(3) Weld Quality

Ensure welds are in accordance with ANSI/AWS D1.2.

To avoid rejection of an entire piece or member that contains unacceptable welding, correct defective welds in accordance with ANSI/AWS D1.2. Repair defective welds if approved by the Resident Engineer, at no additional cost to the Department.

(4) Inspection

To determine compliance for weld quality, the Resident Engineer will visually inspect welds. The Resident Engineer will also inspect welds subjected to computed stress by the dye penetrant method, except for the following:

- For highway sign structures, use the dye penetrant method on fillet welds that connect columns to bases and main chord members, including the associated flanges, gussets, or main load-carrying brackets or members, as well as on fillet welds connecting flanges to the main truss chord members.
- The Resident Engineer will perform dye penetrant tests in accordance with ASTM E 165, Method B, Procedure B-2 or Procedure B-3.
- The Resident Engineer may omit the dye penetrant inspection if the inspector uses a 3X magnifier to examine each layer of weld metal before the next layer is deposited.

B. Welding Requirements for Steel

Ensure welding material and methods, including welder qualification, are in accordance with ANSI/AWS D1.1.

720.04 FABRICATION

Submit to the Resident Engineer a Type A certification in accordance with Subsection 106.04, "Material Certifications," that covers each component part of the structure before fabrication. Ensure the structure has no sharp edges, irregularities, misfits, or structural deficiencies. Ensure each member fits and can be quickly erected.

Before shipment, the Resident Engineer will inspect the completed structure at the fabrication site.

720.05 SHIPPING AND ERECTION

Protect the structures to prevent damage or defacement during transportation or handling. The Resident Engineer will visually inspect the structure when delivered to the project. Repair or replace defects as approved by the Resident Engineer, at no additional cost to the Department. The Department will not allow the use of metal tie-downs in direct contact with the structure.

The Resident Engineer will not accept damaged or defaced galvanized steel structures, unless in the opinion of the Resident Engineer, the injury or defacement is so slight that it can be quickly and efficiently regalvanized or metalized in accordance with AWS C2.2.

720.06 ELECTRICAL REQUIREMENTS

Provide electrical equipment, materials, and installation methods in accordance with NEC and the electrical code in the appropriate jurisdiction.

If power is not present at the project site, provide temporary power to the site to demonstrate proper installation of fixtures and equipment.

SECTION 721
GALVANIZED STEEL SIGN POSTS

721.01 PIPE POSTS

Provide posts made of new galvanized steel pipe in accordance with ASTM A 53 or ASTM F 1083. Use standard weight, Schedule 40 pipe. Provide cap plates made of, AASHTO M 270, Grade 36 structural steel, galvanized in accordance with AASHTO M 111. Galvanize pipe posts after fabrication, hole punching, or drilling, except, for signs that are minor items or incidental construction, drill or punch sign post holes and cut one end to length after galvanizing as approved by the Resident Engineer. Treat the exposed metal surfaces of these minor items or incidental construction by regalvanizing, metalizing, or painting with at least 90 percent zinc-rich paint.

721.02 WIDE FLANGE BEAM POSTS

Provide galvanized steel wide flanged beams in accordance with AASHTO M 270, Grade 36. Galvanize in accordance with AASHTO M 111 after cutting, punching, or drilling holes.

721.03 SQUARE TUBE POSTS

Provide square tube posts made from new hot-rolled carbon sheet steel, structural quality, ASTM A 1011. Provide a finish that is in-line, hot-dip galvanized zinc coating in accordance with AASHTO M 120, followed by a chromate conversion coating, and a clear organic exterior coating. Provide posts with $^{7}/_{16}$ in [11.1 mm] diameter holes or perforated holes spaced 1 in [25.4 mm] on center along the center of each of the four sides.

721.04 FLANGE CHANNEL POSTS

Provide new galvanized flange channel posts of the size shown on the Plans and in accordance with AASHTO M 270, Grade 36. Galvanize posts in accordance with AASHTO M 111 after cutting, punching, or drilling holes.

SECTION 723
REINFORCING STEEL

723.01 BAR STEEL REINFORCEMENT — BILLET STEEL

Provide plain or deformed billet steel bars for concrete reinforcement and dowels in accordance with AASHTO M 31, Grade 60 [400], except, provide deformed billet steel bars for bent tie bars used in concrete paving in accordance with AASHTO M 31, Grade 40 [280].

723.02 WELDED STEEL WIRE FABRIC

Provide cold drawn steel wire fabric for concrete reinforcement in accordance with AASHTO M 55 or AASHTO M 221. Provide the wire size and spacing as shown on the Plans.

Provide reinforcing fabric in flat sheets or rolls. Straighten bent or distorted materials before use. Ensure the fabric is free of excessive rust, scale, or coating that may impair the concrete bond.

723.03 STEEL WIRE STRAND FOR PRESTRESSING

Provide steel wire strands for prestressing in accordance with AASHTO M 203, Grade 270 [1860], for low-relaxation and stress-relieved (normal-relaxation). Provide low-relaxation strand in accordance with the supplementary requirements in AASHTO M 203.

723.04 BARS FOR POSTTENSIONING

Provide high strength alloy steel bars in accordance with AASHTO M 275.

723.05 POSTTENSIONING STEEL WIRE

Provide steel wire strands for post-tensioning in accordance with AASHTO M 204, Type BA or Type WA.

If required by the Contract, provide low-relaxation wire in accordance with the supplementary requirements in AASHTO M 204.

723.06 ANCHORAGES FOR POST-TENSIONED TENDONS

Provide anchorages for post-tensioned tendons with the following characteristics:

- Capable of de-tensioning or re-tensioning prestressing steel at any time before grouting.
- Capable of distributing the load from the anchoring device to the concrete using devices approved by the Resident Engineer.
- Capable of developing the ultimate tendon strength required by the Contract without exceeding anticipated set.
- Ensure bending stresses in the plates or assemblies induced by the pull of the prestressing steel do not exceed the material yield point.
- Ensure anchoring device parts are at least 2 in [50 mm] inside the member final end surfaces.

723.07 COLD DRAWN STEEL WIRE

Provide cold drawn steel wire, in accordance with AASHTO M 32, for spiral ties and other reinforcing shown on the Plans as "W" (Wire) sizes.

723.08 EPOXY COATED REINFORCING BARS

Provide epoxy coated (an electro-statically applied organic coating) reinforcing bars and epoxy coating material in accordance with AASHTO M 284, except for the following:

- Provide reinforcing steel bars in accordance with Subsection 723.01, "Bar Steel Reinforcement — (Billet Steel)."
- Provide finished epoxy coating in a color and tone that easily gives visual indications of holidays, damage, or corrosion staining.

SECTION 724
STRUCTURAL STEEL

724.01 STRUCTURAL STEEL

Provide steel grades as required by the Contract. If the structural steel grade is not specified by the Contract, provide high strength, low alloy structural steel in accordance with AASHTO M 270 (ASTM A 709), Grade 50W [345W]. Provide steel for main load-carrying member components in accordance with the Charpy V-Notch (CVN) Impact Test requirements of AASHTO M 270 for Zone 2.

Components subject to the CVN requirements include, but are not limited to, the following:

- Flanges and webs of welded plate girders,
- Rolled beams,
- Cover plates,
- Stiffeners (longitudinal, intermediate, or bearing),
- Diaphragm and cross-frame components in curved girder bridges,
- Connection plates for main load-carrying components (such as splice plates and filler plates over ¼ in [6 mm] thick), and
- Steel welded to any of these components.

Steel components not subject to CVN requirements include:

- Shoes,
- Diaphragm and cross-frame components in straight girder bridges,
- Lateral bracing,
- Diagonals,
- Armor joints,
- Finger joints,
- Expansion devices,
- Handrails, and
- Guardrails.

Provide rolled steel plates, shapes, sheet piling, and bars for structural steel in accordance with AASHTO M 160. Provide permanent sheet piling in accordance with AASHTO M 160, Grade 50W [345W]. Provide temporary sheet piling in accordance with AASHTO M 160, Grade 50 [345].

Provide mill test reports for each heat of material.

Provide structural steel materials in accordance with Table 724:1.

Table 724:1
Structural Steel Requirements

Material	Requirement
Carbon steel	AASHTO M 270, Grade 36 [250]
High strength, low alloy structural steel	AASHTO M 270, Grade 50 [345] or Grade 50W [345W]
High strength, low alloy, high performance structural steel plate	AASHTO M 270, Grade HPS 70W [HPS 485W]
High yield strength, quenched, and tempered alloy steel plate	AASHTO M 270, Grade 100 [690] or Grade 100W [690W]
Quenched and tempered alloy steel structural shapes and seamless mechanical tubing [a]	AASHTO M 270, Grade 100 [690] or Grade 100W [690W]
Cold-formed welded or seamless structural tubing	ASTM A 500, Grade B
Hot-formed welded or seamless tubing	ASTM A 501
Plain steel sheet for reinforcement in elastomeric bearing pads	ASTM A 1011, Grade 36 [250] Type 1 or Grade 40 [275]

[a] The Department will consider structural shapes with maximum tensile strength of 140 ksi [965 MPa] and seamless mechanical tubing with maximum tensile strength of 145 ksi [1,000 MPa] to be AASHTO M 270 (ASTM A 709), Grades 100 [690] or Grade 100W [690W] steel, provided all other requirements of the specification are met.

724.02 HIGH STRENGTH FASTENERS

A. General Material Requirements

Provide high strength bolts for structural steel joints in accordance with AASHTO M 164 (ASTM A 325) or AASHTO M 253 (ASTM A 490). Provide Type 3 high strength bolts when used with weathering grades of steel.

Ensure the supplier provides a lot number on the shipping package and a certification with the following information:

- Testing time and location,
- The rotational capacity tests, and
- Zinc thickness if using galvanized bolts and nuts.

The Department requires proof load tests for bolts in accordance with ASTM F 606, Method 1. Wedge-test full size bolts when performing proof load tests in accordance with AASHTO M 164 (ASTM A 325). Wedge-test galvanized bolts after galvanizing. For nuts, perform proof load tests in accordance with AASHTO M 291 (ASTM A 563). Perform proof load tests for nuts to be used with galvanized bolts after galvanizing, over-tapping, and lubricating.

Provide nuts for corresponding bolts in accordance with Table 724:2.

Table 724:2
Specifications for Nuts

Bolt Classifications	Nut Classifications
For AASHTO M 164 (ASTM A 325) bolts	AASHTO M 291 (ASTM A 563), Property Class 8S, 8S3, 10S, or 10S3
For AASHTO M 164 (ASTM A 325) bolts, galvanized (hot-dip or mechanical)	AASHTO M 291 (ASTM A 563), Property Class 10S
For AASHTO M 164 (ASTM A 325) bolts, Type 3 (weathering)	AASHTO M 291 (ASTM A 563), Property Class 8S3 or 10S3
For AASHTO M 253 (ASTM A 490) bolts	AASHTO M 291 (ASTM A 563), Property Class 10S or 10S3
For AASHTO M 253 (ASTM A 490) bolts, Type 3 (weathering)	AASHTO M 291 (ASTM A 563), Property Class 10S3

Deliver and install black bolts that are oily to the touch. Clean and re-lubricate weathered or rusted bolts before installation.

Provide hardened steel washers in accordance with AASHTO M 293 (ASTM F 436) and Subsection 506.04.F(6)(d)3), "Washers." Use Type 3 washers with Type 3 weathering bolts.

B. Galvanized High Strength Fasteners

Do not galvanize AASHTO M 253 (ASTM A 490) bolts.

Provide hot-dip galvanized fasteners in accordance with AASHTO M 232 (ASTM A 153), Class C, or provide mechanically galvanized fasteners in accordance with AASHTO M 298 (ASTM B 695), Class 50. Ensure bolts to be galvanized are in accordance with AASHTO M 164 (ASTM A 325), Type 1 or Type 2 and direct tension indicators (DTIs) are in accordance with Subsection 724.02.D, "Direct Tension Indicators." When the Contract requires Type 2 bolts and DTIs to be galvanized, mechanically galvanize in accordance with AASHTO M 298 (ASTM B 695), Class 50. Tension-test galvanized bolts after galvanizing. Galvanize washers, nuts, and bolts using the same process, hot-dip or mechanical.

Over-tap the nuts to the minimum amount required for fastener assembly. Lubricate galvanized nuts with a lubricant containing a visible dye.

C. Alternative Fasteners

The Resident Engineer may approve alternative fasteners that differ in some dimensions from those required in Subsection 724.02.A, "General Material Requirements."

D. Direct Tension Indicators

The Department will allow direct tension indicators (DTIs) with bolts, nuts, and washers in accordance with Subsection 724.02.A, "General Material Requirements." Provide DTIs in accordance with ASTM F 959.

Ensure DTIs used with weathering steel are manufactured from steel in accordance with the chemical specifications of AASHTO M 164 for Type 3 and ASTM F 959.

724.03 WELDING

A. General

For shop and field welding, arc weld in accordance with ANSI/AASHTO/AWS D1.5, Bridge Welding Code. Ensure the welding inspector is an AWS Certified Welding Inspector in accordance with AWS QCI, *Standard for Qualification and Certification of Welding Inspectors*. The Department will allow the fabrication of the following ancillary products without performing the Welding Procedure Specification (WPS) described in the Bridge Welding Code and without an AWS Certified Welding Inspector:

- Bearing plates,
- Expansion joints,
- Hand rails,
- Sheet piling, and
- Other products not subject to calculated tensile stress from live load and not welded to main members in tension areas as determined by the Resident Engineer.

Weld pile splices, excluding sheet piling, in accordance with Subsection 514.04.E(1), "Steel Piles."

The Department will not allow welding when the air temperature is less than 20°F [−6°C] or when surfaces are wet or exposed to rain or snow. Ensure welding is not performed when operators are exposed to high winds or inclement conditions that will hamper good workmanship, except as approved by the Resident Engineer. Use heat to dry surfaces before welding. Provide wind breaks to protect welding operations.

Use a low-stress stencil to place a permanent identification mark adjacent to welds immediately after welding.

B. Qualification of Welders

(1) Field Welders

"Field welder" refers to the welder, the welding machine, and a class or group of manual shielded electrodes for welding structural grades of steel.

The Department's Materials Division will qualify field welders in accordance with the current ANSI/AASHTO/AWS D1.5, Bridge Welding Code and the Department's Materials Engineer instructions. The Department's Materials Laboratory will provide test plates. Ensure the welder applicant pays for cutting and machining test specimens from the test weld plates.

The Department will issue qualification certificates to field welders based on satisfactory test results. The Department will void qualification certificates if the field welder does not accomplish satisfactory welding on a Department project in a 12 month period. Submit qualification evidence of each field welder to the Resident Engineer before welding.

(2) Shop Welders and Welding Operators

The Department's "Shop Inspection" Testing Laboratory will qualify shop welders and welding operators at the shop's expense in accordance with the section on "Qualification" in the ANSI/AASHTO/AWS D1.5 Bridge Welding Code and the Department's Materials Engineer instructions. The shop will provide the base

material test plates for the qualification tests, at no additional cost to the Department. The Department or its representative will issue qualification certificates to shop welders based on satisfactory examination results. Ensure the welder is pre-qualified within 12 months before starting work on the subject structure. The Resident Engineer may accept the welder as qualified if the examination was provided by another state DOT.

Ensure the welder, welding operator, or tacker has performed satisfactory welding of the required type within 3 months before the subject work.

Submit a certification for each welder, welding operator, or tacker, stating the following:

- Name of the welder, welding operator, or tacker;
- Name and title of the person who conducted the examination;
- Kind of specimens;
- Weld positions;
- Test results; and
- Examination date.

C. Procedure

(1) General

Make beam and girder splices using a sequence of alternating weld passes from side to side to prevent heat build-up on one flange edge. Progress upward on passes in the vertical position.

(2) Welding Procedure for Splices

Begin and terminate groove welds at the ends of a joint on extension bars. Ensure edge preparation and thickness of extension bars are the same as the welded member and extend at least ¾ in [20 mm] beyond the joint. After the welding cools, remove extension bars with a cutting torch. Grind the flange edges smooth. Smooth-finish welded flange splices flush with the base metal on surfaces by grinding in the direction of applied stress, along the longitudinal axis of the girder, leaving surfaces free of depressions.

D. Filler Metal

If the Contract requires bare and unpainted structural steel, ensure the deposited weld metal has an atmospheric corrosion resistance and coloring characteristics similar to the base metal. Comply with the steel manufacturer's recommendations, Table 724:3, and ANSI/AASHTO/AWS D1.5, "Bridge Welding Code," paragraph 4.1.

Table 724:3 Filler Metal Specifications	
Filler Metal	**Specification**
Shielded metal arc welding (SMAW) electrodes	ANSI/AWS A5.1 or A5.5
Electrodes and fluxes for submerged arc welding (SAW)	ANSI/AWS A5.17
Electrodes for gas metal arc welding (GMAW)	ANSI/AWS A5.18
Electrodes for flux-cored arc welding (FCAW)	ANSI/AWS A5.20

Ensure electrodes and electrode-flux combinations are compatible with the type and thickness of the welded steel. Use electrodes and electrode-flux combinations with the type current, polarity, and positions in accordance with ANSI/AASHTO/AWS D1.5.

724.04 WELDED STUD SHEAR CONNECTORS

A. General

Provide, install, and inspect end-welded stud shear connectors that are welded to steel beams, girders, or plates to connect them to concrete in composite steel-concrete construction in accordance with the ANSI/AASHTO/AWS D1.5, "Bridge Welding Code."

Before ordering studs, submit the following to the Resident Engineer:

- The stud manufacturer's name,
- A description of the stud and arc shield,
- A certification from the manufacturer that the stud base is qualified, and
- A copy of the qualification test report as certified by the testing laboratory.

B. Materials

Ensure shear connector studs are in accordance with the requirements for Cold Finished-Carbon Steel Bars and Shafting, AASHTO M 169 (ASTM A 108), cold drawn bars, Grade 1015, Grade 1018, or Grade 1020, semi-killed or fully killed deoxidation. If using flux-retaining caps, provide a low carbon grade steel for caps in accordance with the requirements for Cold-Rolled Carbon Steel Strip, ASTM A 109M. Perform tests of bar stock after drawing or of finished studs to ensure the tensile properties are in accordance with Table 724:4.

Table 724:4 Tensile Properties of Shear Connectors	
Property	**Minimum**
Tensile strength	60 ksi [415 MPa]
Yield strength [a]	50 ksi [335 MPa]
Elongation	20% in 2 in [50 mm]
Reduction of area	50%
[a] Determine the yield strength by a 0.2% offset method.	

C. Test Methods

Determine tensile properties in accordance with AASHTO T 244 (ASTM A 370). Test finished studs welded to test plates using a test fixture similar to Figure 7.2 of ANSI/AASHTO/AWS D1.5, "Bridge Welding Code." If a fracture occurs outside of the middle half of the gauge length, repeat the test.

D. Finish

Provide finished studs of uniform quality and condition that are free of defects. Provide a stud finish produced by cold drawing, cold rolling, or machining.

E. Certification

Provide certification from the manufacturer that the studs are in accordance with Subsection 724.04.B, "Materials." Provide certified copies of in-plant quality control test reports to the Resident Engineer.

F. Installation Testing

When the first two studs welded on each beam or girder cool, bend to 45° by striking the studs with a hammer. If failure occurs in the weld of either stud, correct the welding procedure. Continue to correct the procedure until satisfactory test results are obtained for two successive studs before continuing welding operations. Promptly notify the Resident Engineer of procedure changes.

In addition to the first bent studs, bend one of every hundred studs to 45° when the temperature of the base metal is below 32°F [0°C].

724.05 STAINLESS STEEL FOR BRIDGE BEARING ASSEMBLIES

For bridge structure anchor plates, provide stainless steel plate in accordance with ASTM A 240, UNS Designation S31600 (Type 316) .

For bridge structure anchor bolts, provide continuously threaded austenitic stainless steel bars in accordance with ASTM A 320, Class 2, Grade B8M, UNS Designation S 31600 (Type 316) with metric coarse thread series, ANSI B1.13M for the bolt size required by the Contract.

Provide austenitic stainless steel nuts for anchor bolts in accordance with ASTM A 194, Grade 8M. Provide austenitic stainless steel hardened washers for anchor bolts in accordance with ASTM A 320.

724.06 GALVANIZING

Galvanize fasteners and hardware in accordance with AASHTO M 232 (ASTM A 153), except for the modifications in Subsection 724.02, "High Strength Fasteners." Galvanize ferrous metal products, other than fasteners and hardware, in accordance with AASHTO M 111 (ASTM A 123).

SECTION 725
MISCELLANEOUS METALS

725.01 STEEL FORGINGS

Provide steel forgings in accordance with AASHTO M 102 (ASTM A 668), Class C, Class D, Class F, or Class G.

725.02 STEEL CASTINGS

Provide castings that are true to pattern in form and dimensions, and free of defects that affect strength and value for the service intended. Provide covers and gratings that fit into frames and seat uniformly and solidly.

Sandblast or clean castings of scale and sand to present a smooth, clean, uniform surface. Provide steel castings in accordance with Table 725:1.

Table 725:1
Steel Casting Requirements

Material	Requirement
Mild steel castings	AASHTO M 192 (ASTM A 486), Class 70 (485), or AASHTO M 103 (ASTM A 27), Grade 70-36 (485-250)
Chromium alloy-steel castings	AASHTO M 163 (ASTM A 743M), Grade CA-15M

725.03 IRON CASTINGS

Provide iron castings in accordance with AASHTO M 306. Boldly fillet castings at angles and make the arises sharp and perfect.

Ensure components are well-mated, non-rocking, and non-rattling. Ensure covers and grates fit tightly into frames and seat uniformly and solidly.

Identify castings in an area shown on the Plans, or in an area visible when the unit is installed. Recess the lettering $^{1}/_{16}$ in [1.6 mm] from the surrounding surface. If a surface has a grid pattern, recess the lettering into a non-gridded area. Provide lettering content that includes the following:

- Manufacturer or distributor,
- Heat, pour number, or both, and
- Casting date.

Provide iron castings in accordance with Table 725:2:

Table 725:2
Iron Casting Requirements

Material	Requirement
Class 35B Gray Iron Casting	AASHTO M 105
Ductile Iron Casting [a]	ASTM A 536, Grade 65-45-12 (414-276-18)
Malleable Iron Casting	ASTM A 47, Grade 24118

[a] In addition to contract required test coupons, test specimens from parts integral with the castings for castings with a mass greater than 100 lb [450 kg] to determine if finished castings obtain the specified quality.

725.04 ACCESSORIES FOR CASTINGS AND SPECIAL FABRICATED UNITS

A. Accessories for Castings

Provide galvanized (zinc-coated), cadmium plated, or stainless steel machine bolts for casting assemblies in accordance with AASHTO M 164.

Provide support beams for casting assemblies in accordance with AASHTO M 270 Grade 36.

B. Special Fabricated Drainage Grates

Provide welded steel drainage grates with the load bearing members of the grates made with steel in accordance with AASHTO M 270 Grade 36. Provide stiffeners as recommended by the manufacturer. Weld in accordance with Section 724, "Structural Steel."

Provide pipe for fabricated pipe grates in accordance with ASTM A 53, in standard mass, unthreaded mill finish. The Department will waive hydrostatic pressure testing. Clean the grate units after welding. For galvanized units, punch or drill a pressure vent at the location shown on the Plans to prevent welded pipes from bursting during the galvanization process. Provide angle iron and strap iron for end members or spacers in accordance with AASHTO M 270 Grade 36 mill-finish. The Department will allow butt welded pipe for use as grate members.

Provide welded steel drainage grate units galvanized after fabrication or painted with an inorganic zinc ethyl silicate base primer and vinyl finish coat. Galvanize in accordance with AASHTO M 111. Clean grate units and apply paint in accordance with Section 512, "Painting." Use shop-applied paint for both coats.

725.05 BRONZE CASTINGS

Provide bronze castings in accordance with AASHTO M 107, Copper Alloy UNS No. C91100. Provide bronze bearings and expansion plates in accordance with AASHTO M 108 Copper Alloy UNS No. C51000.

SECTION 726
DRAINAGE CONDUITS

726.01 RIGID CONDUITS

A. Rigid Conduit Materials

This subsection covers the following materials:

- Non-reinforced concrete pipe,
- Drain tile porous and perforated pipe,
- Circular reinforced concrete pipe,
- Arched reinforced concrete pipe,
- Elliptical reinforced concrete pipe,
- Precast reinforced concrete manhole sections,
- Precast reinforced concrete curb inlet boxes,
- Precast reinforced concrete junction boxes,
- Precast reinforced concrete box sections, and
- Cast ductile iron pipe.

Provide the material required by the Contract in accordance with Table 726:1.

Table 726:1
Rigid Conduit Material Specifications

Material	Requirement
Concrete	
Culvert, storm drain, and sewer pipe	AASHTO M 86
Drain tile porous and perforated pipe	AASHTO M 178M/M 178
Reinforced concrete culvert, storm drain, and sewer pipe [a]	
Circular	AASHTO M 170
Arch	AASHTO M 206
Elliptical	AASHTO M 207
D-load	AA.SHTO M 242/M 242
Precast reinforced concrete	
Manhole sections	AASHTO M 199M/M 199
Curb inlet boxes	ODOT approved shop drawings
Junction boxes	ODOT approved shop drawings
Boxes for culverts, storm drains, and sewers with 2 ft [600 mm] or more of cover subject to highway loading	AASHTO M 259
Boxes for culverts, storm drains, and sewers with less than 2 ft [600 mm] of cover subject to highway loadings	AASHTO M 273
Ductile iron	
Culvert pipe	AASHTO M 64

[a] For reinforced concrete culvert, storm drain, and sewer pipe, the Department will allow a special design Class IV/V pipe in accordance with AASHTO M 170M, in addition to the pipe classes specified. Design criteria for Class IV/V is a midline interpolation between the design criteria for Class IV (Table 4) and Class V (Table 5) of AASHTO M 170.

B. Joint Filler

(1) Cold Applied Mastic Joint Filler

Apply cold applied mastic joint filler in accordance with the manufacturer's recommendations to ensure it is resilient, adhesive, and maintains a seal through

repeated cycles of expansion and contraction. The Department will not allow the use of cold applied mastic joint filler for pipes larger than 60 in [1,524 mm] in diameter, or precast concrete boxes. Provide material in accordance with Table 726:2:

Table 726:2
Cold Applied Mastic Type Joint Filler

Property	Test Value	Test Method
Soluble in trichloroethylene, %	≥45.0%	AASHTO T 44
Ash, %	15.0 – 55.0%	AASHTO T 111
Penetration, 150 g for 5 sec at 77°F [25°C]	150 – 275	AASHTO T 49 [a]

[a] Ensure penetration is in accordance with AASHTO T 49, except use a penetration cone in place of a standard penetration needle. Provide a cone in accordance with ASTM D 217.

(2) Flexible Watertight Gaskets

Provide flexible watertight gaskets that fit to create a seal in accordance with AASHTO M 198. Use butyl rubber sealant for pipes greater than 60 in [1,524 mm] in diameter.

(3) Flexible Cellular Seals

Provide flexible cellular seals in accordance with ASTM D 1056, Type 2C1. Place the joint material in one continuous piece in accordance with the manufacturer recommendations.

726.02 FLEXIBLE CONDUITS

This subsection covers the following materials:

- Steel conduits (Type I circular or Type II arch),
- Coated and clad steel conduits,
- Structural plates,
- Aluminum conduits,
- Clad aluminum conduits, and
- Nonmetallic conduits.

Provide the material required by the Contract in accordance with Table 726:3.

Table 726:3
Flexible Conduit Material Specifications

Material	Requirement
Steel conduits—culverts	
Metallic coated corrugated steel culverts	AASHTO M 36
Zinc coated (galvanized) sheet steel	AASHTO M 218
Aluminum coated (Type II) hot-dipped sheet steel	AASHTO M 274
Aluminum-zinc alloy coated sheet steel	AASHTO M 289
Externally coated or clad culverts	
Bituminous coated corrugated metal culvert pipe and pipe arches [a]	AASHTO M 190
Precoated corrugated steel culverts	AASHTO M 245
Polymer coated sheet	AASHTO M 246
Aluminum conduits—culverts	
Corrugated aluminum alloy culverts [b]	AASHTO M 196
Clad aluminum alloy sheets for culverts	AASHTO M 197

Table 726:3
Flexible Conduit Material Specifications

Material	Requirement
Nonmetallic conduits—culverts	
Non corrugated polyvinyl chloride (PVC) pipe	AASHTO M 278
Corrugated polyethylene pipe	AASHTO M 294
Nonmetallic conduits—underdrain	
PVC pipe	
Non corrugated PVC pipe	AASHTO M 278
Corrugated PVC pipe	ASTM F 949
Polyethylene drainage tubing	
Corrugated	AASHTO M 252, Type C or Type CP
Smooth interior, corrugated [c]	AASHTO M 252 Type S or Type SP, or AASHTO M 294 Type S
Structural plate for pipe, pipe arches, and arches [d]	
Corrugated galvanized or coated steel	AASHTO M 167
Aluminum alloy	AASHTO M 219

[a] Use Type A bituminous coating unless the Contract requires Type B, Type C, or Type D.
[b] If required by the Contract, provide a Type A bituminous coating in accordance with AASHTO M 190.
[c] Ensure polyethylene pipe is manufactured from High Density Polyethylene virgin compounds in accordance with ASTM D 3350, cell class 324420 C. Provide Type SP conduit with Class 2 perforations.
[d] Fabricate in accordance with the applicable section of the AASHTO *Standard Specifications for Highway Bridges*.

726.03 STEEL END SECTIONS

Provide materials for steel end sections in accordance with AASHTO M 36. Manufacture steel end sections as integral units for ready assembly and in-place erection.

Use galvanized bolts for end section assembly if skirts are made of more than one piece, and sections are not riveted together.

The Resident Engineer will reject materials for the following reasons:

- Non-conformance to the shapes or dimensions shown on the Plans,
- Uneven laps,
- Ragged sheared edges,
- Loose, unevenly lined, or spaced rivets,
- Poorly formed rivet heads,
- Illegible brands,
- Lack of rigidity, or
- Dents or bends in the metal.

SECTION 730
PAINT FOR STRUCTURAL STEEL

730.01 GENERAL REQUIREMENTS

A. General

Provide a paint system from the Department's Materials Division approved products list (APL).

B. Paint System Acceptance

For each paint system, the paint manufacturer must submit a Type A certification in accordance with Subsection 106.04, “Materials Certification,” showing test results from an approved testing laboratory. Ensure the certification includes the following:

- The manufacturer’s name,
- System performance test results,
- Dates,
- Paint test results and dates,
- Paint brand name,
- Lot number, and
- Manufacture date.

The Materials Engineer will require a new certification if the following conditions occur:

- The manufacturing process or paint formulation changes,
- Testing indicates nonconformance to the specifications, or
- The certification is older than 5 years.

C. General System Performance Requirements

Evaluate paint systems in accordance with AASHTO R31.

Provide paint in strong, tightly sealed containers. Label containers with the following:

- Manufacturer’s name,
- Paint type,
- Volatile Organic Compounds (VOC) content,
- Manufacture date,
- Lot number,
- Mixing instructions, and
- Equipment cleanup instructions.

Provide copies of the Material Safety Data Sheets (MSDS) and Product Data Sheets (PDS) for all components of each paint system to the Engineer and post on the project site before painting.

Do not use paint, coatings, and compounds with more than 0.19 percent lead by weight [mass] of the total nonvolatile paint content.

The Department will not allow the use of paints containing leachable hazardous elements exceeding the limits specified in Table 730:1, "Leachable Hazardous

Material Limits," when tested in accordance with the Toxicity Characteristic Leaching Procedure (TCLP), 40 CFR 261, “Identification and Listing of Hazardous Waste.” Include the TCLP test with the Type A certification.

Table 730:1
Leachable Hazardous Material Limits

Hazardous Material	Limit, *ppm*
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0

Ensure the maximum VOC content of paint, thinned for application, is 2.9 lb/gal [350 g/L] when tested in accordance with ASTM D3960. VOC regulations of the EPA or ODEQ may be stricter than Department regulations. Comply with the most restrictive VOC regulations.

730.02 REQUIREMENTS FOR PAINT SYSTEMS

A. Inorganic Zinc/Epoxy/Urethane System

Provide an inorganic Zinc/Epoxy/Urethane (IZ-E-U) system that meets the requirements of Table 730:2.

Table 730:2
Inorganic Zinc/Epoxy/Urethane Coating Properties

Property	Test Value Test Method
Slip coefficient	Class B (not less than 0.5)
Salt Fog Resistance:	
Delamination	None
Rust criteria @ 5,000 hours	4 mm Maximum creep and 2 mm Average creep
Blister Criteria @4,000 hours	Blister conversion value of 8
Cyclic Weathering Resistance:	
Delamination	None
Rust criteria @ 5,000 hours	4 mm Maximum creep and 2 mm Average creep
Blister criteria @4,000 hours	Blister conversion value of 9
Gloss value	Report value only
% Gloss retention	Report value only
Color change, Δe	Report value only
Abrasion resistance	Weight loss and wear index – Report only
Adhesion	350 psi [2.4 MPa]
Freeze thaw stability	210 psi [1.4 MPa]

B. Organic Zinc/Epoxy/Urethane System

Provide an organic Zinc/Epoxy/Urethane (OZ-E-U) system that meets the requirements of Table 730:3.

Table 730:3 Organic Zinc/Epoxy/Urethane Coating Properties	
Property	**Test Value**
Slip Coefficient	Class B (not less than 0.5)
Salt Fog Resistance:	
Delamination	None
Rust Criteria @ 5,000 hours	4 mm Maximum creep and 2 mm Average creep
Blister Criteria @4,000 hours	Blister conversion value of 7
Cyclic Weathering Resistance:	
Delamination	None
Rust Criteria @ 5,000 hours	8 mm Maximum creep and 4 mm Average creep
Blister Criteria @4,000 hours	Blister conversion value of 8
Gloss Value	Report value only
% Gloss Retention	Report value only
Color Change, Δe	Report value only
Abrasion Resistance	Weight loss and Wear index – Report only
Adhesion	600 psi [4.1 MPa]
Freeze Thaw Stability	360 psi [2.4 MPa]

C. Single-Component Moisture-Cured Urethane System

Provide a Single-Component Moisture-Cured Urethane (SC-MC-U) system that meets the requirements of Table 730:4. Use a zinc-rich or zinc and micaceous iron oxide (MIO) primer for the first coat. Formulate the primer with either synthetic or natural MIO. Provide a single-component or two-component primer. Formulate the intermediate coat and topcoat with natural MIO. Provide an MIO intermediate coat that is a Single-Component Moisture-Cured Urethane paint. Provide a top coat that is an MIO-based Single-Component Moisture-Cured-Aliphatic Urethane paint.

Table 730:4 Single-Component/Moisture-Cured/Urethane Coating Properties	
Property	**Test Value**
Slip coefficient	Class B (not less than 0.5)
Salt Fog Resistance:	
Delamination	None
Rust criteria @ 5,000 hours	4 mm Maximum creep and 2 mm Average creep
Blister criteria @4,000 hours	Blister conversion value of 8
Cyclic Weathering Resistance:	
Delamination	None
Rust criteria @ 5,000 hours	4 mm Maximum creep and 2 mm Average creep
Blister criteria @4,000 hours	Blister conversion value of 9
Gloss value	Report value only
% Gloss retention	Report value only
Color change, Δe	Report value only
Abrasion resistance	Weight loss and Wear index – Report only
Adhesion	350 psi [2.4 MPa]
Freeze thaw stability	210 psi [1.4 MPa]

D. Repair Paint Systems

Provide coating systems for Category R and Category O applications, defined in Subsection 730.02.A, B, or C, in accordance with Table 730:5. A repair system may be applied with either two or three coats.

Table 730:5 Repair Coating Properties	
Property	**Test Value**
Slip coefficient	Report value only
Salt Fog Resistance:	
Delamination	None
Rust criteria @ 5,000 hours	8 mm Maximum creep and 4 mm Average creep
Blister criteria @4,000 hours	Blister conversion value of 6
Cyclic Weathering Resistance:	
Delamination	None
Rust criteria @ 5,000 hours	10 mm Maximum creep and 5 mm Average creep
Blister criteria @4,000 hours	Blister conversion value of 7
Gloss value	Report value only
% Gloss retention	Report value only
Color change, Δe	Report value only
Abrasion resistance	Weight loss and Wear index – Report only
Adhesion	350 psi [2.4 MPa]
Freeze thaw stability	210 psi [1.4 MPa]

SECTION 731
TIMBER PRESERVATIVES AND TREATMENT

731.01 MATERIALS

Provide timber preservative in accordance with AASHTO M 133.

731.02 PREPARATION FOR TREATMENT

A. General Requirements

The Department's "Shop Inspection" Testing Laboratory will inspect all lumber and timber products at the treatment facility. Ensure the treatment facility is equipped with the necessary gauges, appliances, and facilities, and make available to the Department's representative.

B. Inspection

Notify the Department's "Shop Inspection" Testing Laboratory immediately before treatment of lumber, timber, piling, and posts. The Department's representative will inspect the following:

- Lumber, timber, piling, and posts for the grades and sizes required by the Contract; and
- Materials and processes used in the treatment in accordance with AWPA M2.

731.03 STORING AND HANDLING

After treatment, store the lumber or timber on dunnage to prevent contact with the ground or paved surfaces, and allow to thoroughly dry.

SECTION 732
MATERIALS FOR GUARD RAIL, GUIDE POSTS, BRIDGE RAIL, MISCELLANEOUS RAILING, AND FENCES

732.01 METAL GUARD RAIL

Provide guard rail items in accordance with the testing and performance requirements of NCHRP 350, and the following:

A. Beams

Provide corrugated steel beams in accordance with AASHTO M 180, Type I or Type II.

B. Guard Rail Posts

(1) Steel Posts

Provide hot rolled (forged) steel shapes in accordance with AASHTO M 270, Grade 36. Provide shapes that are galvanized in accordance with AASHTO M 111. Complete punching, drilling, cutting, shearing, and grinding before galvanization.

Repair surface defects by grinding, cutting, or welding. Ensure surfaces are coated with two coats of zinc-dust zinc-oxide primer in accordance with Section 730, "Paint for Structural Steel." Perform alternative repairs in accordance with ASTM A 780.

Alternatively, the Department will accept steel posts fabricated in accordance with ASTM A 769. Ensure fabricated posts do not vary more than 5 percent from the mass, dimensions, and section properties for hot rolled shapes. Ensure dimensions, mass, and section properties are in accordance with the American Institute of Steel Construction (AISC) *Steel Construction Manual*, or the supplier's technical publications endorsed by the AISC.

Provide fabricated posts with sharp, sheared edges that are dulled in the upper 18 in [450 mm] of the post, using grinding, secondary rolling, or sand or shot-blasting. Complete dulling operations in accordance with AASHTO M 111 before galvanization.

Provide steel base plates and miscellaneous fabricated guard rail hardware in accordance with AASHTO M 270, Grade 36, and galvanized in accordance with AASHTO M 111. Galvanize after cutting, welding, punching, and drilling.

(2) Wood Posts

Provide wood posts of the length and size shown on the Plans. Provide sawed and round posts cut from live trees with close grain.

(a) *Sawed and Treated Posts*

Provide sawed and treated posts in accordance with AASHTO M 168 and Section 731, "Timber Preservative and Treatment."

(b)*Post Weakening*

Weaken the leading posts in the approach anchor unit by drilling holes at the ground line as shown on the Plans. Uniformly treat ground-line and enlarged holes by pulling or pushing a rag saturated with preservative solution through the holes to reach the same treatment level as the rest of the post.

C. Spacer Blocks

Provide spacer blocks made of plastic.

D. Guard Rail Hardware

Provide fittings, bolts, washers, and other accessories in accordance with the guard rail manufacturer's recommendations. Galvanize them in accordance with AASHTO M 111 or AASHTO M 232, whichever applies.

732.02 GUIDE POSTS

Provide round wood posts for guide posts and underdrain marker posts in accordance with Subsection 732.01.B(2), "Wood Posts." Provide un-slabbed and un-drilled posts.

732.03 METAL BRIDGE RAILING MATERIALS

A. Structural Steel Shapes for Posts and Rails

Provide structural steel shapes for posts and rail in accordance with Section 724, "Structural Steel."

B. Metal Beams

Provide metal beams in accordance with Subsection 732.01, "Metal Guard Rail."

C. Aluminum Alloy Tubes

Provide aluminum alloy tubes for bridge railing in accordance with ASTM B 221, alloy 6063 or 6061 T6. If shown on the Plans, weld in accordance with Subsection 720.03.A, "Welding Requirements for Aluminum."

732.04 PIPE RAILING

Provide galvanized or black steel pipe and fittings in accordance with ASTM A 53 for standard weight pipe, except for the requirement for hydrostatic testing. Provide galvanized steel pipes and fittings in accordance with AASHTO M 111 or AASHTO M 232.

732.05 WIRE CABLE AND FITTINGS

Provide wire cables and fittings in accordance with AASHTO M 30.

732.06 FENCE, STYLE WWF OR FENCE, STYLE SWF

A. Description

Provide fabric, strand wire, wire items, framework for fence and gates, and fastening and bracing hardware for constructing woven wire or strand wire fence as required by the Contract.

B. Materials

(1) Wire Items

(a) *Woven Wire*

Provide woven wire in accordance with AASHTO M 279, design number 832-6-12½, Grade 60, with a Type Z, Class 1 zinc coating, or a Type A aluminum coating.

(b) *Barbed Wire*

Provide barbed wire in accordance with AASHTO M 280, design number 12-4-5-14R or 12-4-5-14H, with a Type Z, Class 1 zinc coating, or a Type A aluminum coating.

(c) *Smooth or Tension Wire*

Provide smooth wire in accordance with the ASTM A 641 and Table 732:1:

Table 732:1
Smooth or Tension Wire Properties

Wire Gauge	Wire Diameter, *in [mm]*	Temper	Tensile Strength, *ksi [MPa]*	Zinc Coating
9	0.148 [3.76]	Soft	≥60 [414]	Class 1
11	0.120 [3.05]	Medium or Hard	≥85 [586]	Class 1

(d) *Barbless Wire*

Provide wire in accordance with Subsection 732.06.B(1)(b), "Barbed Wire," without the barbs.

(e) *Post Ties (Wire Ties)*

Provide post ties in accordance with AASHTO M 281.

(2) Posts, Gates, and Hardware

(a) *Fan, Corner, End, Stretcher, and Gate Posts*

Provide straight wood or steel posts for fans, corners, ends, and gate posts.

1) Wood Posts

Treat wood posts in accordance with Section 731, "Timber Preservatives and Treatment." Ensure the wood post quality standard grades are in accordance with ASTM F 537.

2) Steel Posts

Provide steel posts in accordance with ASTM F 1083, standard weight, Schedule 40 steel pipe. Ensure the posts are pipe with at least 1.66 in [42.2 mm] outside diameter and a wall thickness of 0.140 in [3.56 mm]. The Resident Engineer will accept pipe in accordance with the substitute pipe equation in Subsection 732.07.C(2), "Framework Items."

If welding steel posts, apply at least a 90 percent zinc rich paint to the weld.

(b)*Line Posts*

Provide line posts of either preservative treated wood or steel. Use the same post material throughout the project, unless the Resident Engineer approves a mixture of materials in writing.

Provide wood line posts in accordance with ASTM F 537, treated with preservative in accordance with Section 731, “Timber Preservatives and Treatment.”

Provide galvanized or painted steel posts in accordance with AASHTO M 281. If steel posts do not have deformable clip protrusions on the post, provide the same number of wire ties as the number of strands joined to the posts.

(c)*Gates*

Provide gates with a pipe or tubular framework, covered with the same type strand or woven wire as the fence. Provide the pipe or tubing in accordance with ASTM F 1083, Schedule 40 steel pipe. Provide pipe with at least 1.66 in [42.2 mm] outside diameter and a wall thickness of 0.140 in [3.56 mm]. Cover and brace the frame as shown on the Plans. The Resident Engineer will accept pipe in accordance with Subsection 732.07.C(2), "Framework Items," for steel posts.

Alternatively, the Resident Engineer will accept commercially available ranch-type metal panel gates. Provide ranch-type gates made of aluminum coated steel, aluminum alloy, or galvanized steel, mill finished or painted.

(d)*Hardware*

Provide hardware, hinges, fittings, and gate latches in accordance with the gate manufacturer recommendations. Ensure hardware, hinges, fittings, and gate latches are galvanized in accordance with AASHTO M 232, or have a protective coating compatible with the gate coating or alloy.

Provide galvanized eye bolts for fastening fence to existing headwalls or wingwalls on culverts.

Provide staples for fastening wire to wood made of 9 gauge (0.148 in) [3.76 mm] galvanized wire. Ensure staples are at least 1½ in [38.1 mm] long.

Provide galvanized nails made of round or oval steel wire. Ensure nails are 40 pwt nails or 20 pwt spikes.

732.07 FENCE, STYLE CLF

A. Description

Provide chain link fabric, other wire items, framework for fences and gates, and fastening and bracing hardware to construct chain link fence. Ensure the height of the fence fabric, the width and height of the gate openings, the size, shape and length of posts and the size and shape of framework members are as shown on the Plans.

B. Classifications

The Department defines Class A as fence or gate without climb barrier, and Class B as fence or gate with climb barrier. Provide the following types as Class A or Class B:

- Type I: galvanized steel wire fabric on a steel or aluminum mounting system;
- Type II: aluminum-coated steel wire fabric on a steel or aluminum mounting system;
- Type III: aluminum alloy fabric on a steel or aluminum mounting system; and
- Type IV: vinyl-coated or PVC plastic coated galvanized steel wire fabric on a zinc-coated steel or aluminum mounting system of the same color or a harmonizing color.

C. Materials

(1) Wire Items

(a) *Fabric*

Provide 9 gauge (0.148 in) [3.76 mm] wire woven into fabric in 2 in [50.8 mm] mesh in accordance with AASHTO M 181.

(b) *Tension Wire*

Provide tension wire in accordance with AASHTO M 181, with a coating that matches the fence required by the Contract.

(c) *Barbed Wire*

Provide barbed wire in accordance with Subsection 732.06.B(1)(b), "Barbed Wire."

(d) *Post Ties*

Provide post ties and clips in accordance with ASTM F 626.

(2) Framework Items

Provide posts, rail, and gate frames in the sizes and shapes shown on the Plans. Provide steel pipe for posts in accordance with AASHTO M 181, Grade 1 or Grade 2.

Provide PVC coated steel pipe for Type IV fence in accordance with AASHTO M 181, Grade 1 or Grade 2, with PVC coating in stead of organic exterior coating on Grade 2 pipe.

Alternatively, use thin walled pipe with the outside diameter and coating for Grade 2 pipe in accordance with AASHTO M 181. Test the pipe or tubing to determine the tensile and yield strengths. If using substitute pipe, ensure the product of the substitute section modulus and the yield strength equals or exceeds the section modulus schedule shown on the Plans multiplied by 30,000 psi [205 MPa] (the minimum yield strength for Schedule 40 pipe). Ensure steel used in substitute pipe has a yield strength of at least 50,000 psi [344.7 MPa]. Determine the section modulus of the pipe using the following equation:

$$SM = \frac{\pi \times (OD^4 - ID^4)}{32 \times OD}$$

where

SM = Section modulus,
OD = Outside diameter,
ID = Inside Diameter, and
π = 3.1416.

(3) Fence Fittings

Ensure the materials requirements, coating specifications, and inspection procedures of the following items for CLF are in accordance with ASTM F 626:

- Post and line post caps,
- Rail and brace ends,
- Sleeves for top rail,
- Tension and brace bands,
- Tension bars,
- Truss rods, and
- Barb arms.

732.08 FENCE, STYLE GDF

A. Description

Provide fence fabric, other wire items, fence framework, and fastening and bracing hardware to construct glare deflector fence.

B. Classifications

The Department defines Class R as GDF mounted on a guardrail, Class P as GDF mounted on ground-mounted posts, and Class W as GDF mounted on a parapet wall or median barrier. Provide the following types as Class R, Class P, or Class W:

- Type I: galvanized steel wire fabric on a steel or aluminum mounting system;
- Type II: aluminum-coated steel wire fabric on a steel or aluminum mounting system;
- Type III: aluminum alloy fabric on a steel or aluminum mounting system; and
- Type IV; vinyl-coated or PVC plastic-coated galvanized steel wire fabric, on a zinc-coated steel or aluminum mounting system of the same color or a harmonizing color.

C. Materials

(1) Wire Items

(a) *Fabric*

Provide fabric of 9 gauge (0.148 in) [3.76 mm] wire woven in 1 in [25.4 mm] mesh. Provide other material in accordance with Subsection 732.07.C(1)(a), “Fabric.”

(b) *Tension Wire*

Provide tension wire in accordance with Subsection 732.07.C(1)(b), “Tension Wire.”

(c) *Post Ties (Wire Ties)*

Provide post ties in accordance with Subsection 732.07.C(1)(d), “Post Ties.”

(2) Framework Items

Provide framework items, posts, line posts, top rail, and brace rail in accordance with Subsection 732.07.C(2), “Framework Items.”

(3) Fence Fittings

Provide fittings in accordance with Subsection 732.07.C(3), “Fence Fittings.”

732.09 WIRE BASKETS FOR GABIONS AND REVETMENT MATTRESSES

A. General

Provide wire baskets constructed of double twisted hexagonal wire mesh or, if shown on the Plans, welded-wire mesh. Use non-raveling wire mesh that will not separate at twists or detach at welds if a wire in the mesh is cut.

B. Wire Requirements

Provide mesh, selvage, lacing, internal-connecting, and spiral wires in accordance with ASTM A 641, Class 3, Soft (tensile strength from 55 ksi to 75 ksi [380 MPa to 520 MPa]) and ASTM A 853. Provide wire with High Grade or Special High Grade zinc-coating in accordance with ASTM B 6, Table 1. For welded-wire mesh, ensure the coating uniformity equals or exceeds four 1 min dips by the Preece Test, in accordance with ASTM A 239.

C. Twisted-Wire Mesh Baskets

(1) General

Provide mesh wires wrapped around the selvage wire with the number of turns necessary to interconnect each of them with adjacent mesh wires. Ensure wire is galvanized before mesh fabrication.

(2) Gabions

Provide galvanized baskets manufactured from 11 gauge [3 mm] mesh wires and 9 gauge [3.9 mm] selvage wires. Provide PVC-coated baskets manufactured from 12 gauge [2.7 mm] mesh wire and 10 gauge [3.4 mm] selvage wire.

(3) Revetment Mattresses

For 12 in [300 mm] thick revetment mattresses, provide baskets manufactured from 13.5 gauge [2.2 mm] mesh wires and 12 gauge [2.7 mm] selvage wire. For thinner revetment mattresses, provide baskets manufactured from 13.5 gauge [2.2 mm] mesh wires.

D. Welded-Wire Mesh Baskets

(1) General

Provide welded-wire mesh baskets with resistance welds. Ensure mesh is in accordance with ASTM A 185.

(2) Gabions

Provide baskets manufactured from 11 gauge [3 mm] wire. Provide PVC-coated baskets manufactured from 12 gauge [2.7 mm] wire.

(3) Revetment Mattresses

For 12 in [300 mm] thick revetment mattresses, provide baskets manufactured from 13.5 gauge [2.2 mm] mesh wires. For thinner revetment mattresses, provide baskets manufactured from 14 gauge [2.0 mm] mesh wires.

E. Connection Wires

Provide connection wires of the sizes specified in Table 732:2.

Table 732:2
Connection Wire Sizes

Wire Type	Minimum Wire Size
Lacing wire	13.5 gauge [2.2 mm]
Spiral wire	12 gauge [2.7 mm]
Internal connecting wire	13.5 gauge [2.2 mm]

Provide enough lacing and connection wire to fasten gabion basket and diaphragm edges.

F. Basket Strength and Flexibility Requirements

(1) Elongation

Before basket fabrication, ensure elongation tests are made on a wire sample 12 in [300 mm] long. Ensure elongation is at least 12 percent, in accordance with ASTM A 370.

(2) Punch Test

Ensure the 3 in × 5 in [75 mm × 125 mm] wire mesh will not rupture when a 6,000 lb [26.7 kN] load is applied as follows:

- Place a 6 ft [1.83 m] long, 3 ft [0.91 m] wide or wider section of wire mesh in testing machine seats without binding individual wires. Ensure the sample includes the selvedge bindings along the width, or in the middle for widths greater than 3 ft [0.91 m].
- Apply tension to elongate the section 10 percent.
- Apply a 6,000 lb [26.7 kN] load to 1 ft² [0.093 m²] located in the center of the sample between the clamps. Ensure the load is perpendicular to the elongation tension force direction. Apply it with a circular ram head with beveled or rounded edges to prevent cutting the wires.

(3) Strength

Ensure wire strength is in accordance with Subsection 732.09.F(2), “Punch Test,” and Table 732:3, “Wire Mesh Strengths,” when tested in accordance with the Colorado Procedure for Methods of Conducting Strength Tests of Gabions (CP I-6130).

Table 732:3
Wire Mesh Strengths

Wire Mesh	Wire Strength, *lb/ft [kN/m]*		
	Galvanized Gabions	PVC Coated Gabions	Revetment Mattresses
Pulled parallel to wire twist	2,300 [34]	2,000 [29]	1,800 [26]
Pulled perpendicular to wire twist	1,800 [26]	1,400 [20]	900 [13]
Connection to selvedges	1,400 [20]	1,200 [18]	900 [13]
Joint connection strength-lacing wire or ring wire fastener	1,400 [20]	1,200 [18]	900 [13]

G. PVC Coating

Provide wire with PVC coating. Ensure the PVC-coated wire is in accordance with the Table 732:4.

Table 732:4
PVC Coating Properties

Property	Test	Value
Coating thickness, nominal 20 mil [500 µm]	—	≥15 mil [380 µm]
Specific gravity [a]	ASTM D 2287, ASTM D 792	1.20 – 1.4
Tensile strength [a]	ASTM D 412	≥2,900 psi [20 MPa]
Modulus of elasticity [a]	—	≥2,600 psi [18 MPa]
Brittleness temperature	ASTM D 746	≤−10°C
Abrasion resistance [a] CSI-A Abrader Tape, 80 Grit	ASTM D 1242, Method D Method B at 200 cycles	≤12% weight loss
Salt spray test [b]	ASTM B 117	≥3,000 hr
Ultraviolet light exposure [b] Apparatus Type E at 145°F [63°C]	ASTM D 1499, ASTM G 23	≥3,000 hr

[a] After salt spray and ultraviolet light testing, reject the PVC coating if specific gravity changes more than 6%, tensile strength more than 25%, modulus of elasticity more than 25%, or resistance to abrasion more than 10%.
[b] Reject the PVC coating if, after salt spray and ultraviolet light testing, the coating is cracked, blistered, split, or shows color change.

SECTION 733
MISCELLANEOUS MATERIALS

733.01 CAST IRON WATER PIPE, FITTINGS, VALVES, ETC

A. Materials Covered

Provide cast iron water pipe, fittings, valves, valve boxes, fire hydrants, and jointing materials for construction, extension, or repairs of cast iron water lines in accordance with the local municipalities' requirements. When no municipality requirements are applicable, provide cast iron water pipe, fittings, valves, valve boxes, fire hydrants, and jointing materials in accordance with Subsection 733.01.B, C, D, E, F, G, and H.

B. Pipes

(1) Cast Iron Water Pipe

Provide 18 ft [5.49 m] or 20 ft [6.10 m] long cast iron pipes. Provide cast iron pipes with a class 22 thickness for diameters from 3 in [76.2 mm] to 12 in [304.8 mm], and a class 24 thickness for diameters greater than 12 in [304.8 mm] in accordance with AWWA C 106 or AWWA C 108. Ensure the pipes have an 18/40 iron strength.

Provide 2 in [50.8 mm] and 2¼ in [57.2 mm] cast iron pipe in accordance with AWWA C 112 . Provide in 12 ft [3.66 m], 18 ft [5.49 m], or 20 ft [6.10 m] long lengths of pipe.

(2) Ductile Iron Water Pipe

Provide ductile iron in accordance with AWWA C 151.

C. Fittings

Provide and test cast iron fittings in accordance with AWWA C 110 standards for 2 in [50.8 mm] through 48 in [1,219 mm] pipe with a pressure rating of 250 psi [1.72 MPa].

D. Valves

(1) Gate Valves

Provide gate valves in accordance with AWWA C 500. Provide gate valves with the following characteristics:

- Double disc parallel seats,
- Non-rising stem,
- Vertical mounting,
- **O**-ring stem seal,
- Counterclockwise opening, and
- Push-on mechanical, bell and spigot, or flanged ends to fit the pipe or fittings.

Provide Crane, Darling, Ludlow-Rensselaer, M & H, Mueller, A.P. Smith, or an equivalent gate valve approved by the Engineer.

(2) Ball Valves

Provide ball valves with the following characteristics:

- Double-seated natural or synthetic rubber,
- Bronze, or monel metal seats,
- Designated for 150 psi [1.03 MPa] working pressure,
- Flanged ends, and
- **O**-ring rotor bearing seals of high-tensile strength cast iron with the following:
  - Enclosed manual operators,
  - An open-close indicator, and
  - Hand wheel with standard size square wrench nut for one-man operation at 150 psi [1.03 MPa] unbalance across the valve.

Test valves with a hydrostatic pressure of 250 psi [1.72 MPa] on the valve body, with the rotor open, and 150 psi [1.03 MPa] on each side of the valve; open the opposite side of the valve. Submit four copies of the test results and manufacturer's drawings for approval by the Engineer before valve delivery.

Provide Allis-Chalmers, Henry Pratt, Williamette Iron & Steel, or an equivalent ball valve approved by the Engineer.

(3) Air Relief Valves

Provide 2 in [50.8 mm] air relief valves with heavy-duty combination air release and vacuum tested to 300 psi [2.07 MPa] water working pressure. Provide a cast iron body, cover, and baffle with high-quality stainless steel or bronze internal parts. Ensure the inside of the valve is coated with rust inhibitor.

Provide Apco No. 145C, Darling, Rensselaer, or an equivalent air relief valve approved by the Engineer.

(4) Check Valves

Provide swing type check valves with the following characteristics:

- Single disc,
- Horizontal mounting,
- Diameter passage that minimizes pressure loss,
- Non-slamming for the installation of outside lever and weight,
- Bronze disc faces and seat rings, and
- Push-on mechanical, bell and spigot, or flanged ends to fit the pipe or fittings.

Provide Crane, Darling, Ludlow-Rensselaer, M & H, Mueller, A.P. Smith, or an equivalent check valve approved by the Engineer.

E. Valve Boxes

Provide screw, adjustable valve boxes with drop cover.

F. Fire Hydrants

Provide and test fire hydrants in accordance with AWWA C 502. Provide hydrants with the following characteristics:

- Breakable connection features with a lower breaking point than the rest of the unit

- Breakable coupling on the stem immediately above the bury line with a lower breaking point than the rest of the unit;
- Compression main valve - 4½ in [114.3 mm];
- Inlet connection - 6 in [152.4 mm];
- Bell, flange, or mechanical joint inlet;
- Bury length - 4½ ft [1.37 m];
- Two hose nozzles - 2½ in [63.5 mm] (with National Standard threads);
- One pumper nozzle - 4 in [101.6 mm];
- **O**-ring seal;
- Drain valve;
- Counterclockwise opening;
- Yellow finish paint above ground line; and
- National Standard pentagon operating nut that can accommodate the installed fire hydrant.

Provide Darling, Mueller Improved, M& H, or an equivalent fire hydrant approved by the Engineer.

G. Joints

Provide joint cast iron pipe and fittings with any of the following end types:

- Test push-on joints,
- Mechanical joints,
- Bell-and-spigot joints, or
- Flange joints.

Use flange joint ends only if shown on the Plans, except, always provide flanged joints at valve connection ends of tapping sleeves.

Provide push-on joints and mechanical joints in accordance with AWWA C 111. Provide bell-and-spigot joints with square, braided, sterilized hemp and 99.73 percent pure lead caulking. Provide flange joints in accordance with ASA B 16.1.

H. Lining

If required by the Contract, line cast iron pipe and fittings in accordance with AWWA C 104.

733.02 COPPER WATER SERVICE PIPE AND FITTINGS

A. Materials Covered

Provide copper water service pipe and fittings for construction of water service lines in accordance with the local municipalities' requirements. When no municipality requirements are applicable, provide copper water service pipe and fittings in accordance with Subsection 733.02.B, "Copper Service Pipe," and Subsection 733.02.C, "Fittings."

B. Copper Service Pipe

Provide Type K soft annealed seamless copper tubing service pipe cold drawn to size in accordance with ASTM B88.

C. Fittings

Provide sound, clean, and defect free cast brass or bronze fittings, including corporation and curb stops. Ensure the name or trademark of the manufacturer is permanently cast in each fitting.

733.03 GALVANIZED STEEL WATER PIPES AND FITTINGS

A. Materials Covered

Provide galvanized steel pipe for water service lines and fittings in accordance with the local municipalities' requirements. When no municipality requirements are applicable, provide galvanized steel pipe for water service lines and fittings in accordance with Subsection 733.03.B, "Galvanized Steel Pipe" and Subsection 733.03C, "Fittings."

B. Galvanized Steel Pipe

Provide galvanized steel pipe in accordance with ASTM A53. Ensure the pipes are first class galvanized welded and seamless steel pipe of standard mass and dimensions, new stock, smoothly finished, and defect free.

C. Fittings

Provide wrought iron or steel galvanized fittings. Provide standard, right-hand screw threads for connections.

733.04 NONMETALLIC WATERLINE PIPE AND FITTINGS

Provide nonmetallic pressure waterline pipe and fittings in accordance with the local municipalities' requirements. Where no municipality requirements are applicable, provide nonmetallic pressure waterline pipe and fittings in accordance with the following ASTM specifications:

Material:	ASTM Specification:
Polyvinyl Chloride (PVC)	D1785
Acrylonitrile Butadiene-Styrene (ABS)	D1527
Polyethylene (PE)	D2104
Polybutlene (PB)	D2662

733.05 REFLECTIVE SHEETING FOR GUIDE POSTS

Provide Type II reflective sheeting in accordance with Subsection 719.04, "Retroflective Sheeting." for the following:

- Guide posts
- Barrier reflectors, and
- Underdrain outlet posts.

Provide metal backing plates for reflective posts in accordance with ASTM A526 with at least a 30 gauge [399 µm] thickness for galvanized sheet, or ASTM B209 Alloy 1060-H12 with at least a 406 µm thickness. Degrease and clean, or caustic etch metal bands to prepare them to receive the reflective sheeting.

733.06 ELASTOMERIC BEARING PADS

A. Description

Provide plain and laminated elastomeric bearing pads for bearings under structural members with the Durometer and dimensions as shown on the Plans. Provide shop drawings to the Engineer for review and approval before beginning pad manufacture.

B. Materials

Provide materials, fabrication, fabrication tolerances, markings and certification, testing, and installation for elastomeric bearing pads in accordance with AASHTO *Standard Specifications for Highway Bridges*.

Ensure the shear modulus for the Durometer Hardness shown on the Plans is in accordance with Table 733:1:

Table 733:1
Shear Modulus for Durometer Hardness

Durometer Hardness	Shear Modulus [a], *psi [MPa]*
50	110 [0.76]
60	150 [1.03]
70	235 [1.62]

[a] At 73 °F [22.8 °C].

Provide low temperature Grade 2 elastomer compounds. Provide ⅛ in [3.2 mm] embedded laminate edge covers or connection members for steel reinforced bearing pads. If the Plans show the anchor plate bonded to the bearing pad, use a heat-bonded connection made by the pad manufacturer during the vulcanization process.

C. Acceptance

The Resident Engineer will accept bearing pads based on the following:

- Submit to the Engineer a Type A certification showing compliance with the Contract requirements.
- Submit to the Engineer one full-size finished bearing pad per size or type, per project, shipment, or lot for dimensional and Durometer Hardness checks by the Department's Materials Division. The Department's Materials Division may conduct on-site inspection of bearing pads for slab bridges or other pads deemed by the Department's Materials Engineer to be too cumbersome for submittal to the laboratory
- Upon test completion, approved bearing pads may be collected by the contractor or the pad manufacturer from the Department's Materials Laboratory. The Department will not return failed bearing pads.

733.07 NON-SHRINK GROUT

A. General

Provide non-shrink grout with a mixture of portland cement, fine aggregate, water, and a non-shrink admixture proportioned as approved by the Resident Engineer.

B. Materials

(1) Portland Cement, Water, and Aggregate

Provide portland cement, mixing water, and aggregate, except for gradation, in accordance with Section 701, "Portland Cement Concrete." Provide an aggregate gradation in accordance with the requirements in Table 733:2.

Table 733:2
Aggregate Gradation Requirements

Sieve Size	Percent Passing
No. 16 [1.18 mm]	100
No. 50 [300 µm]	20 – 50
No. 200 [75 µm]	0 - 10

(2) Non-Shrink Admixture

Provide non-shrink admixture manufactured under a trade name for use in non-shrink grout.

(3) Premix

Ensure the Engineer pre-approves the manufacturer's premix formulations.

C. Non-Shrink Mortar

(1) Proportioning

Unless the non-shrink admixture manufacturer recommends otherwise, proportion the dry materials (portland cement, sand, and non-shrink admixture) on a 1:1:2 weight [mass] ratio in accordance with the requirements in Table 733.3:

Table 733:3
Non-shrink Admixture Proportions

Material	Weight [Mass], *lb [kg]*
Portland cement	94 [42.64]
Sand	100 [45.36]
Non-shrink admixture	200 [90.72]

(2) Mixing

Combine and mix the proportioned materials until thoroughly blended. If the sand is noticeably wet, determine the quantity of free moisture as a percent of the dry mass and the mass of sand. Add the water incrementally to obtain a workable consistency within the proportioning limits approved by the Engineer. Discard unused mortar 20 min after completing the mixing operation. The Department will not allow mortar re-tempering.

733.08 WATERSTOPS

A. General

Provide plastic waterstops and rubber waterstops for structural concrete construction joints.

Provide waterstops with a dense, homogeneous cross section. Ensure waterstops are produced in continuous lengths no greater than 100 ft [30.48 m]. Make field splices in accordance with the manufacturer's recommendations.

B. Materials

The Engineer will visually inspect and approve material from a source on the basis of the manufacturer's identification markings that show the material grade. To qualify as an approved material source, the manufacturer must submit to the Resident Engineer test certifications showing compliance with the Contract requirements, for review by the Department's Materials Engineer and approval by the Resident Engineer.

(1) Plastic Waterstops

Provide waterstops from an elastomeric plastic compound with PVC as the basic resin.

Sample in accordance with ASTM D15 and Federal Test Method No. 601.

Provide materials for plastic waterstops in accordance with Table 733:4.

Table 733:4
Plastic Waterstop Requirements

Property	Test Method	Requirements
Tensile strength (die III)	4111[a]	≥1,750 psi [12.07 MPa]
Ultimate elongation (die III)	4121[a]	≥305%
Low temperature brittleness, no failure	ASTM D746	−35 °F [−37.2 °C]
Stiffness in flexure, ½ in [12.7 mm] span	ASTM D747	≥400 psi [2.76 MPa]

[a] Federal Test Method Standard No. 601

(2) Rubber Waterstops

The Department will allow natural rubber, synthetic rubber, or both, for rubber waterstops.

Sample in accordance with ASTM D15 and Federal Test Method No. 601.

Provide materials for rubber waterstops in accordance with Table 733:5.

Table 733:5
Rubber Waterstop Requirements

Property	Test Method [a]	Requirements
Tensile strength (die III)	4111	≥2,500 psi [17.24 MPa]
Hardness, shore diameter, Type A	3021	60 – 70
Ultimate elongation (die III)	4121	≥450%
300 % Modulus	4131	≥900 psi [6.21 MPa]
Water absorption, 7 day immersion, 71.4 °F [22 °C] to 75.4 °F [24 °C]	6631	≤5%
Compression set	3311 or ASTM D395 Method B	≤30%
Tensile strength after aging, oxygen bomb method	7111	≥80%

[a] Federal Test Method No. 601

733.09 SLURRY GROUT

A. Description

Provide a slurry type grout for stabilizing and under-sealing portland cement concrete pavements using the pressure grouting method.

B. Materials

Provide grout consisting of a mixture of portland cement, fly ash, and water. Ensure the portland cement, fly ash, water, and admixtures are in accordance with the following section and subsections:

Material:	Section and Subsections:
Portland Cement	701.02
Admixtures	701.03
Water	701.04
Fly Ash	702

C. Mix Designs and Tests

Submit a mix design for review and approval by the Engineer. Include job mix test results of the grout from an independent laboratory, showing the following:

- Seven day strengths in accordance with ASTM C942;
- Flow cone rate in accordance with the Corps of Engineers Method and ASTM C939;
- Shrinkage and expansion in accordance with ASTM C940 or ASTM C827; and
- Initial set time in accordance with ASTM C403 or AASHTO T 197.

Ensure the 7 day strength is at least 800 psi [5.52 MPa], and the flow cone rate is from 10 s to16 s.

733.10 ADA COMPLIANT TACTILE WARNINGS - PRE-FORMED MODULAR CONCRETE

Ensure compressive strengths, tested in accordance with ASTM D695-91, are at least 10,000 psi.

Ensure the slip resistance, tested in accordance with ASTM C1028, combined wet-dry friction coefficient is 0.70 on top of domes and remaining areas.

Ensure the color of cured material provides at least 70 percent contrast with surrounding surfaces.

SECTION 735
MATERIAL FOR ROADSIDE DEVELOPMENT AND EROSION CONTROL

735.01 SODDING AND SPRIGGING MATERIALS

A. General

Provide a dense source of bermuda grass sod or sprigs with a deep-rooted stand on fertile topsoil.

Ensure the source for sod and sprigs is free of weeds classified as "Prohibited Noxious" and legally "Restricted Noxious" plant materials in accordance with Oklahoma Department of Agriculture Seed Law. The Resident Engineer must approve the source of sod or sprigs before beginning sodding or sprigging operations. Before approval, do not mow or till the area. After approval, mow vegetative growth higher than 3 in [75 mm] and remove the residue before harvesting the sod or sprigs.

Keep the sod or sprigs moist from excavating at the source until planting. Discard dry sod.

B. Sodding

Sodding consists of bermuda grass vegetative parts (rhizomes, stolons, and roots) with an appreciable quantity of adhering soil.

(1) Solid Slab Sod

Provide solid slab sod in rectangular slabs of bermuda grass with dimensions as shown on the Plans. Ensure bermuda grass vegetative parts exist throughout the slab and come from soils with a Plasticity Index of at least 3. Provide slabs of dense vegetative growth capable of being transported in its original state.

(2) Mulch Sod

Provide mulch sod consisting of fertile topsoil with bermuda grass vegetative parts not harvested within the previous 12 months. Before excavation, disk the sod in different directions to the excavation depth. Make each pass of the disk at right angles to the preceding pass until the bermuda grass vegetative parts are cut into small pieces. Excavate to 6 in [150 mm] or less, immediately after disking.

C. Sprigging

Sprigging consists of bermuda grass vegetative parts separated from the adhering soil.

Remove sprigs for row and broadcast sprigging with an automatic sprig harvester that digs, cleans, and loads the sprigs in one continuous operation. Use a vehicle with closed sides to transport sprigs.

After loading the vehicle, wet and cover the sprigs to reduce moisture loss. Keep the sprigs covered until planting. Plant sprigs within 48 hr of harvesting.

735.02 PLANTING MATERIALS

A. Plant Materials

Refer to ANSI Z-60.1, Nursery Stock for grading tolerances, quality definitions, balling and burlapping specifications, container, and plant material bare-root requirements, except as modified by the following:

Unless otherwise required by the Contract, provide healthy, nursery-grown plant materials representative of the normal species with a developed root system.

Provide well branched and symmetrical trees with straight stems in accordance with their natural growth habits. Ensure the branch system is free of disfiguring knots, sun scald damage, bark abrasions, dead or dry wood, and broken terminal growth.

The Department considers nursery grown stock to be plants that are grown using cultural treatment and are transplanted or root pruned at least two times in accordance with nursery practices. Provide evergreens that are balled and burlapped (B&B), or in a container. Provide deciduous plants that are bare-rooted (BR), B&B, or in a container. Ensure B&B plants have solid, firm balls, dug from firm non-sandy soil.

If nursery grown plants are unavailable, substitute with collected plants with the written approval of the Resident Engineer. Ensure a Resident Engineer-approved nursery digs up the collected plants. Notify the Resident Engineer in writing at least 2 weeks before digging collected plants for inspection. Provide materials, equipment, labor, and incidentals for substituting nursery grown plants with collected plants at no additional cost to the Department.

Ensure the collected plant root spread and ball size is at least 33 percent greater than the substituted nursery-grown plant, in accordance with ANSI Z-60.1.

Pack plants to protect them against damage during transit. Keep BR plant roots moist.

The Resident Engineer may inspect plant materials for provisional approval at any point during the duration of the Contract.

At the time of delivery, tag plant materials with names and sizes. Provide the Resident Engineer with a written statement that includes shipment origin and an invoice showing quantities, sizes, varieties, and inspection certificates, in accordance with federal and state laws, certifying the plant is free of disease and insects.

B. Planting Soil Mix

Provide planting soil mix containing one part sand, three parts sandy loam, and one part peat moss, by volume. Provide these materials in accordance with the following:

Sand. Soil material containing at least 85 percent sand, by weight [mass]. Ensure the combined percent of silt and one and one-half times the clay is 15 percent or less of the total weight [mass]. Sand includes coarse, fine, and very fine sand.

Sandy Loam. Sandy loam is soil material that meets one of the following criteria:

- Contains 20 percent or less clay by weight [mass]; the silt percentage plus two times the clay percentage is greater than 30 percent; and contains at least 52 percent sand by weight [mass].

- Contains less than 7 percent clay, less than 50 percent silt, and from 43 to 50 percent sand (all percentages by weight [mass]).

Peat Moss. Material containing at least 75 percent partially decomposed stems and leaves of mosses (e.g. sphagnum, hypnum, polytrichum) in which the fibrous and cellular structure is recognizable. Ensure the peat moss is a brown to black color. The Department will not allow humus peat. Provide peat moss with the following characteristics:

- Moisture content of less than 60 percent by weight [mass];
- Ash content of less than 20 percent, based on the oven dry weight [mass] of the material;
- A pH value from 3.2 to 7.0 at 77 °F [25 °C]; and
- A water holding capacity of at least 400 percent by weight [mass], on an oven dry basis.

Submit to the Resident Engineer a certificate stating the peat moss type, brand name, and place of origin. Ensure the certificate contains the volume (cubic feet [cubic meter]) of compressed material, the compression ratio, and the weight per cubic foot [mass per cubic meter]. The Department will not require a certificate for bales marked with this information.

Blend the materials until homogenous in texture and composition in accordance with U.S Department of Agriculture Soil Classifications and the OHD *Manuals of Engineering Classification of Geological Material*, R&D Division.

Provide planting soil mix that is free of materials that interfere with planting procedures and maintenance, toxic salts, and materials that retard establishment or interfere with growth. Ensure the mix does not contain reproducing weed parts classified as “Prohibited Noxious” or legally “Restricted Noxious” plant materials in accordance with Oklahoma Department of Agriculture Seed Law.

Stockpile and mix the planting soil materials at a location approved by the Resident Engineer.

C. Organic Mulch

Provide organic mulch free of reproducing weed parts classified as “Prohibited Noxious” or legally “Restricted Noxious” plant materials in accordance with Oklahoma Department of Agriculture Seed Law. Allowable mulch includes cottonseed hulls, partially decayed and chopped cotton burrs, peat moss, chopped peanut hulls, pine straw, wood chips, pecan shells, compost, or a combination of these items.

735.03 SEEDING MATERIALS

Provide seed in accordance with Table 735:1 “Seed Specifications.” If mixtures are shown on the Plans, provide each seed lot in a separate, sealed bag. Ensure the labels, required by applicable laws, are intact and legible. Submit to the Resident Engineer two legible copies of the invoices and seed tags. Ensure the invoice identifies each species name, variety, and treatment.

Ensure the Oklahoma State Board of Agriculture samples and tests each lot within 9 months before delivery. Submit to the Resident Engineer two copies of the report.

The Resident Engineer will accept seed lots if the seed report correlates with the seed tags of the same lot number.

Remove the seed and tags from the original tagged and sealed bag when approved by the Resident Engineer. After approval, mix, sack, and batch the seed as required by the Contract. Tag the seed with identification and mass. Mix or sack into batches under the Resident Engineer's supervision. Ensure the seeds do not contain Johnson grass seed.

Table 735:1
Seed Specifications

Seed Type	PLS Index [a], minimum	%, minimum		
		Purity	Germination	Weed Seeds
Bermuda grass:				
Common (Cynodon dactylon)				
Unhulled	80	—	—	0.2
Hulled	82	—	—	0.2
Guymon variety (Cynodon dactylon):				
Unhulled	80	—	—	2.0
Hulled	82	—	—	2.0
Bluestem:				
Big (Andropogon gerardi) [b]	20	—	—	—
Caucasian (Andropogon caucasicus)	15	—	—	—
Little (Andropogon scoparius) [b]	15	—	—	—
Plains (Bothrichloa ischaemum)	30	—	—	1.0
Sand (Andropogon halli) [c]	20	—	—	—
Yellow (Andropogon ischaemum)	18	—	—	—
Brome, smooth (Bromus inermis)	70	—	—	2.0
Buffalo grass (Buchloe dactyloides) [b,c]	55	—	—	—
Bur-clover (Medicago hispida, arabica or rigidula)	—	98	85	1.0
Clover:				
Crimson (Trifolium incarnatum)	—	95	85	0.5
Large hop (Trifolium procumbens) [c]	—	95	85	0.5
Small hop (Trifolium dubium) [c]	—	95	85	0.5
Drop seed, sand (Sporobolus cryptandrus)	70	—	—	2.0
Fescue, tall (Festuca arundinacea)	80	—	—	0.5
Grama:				
Blue (Bouteloua gracilis) [b]	25	—	—	—
Side-oats (Bouteloua curtipendula) [b]	30	—	—	—
Indian grass (Sorghastrum nutans) [b]	35	—	—	2.0
Lespedeza:				
Common (Lespedeza striata)	—	97	90	0.5
Korean (Lespedeza stipulacea) [d]	—	97	90	0.5
Roundhead (Lespedeza capitata)	—	97	90	0.5
Sericea (Lespedeza cuneata) [d]	—	98	90	0.5
Love grass:				
Sand (Eragrostis trichodes) [b]	65	—	—	0.5

Table 735:1
Seed Specifications

Seed Type	PLS Index [a], minimum	%, minimum		
		Purity	Germination	Weed Seeds
Weeping (Eragrostis curvula)	80	—	—	0.3
Millet, German foxtail (Setaria italica)	—	98	80	0.5
Native grasses (Mostly little bluestem) [b]	15	—	—	—
Oats (Avena sativa)	—	95	80	0.5
Rye (Secale cereale)	—	90	70	0.3
Ryegrass:				
Annual (Lolium multiflorum)	85	—	—	0.2
Perennial (Lolium perenne)	85	—	—	0.2
Sudan grass (Sorghum vulgare sudanense)	—	98	80	0.5
Switch grass (Panicum virgatum)	60	—	—	2.0
Wheat (Triticum aestivum)	—	96	80	0.1
Wheat grass, western (Agropyron smithii) [b]	56	—	—	1.0

[a] Calculate the Pure Live Seed (PLS) Index in accordance with the equations following Table 735:1.
[b] The seed must come from Oklahoma, Texas, Kansas, or New Mexico.
[c] Provide seed that is pre-chilled and treated with potassium nitrate in accordance with the Hays Treatment Technique.
[d] Treat the seed with a nitrogen fixing inoculant, manufactured by commercial laboratories for the legume. Store and handle the inoculant in accordance with the manufacturer's directions.

Calculate the PLS Index from information on the seed tag, in accordance with the following equation:

$$PLS_p = \frac{P \times (G + FS)}{100}$$

where

PLS_p = PLS Index of seed provided,
P = Percent purity,
G = Percent germination, and
FS = Percent firm seed.

The Department defines the weight [mass] of seed in pounds [kilograms] of bulk seed. If the PLS Index of a seed lot exceeds the minimum PLS Index, specified in Table 735:1, "Seed Specifications," by at least 25 percent, adjust the amount of bulk seed for planting using the following equation:

$$BS_r = \frac{PLS_r \times BS_p}{PLS_p}$$

where

BS_r = Weight [mass] of bulk seed required for planting, in pounds [kilograms],

PLS_r = PLS Index of seeds required in Table 735:1, "Seed Specifications,"

BS_p = Weight [mass] of bulk seed required by the Contract, in pounds [kilograms],

and

PLS_p = PLS Index of seed provided.

735.04 MULCHING MATERIALS

A. Vegetative Mulch

Vegetative mulch consists of straw or hay in accordance with the following:

- Straw is the mature barley, oat, rye, or wheat stem.
- Hay is mature weeping love grass, caucasian bluestem, K.R. bluestem, or pure stands of the other bluestem hays. Ensure the hay is free of annual grass, short grass or immature tall grass.

Provide well preserved vegetative mulch free of mold or rot, well preserved, and primarily long, heavy-stemmed material. Deliver the material in dry bales. Keep the material dry until application. Ensure the mulch does not contain seeds classified as "Prohibited Noxious" and legally "Restricted Noxious" in accordance with the Oklahoma Department of Agriculture Seed Law.

B. Asphalt Mulch

Provide MS-2 emulsified asphalt mulch in accordance with Subsection 708.03, "Asphalt Materials." Before application, dilute the mulching asphalt with 3 gal water to 1 gal emulsified asphalt.

C. Excelsior Mat

Excelsior mat consists of a machine-produced wood excelsior mat, with interlocking fibers that form a continuous web. Ensure at least 80 percent of the fibers are at least 8 in [200 mm] long and the web is uniformly distributed throughout the mat, creating uniform thickness and density. Cover the mat on one side with extruded plastic netting with a mesh size no greater than 1 in × 2 in [25 mm × 50 mm]. Provide mats with the following dimensions:

- Length: at least 130 ft [45 m],
- Width: 48 in [1,220 mm], or from 59 in to 61 in [1,500 mm to 1,550 mm], and
- Dry mass per area: 0.8 lb/yd² [0.43 kg/m²].

Provide mat with smolder resistant, non-leaching treatment that will not harm vegetation, animals, and humans. Test for leaching resistance in accordance with Federal Test Method 191, Method 5830. After the leaching test, conduct the smolder resistance test on the air-dried sample. Submit to the Resident Engineer a Type D certification for excelsior mat material.

Anchor the mat using fasteners in accordance with Subsection 735.05.B, "Mat Fasteners."

D. Jute Mesh

Provide uniform, open, plain weave jute mesh made of new single jute yarn. Ensure the yarn is loosely twisted and does not vary in thickness by more than half its normal diameter. Provide jute mesh with the following dimensions:

- Length: at least 150 ft [45 m],
- 78 Warp ends per width,
- 41 Weft ends per yard [meter], and
- Mass per area: at least 0.9 lb/yd² [0.49 kg/m²].

Anchor the mat using fasteners in accordance with Subsection 735.05.B, "Mat Fasteners."

E. Excelsior Mulch

Excelsior mulch consists of wood fibers cut from sound green timber. Make the cut at a slight angle to the natural wood grain so the fiber splinters when weathered. Provide excelsior mulch with the following properties:

- Burred wood fibers 4 in [100 mm] long. Ensure the fiber is within 20 percent of 0.024 in [0.61 mm] × 0.031 in [0.79 mm].
- Ensure the total volatile content at the time of manufacture does not exceed 45 percent in accordance with the following equation:

$$V = (a - b) \times \frac{100}{a}$$

where

V = Percent volatile content,
a = Weight [mass] of original sample, and
b = Weight [mass] of dry sample.

Deliver the material in bales from 80 lb [36 kg] to 90 lb [41 kg]. Tag each bale with the weight [mass] at the time of manufacture. Ensure the bale density is from 11 lb/ft³ [175 kg/m³] to 15 lb/ft³ [240 kg/m³].

F. Wood Cellulose Fiber

Wood cellulose fiber consists of natural wood fiber produced from wood by-products. Ensure the wood cellulose fiber does not contain growth or germination inhibitors, and contains a water soluble, nontoxic coloring agent.

G. Nylon Erosion Control Mat

Provide a nylon erosion control mat consisting of a bulky structure of entangled nylon monofilaments, melt-bonded at intersections, forming a stable mat. Submit to the Resident Engineer a Type D certification with each shipment.

Anchor the mat using fasteners in accordance with Subsection 735.05.B, "Mat Fasteners."

Provide common bermuda grass seed, un-hulled in accordance with Subsection 735.03, "Seeding Material."

Provide a resilient, permeable mat that resists environmental deterioration and ultraviolet degradation. Provide a black mat of Nylon 6 with at least 0.5 percent by weight [mass] carbon black with the following properties:

(1) Physical Properties

- Filament diameter: 0.0157 in [0.40 mm],
- Mass per unit area: 0.747 lb/yd² [0.41 kg/m²],
- Thickness of mat: 0.71 in [18 mm],
- Width: 38.2 in [970 mm], and
- Roll length: from 105.7 yd [97 m] to 112.3 yd [103 m].

(2) Tensile Properties

- Tensile strength length: at least 282 lb/yd [1,372 N/m],
- Width elongation: at least 161 lb/yd [783 N/m],
- Length direction: at least 50 percent, and
- Width direction: at least 50 percent.

Modify the ASTM D 1682 strip test procedure to obtain filament bond strength for indicating tensile properties.

(3) Resiliency

- Compression load cycling: 100 psi [689.4 kPa] on a 2 in [50.8 mm] × 2 in [50.8 mm] sample,
- Crosshead speed: 2 in/min [50.8 mm/min], and
- Recovery, 30 min (3 cycles): at least 80 percent.

H. Inspection of Materials

Before delivery of the mulching material, provide the Resident Engineer with the following:

- Notification of the intended material sources and quantities, and
- Representative samples of the materials.

The Resident Engineer may use the samples for provisional approval before delivery and will reject material with evidence of deterioration.

The Resident Engineer will reject mulching material not applied or fastened, as required by the Contract, during application or after placement.

735.05 MULCH FASTENING MATERIALS

A. Adhesive Fastener

Provide adhesive fasteners in accordance with Section 708, “Plant Mix Bituminous Bases and Surfaces.”

B. Mat Fasteners

Provide mat fasteners as shown on the Plans.

735.06 FERTILIZER AND AGRICULTURE LIMING MATERIALS

A. Fertilizer

Provide a commercial fertilizer consisting of the standard materials of the grade required by the Contract. Fertilizer grade refers to the percentage of total nitrogen, available phosphate, and soluble potash, in accordance with the Oklahoma Department of Agriculture, Food and Forestry. Provide fertilizer in standard, factory-sealed

containers, labeled in accordance with the Oklahoma Department of Agriculture, Food and Forestry. Ensure the labels remain intact and legible until use of the contents.

Ensure two legible copies of the purchase receipt accompany each vehicle bulk load of fertilizer. Give the receipt to the Resident Engineer upon delivery. Ensure each receipt shows the mass, brand name, and the labeling requirements in accordance with Table 735:2, "Oklahoma Department of Agriculture, Food, and Forestry Label Requirements." Include the name and address of the person, firm, or corporation registering or guaranteeing the fertilizer.

Table 735:2
Oklahoma Department of Agriculture, Food, and Forestry Label Requirements

Requirement	Example
Grade	"10-20-10"
Derived from statement	"Plant nutrients derived from urea, diammonium phosphate, and muriate of potash, magnesium sulfate, ammonium sulfate, iron oxide."
Directions for use	Specify an application rate or include a statement to use in accordance with recommendations by a qualified institution or according to an approved plan.
Manufacturer	Company name and address

Broadcast dry fertilizer in a pellet or other granular form. Ensure powder spray-applied material is soluble in water and uniform in suspension. The Department will allow a higher grade fertilizer with an identical NPK ratio. If using a higher grade fertilizer, adjust the application rate to provide an equivalent weight [mass] of each element per unit of area as that of the grade required by the Contract.

Adjust the application rate of higher grade fertilizers using the following equation:

$$a = \frac{b \times c}{d}$$

where

a = Adjusted application rate,
b = Grade of fertilizer required by the Contract (NPK converted to decimal),
c = Application rate of fertilizer grade required by the Contract, and
d = Grade of higher grade fertilizer (NPK converted to decimal).

B. Agricultural Liming Material

Agricultural liming material consists of agricultural limestone or hydrated lime in accordance with Section 706, "Lime." If the Contract requires agricultural limestone, the Department will allow the substitution of 100 lb [100 kg] of agriculture limestone with 70 lb [70 kg] of hydrated lime. If the Contract requires hydrated lime, the Department will not allow the substitution of hydrated lime with agricultural limestone.

Provide liming material in standard factory-sealed containers labeled in accordance with the Oklahoma Agricultural Liming Materials Act.

Ensure two legible copies of the purchase receipt accompany each vehicle bulk load of liming material. Give the receipt to the Resident Engineer upon delivery. Ensure each receipt includes the following information:

- Liming material name,

- The brand or trade name,
- The net weight [mass],
- The percent effective calcium carbonate equivalent, and
- The name and address of the manufacturer, producer, or distributor.

The Resident Engineer will take a 1 qt [1 L] sample from each vehicle load for testing by the Department's Materials Laboratory.

735.07 TEMPORARY SILT DIKE MATERIALS

Provide a triangular-shaped temporary silt dike with a height in the center from 8 in [200 mm] to 10 in [250 mm], equal length sides, and a base from 16 in [400 mm] to 20 in [500 mm]. Ensure the outer cover is a woven geotextile fabric that extends from 24 in [600 mm] to 36 in [900 mm] beyond both triangle sides. Provide mildew resistant, rot-proof, ultraviolet radiation resistant geotextile fabric in accordance with AASHTO M 288. Treat the edges to prevent unraveling and reinforce seams and stress points. Ensure the fabric cover and apron consist of a continuous fabric wrapping and the apron is a continuous extension of the upstream face. Use urethane foam as the inner layer of the silt dike in accordance with ASTM D 3574.

735.08 WATER

Provide water free of harmful quantities of toxic salts and other substances that may damage new and existing plants on the project.

SECTION 736
PAVEMENT MARKERS

736.01 CLASS A REFLECTIVE PAVEMENT MARKERS

A. Design and Shape

Provide Group 1, Class 3, prismatic reflectorized markers of the size and shape shown on the Plans, smooth, and molded of methyl methacrylate in accordance with ASTM D 788 and Federal Specification L-P-380a, Type 1, Class 3. Ensure moisture and road grime will not damage markers, and the shape and color do not change when subjected to Test Method OHD L-24 at 140°F [60°C]. Provide markers with a strong, resilient, potting compound filler that is capable of withstanding a load of 9,000 lb [40 kN] without breaking or deforming when tested in accordance with Test Method OHD L-23.

B. Reflector

Ensure the specific intensity of the reflector is in accordance with ASTM D 4383.

736.02 CLASS B NON-REFLECTIVE PAVEMENT MARKERS

A. Design and Shape

Provide uniformly curved, dome-shaped traffic buttons for Class B non-reflective pavement markers. Ensure the top and sides are smooth and uniform in color. Ensure the bottom is rough and free of substances that may reduce the adhesive bond.

Provide non-reflective markers from ⅝ in to ¾ in [15.9 mm to 19.1 mm] high and with a base diameter from 3⅞ in to 4⅛ in [98.4 mm to 104.8 mm]. Ensure the base deviates from a plane by no more than $^{1}/_{16}$ in [1.6 mm].

B. Physical Requirements

Provide a button with no greater than 1.0 percent water absorption when tested in accordance with ASTM C 373.

Ensure the glazed button surface does not craze, spall, or peel when subjected to one cycle of the autoclave test at 250 psi [1.72 MPa] in accordance with ASTM C 424.

Provide a random sample of five buttons for compressive load testing and ensure the following characteristics:

- An internal diameter of 3 in [76.2 mm], and a wall thickness of ¼ in [6.4 mm].
- The sample averages a compressive strength of at least 1,500 lb [6.67 kN].
- Each button has a compressive strength of at least 1,200 lb [5.34 kN].
- The button is centered, base down, over the open end of a 1 in [25.4 mm] high, vertical, hollow, metal cylinder.
- The button breaks under a 1 in [25.4 mm] diameter solid metal cylinder centered above the button and moving at 0.2 in/min [5.1 mm/min].

If a sample fails the compressive load test, test five additional buttons. The Resident Engineer will reject the lot if re-samples fail.

Provide a random sample of five buttons for impact resistance testing and ensure the following characteristics:

- Buttons are heat-aged at least 10 days at 150°F [65.6°C] before testing for impact resistance.
- The impact tests occurs from 40°F to 45°F [4.4°C to 7.2°C].
- The button rests on, but is not bonded to, a flat steel plate.
- The button does not break, chip, or crack under the impact of a 1 lb [454 g] steel ball falling freely from a height of 24 in [610 mm].

If a sample fails the impact resistance test, test five additional buttons. The Resident Engineer will reject the lot if re samples fail.

C. Color

Provide buttons of a uniform color as shown on the Plans, determined by visually comparing them with calibrated standards in accordance with CIE Chromaticity and Federal Test Method TT-T-141, Method 4252, falling in an area with corner points in accordance with Table 736:1:

Table 736:1
Corner Points

Color	1		2		3		4		Brightness, *% MgO*
	x	y	x	y	x	y	x	y	
White	0.290	0.316	0.310	0.296	0.330	0.321	0.310	0.342	≥80
Yellow	0.470	0.460	0.515	0.485	0.545	0.455	0.490	0.425	≥40

D. Glaze Thickness

Ensure the glazed surface has an average thickness of at least 0.005 in [125 µm] when measured at least ¼ in [6.4 mm] away from the button edge. Measure the glaze

thickness with a calibrated scale microscope on a fractured edge of the button to the nearest 0.001 in [25 µm].

736.03 CLASS C REFLECTIVE ALL-WEATHER PAVEMENT MARKERS

A. Design and Shape

Provide pavement markers that are an iron casting to which replaceable prismatic reflectors are attached. Ensure markers have the following characteristics:

- The forward portions are shaped to deflect snowplow blades and highway maintenance equipment without snag damages.
- The bottom of the casting incorporates anchoring devices that fit into slots or grooves cut in the roadway.
- The marker bonds to the roadway pavement with an approved adhesive, anchored so traffic, snowplows, and highway maintenance equipment will not dislodge it.
- The casting is designed so the reflector-mounting surface is 30° to the horizontal and contain provisions for attaching replaceable reflectors.
- Reflectors can be quickly and easily replaced using common hand tools without disturbing the anchorage.
- The marker can withstand a load of 9,000 lb [40.0 kN] without breaking or being deformed when tested in accordance with OHD L-23.

B. Casting

Provide markers, cast to conform to the shape and dimensions shown on the Plans, clean and free of defects. Ensure smooth marker surfaces free from burnt-on sand. Ensure runners, risers, fins, and other cast-on pieces are ground smooth. Ensure corners and edges exposed to traffic are rounded. Provide castings of ductile iron, Grade 65-45-12, in accordance with ASTM A 536, unless otherwise required by the Contract. Ensure the forward rail tops have a hardness from 50 HRC to 55 HRC when tested in accordance with ASTM E 18.

C. Reflector

Provide Group 1, Class 3, marker reflectors made of methyl methacrylate in accordance with ASTM D 788, of the shape and dimensions shown on the Plans, and ensure marker reflectors prevent moisture and road grime from penetrating or causing damage.

Ensure the reflector does not change shape or color when tested in accordance with OHD L-24 at 140°F [60°C] with the marker in a vertical position. Ensure the specific intensity of the reflector is in accordance with ASTM D 4383.

736.04 ADHESIVES FOR USE WITH PAVEMENT MARKERS

A. Epoxy Resin Adhesives

Provide epoxy resin adhesives for securing Class A, Class B, and Class C pavement markers to the roadway in accordance with Subsection 701.13, “Epoxy Resin and Other Adhesives for General Use with Concrete,” Type C.

B. Bituminous Type Hot-Melt Adhesives

Provide bituminous hot-melt adhesive to secure the Class A and Class B construction zone pavement markers and tube channelizers to the roadway surface.

(1)Description

Provide an adhesive for bonding ceramic and plastic markers to portland cement concrete (PCC), asphaltic concrete, and chip-sealed road surfaces, and when road surface and marker temperatures are from 40°F to 160°F [4°C to 70°C]. Ensure the composition of the adhesive prevents deterioration when heated and applied at temperatures up to 430°F [220°C], using air or oil-jacketed melters.

(2)Materials

For the adhesive, provide an asphalt material with a homogeneous mineral filler in accordance with Table 736:2:

Table 736:2
Adhesive Properties

Property	Value	Test
Softening point	≥200°F [93.3°C]	ASTM D 36
Penetration	10 – 20	ASTM D 5
Flow	≤0.2 in [5.1 mm]	ASTM D 3407 [a]
Heat stability flow	≤0.2 in [5.1 mm]	Subsection 736.04.B(3)(b), "Heat Stability Flow"
Viscosity	≤7.5 Pa•s	ASTM D 2669 [b]
Flash point, COC	≥500°F [260°C]	ASTM D 92

[a] As modified in accordance with Subsection 736.04.B(3)(a), "Flow."
[b] As modified in accordance with Subsection 736.04.B(3)(c), "Viscosity."

The asphalt properties in Table 736:3 are determined on the filler-free material derived from the extraction and Abson recovery process:

Table 736:3
Asphalt Properties

Property	Value	Test
Penetration, 100 g, 5 sec, 77°F [25°C]	≥25	ASTM D 5
Viscosity, 275°F [135°C]	≥1.2 Pa•s	ASTM D 2171
Viscosity ratio, 275°F [135°C]	≤2.2	Subsection 736.04.B(3)(e), "Viscosity Ratio"

The filler properties specified in Table 736:4 are determined using the filler separation technique:

Table 736:4
Filler Properties

Property	Value	Test
Filler content, %	50 – 75	Subsection 736.04.B(3)(f), "Filler Content"
Filler fineness, %	—	ASTM C 430 [a]
45 µm	≥75	
75 µm	≥95	
150 µm	≥100	

[a] As modified in accordance with Subsection 736.04.B(3)(g), "Filler Fineness."

(3) Test Methods

(a) *Flow*

Determine flow in accordance with ASTM D 3407, Section 6, except use an oven temperature from 158°F ±2°F [70°C ±1°C]. Prepare samples in accordance with ASTM D 5, Section 7.1.

(b) *Heat Stability Flow*

Determine heat stability flow in accordance with flow test methods, except, place 2 lb [1,000 g] of adhesive in a covered liter can, heat the adhesive to 430°F [220°C], and maintained the temperature for 4 hr before preparing the sample panel.

(c) *Viscosity*

Determine viscosity in accordance with ASTM D 2669, except, heat the adhesive to 410°F [210°C], and allow it to cool. Provide a spindle speed of 1.88 rad/s to determine viscosity at temperatures from 400°F ±1°F [204.4°C ±0.6°C] in accordance with ASTM D 2669.

(d) *Base Asphalt Properties*

Provide the material obtained from the following extraction and Abson recovery methods to determine the properties of the base asphalt.

Extract the asphalt by heating the adhesive until it flows easily. Remove extracted asphalt from the adhesive and mix from 125 g to 150 g with 400 mL of trichloroethylene. Ensure the temperature of the trichloroethylene is from 125°F to 150°F [52°C to 66°C]. Stir the mixture to dissolve the asphalt. Decant the mixture and recover the asphalt using the Abson recovery methods in accordance with ASTM D 1856, except as modified by the following:

- The extraction methods of ASTM D 271s do not apply.
- Do not filter the solvent-asphalt solution.
- Centrifuge the solution for at least 30 min at 770 times gravity in a batch centrifuge.
- Decant the solution into the distillation flask, excluding filler sediment.
- Apply heat, and bubble carbon dioxide slowly to bring the solution temperature to 300°F [149°C].
- Increase the carbon dioxide flow to 800 mL/min to 900 mL/min.
- Maintain the solution temperature from 320°F to 335°F [160°C to 168°C] with this carbon dioxide flow rate for at least 20 min and until the trichloroethylene vapors are absent from the distillation flask.
- Repeat the extraction-recovery method as necessary to obtain the desired quantity of asphalt.

Use the recovered asphalt to determine penetration, 275°F [135°C] viscosity, and 275°F [135°C] viscosity ratio.

(e) *Viscosity Ratio*

Determine the 275°F [135°C] viscosity ratio by comparing the 275°F [135°C] viscosity on the base asphalt before and after the thin-film oven test. Perform the thin-film oven test in accordance with ASTM D 1754. Determine the specific gravity by pycnometer in accordance with ASTM D 70 for the

thin-film oven test. Calculate the 275°F [135°C] viscosity ratio by dividing the viscosity after the thin-film oven test by the original 275°F [135°C] viscosity.

(f) ***Filler Content***

Separate the filler material from the asphalt to determine filler content and fineness. The portion by mass of the adhesive insoluble in trichloroethylene is considered the filler content. Determine filler content by placing from 9 g to 11 g of solid adhesive into a centrifuge flask with 100 mL capacity in accordance with ASTM D 1796. Break the adhesive into small pieces, and add 50 mL of trichloroethylene. Stir with a fine rod without losing solids, place the sample flask in a balanced centrifuge, and spin using a relative centrifugal force of at least 150, in accordance with Section 6 of ASTM D 1796, for 10 min. Remove the sample flask. Decant the solvent without losing solids. Repeat the solvent application and centrifuging until the solvent becomes clear and the filler is visually free of asphalt. Dry the filler at 160°F ±5°F [71°C ±3°C] to remove solvent and determine the mass of the resulting filler. Filter the decanted solvent to verify there is no loss of filler. Calculate the percent filler using the following equation:

$$FC = (F / OA) \times 100$$

where

FC = Filler content, percent;
F = Weight of filler; and
OA = Weight of original adhesive.

(g) ***Filler Fineness***

Determine filler fineness in accordance with ASTM C 430 using No. 325 [45 µm], No. 200 [75 µm], and No. 100 [150 µm] sieves. Modify this method with a water-soluble, non-toxic wetting agent. Ensure the concentration of the surfactant solution is 1 percent by mass. Wet the 1 g dry sample in the surfactant solution. Allow the sample to soak for 30 min. Transfer the filler into the sieve cup. Apply the filler for 2 min by water-spraying. Add the surfactant solution as needed to disperse clumped particles. Dry and handle the sample in accordance with ASTM C 430.

(4) Packaging and Labeling

Provide adhesive packaged in self-releasing, stackable cardboard containers. Ensure containers have a maximum net weight of 120 lb [54.4 kg]. Ensure the label shows the manufacturer, quantity, and lot or batch number with “bituminous adhesive for traffic markers” printed in bold lettering.

SECTION 737
CONCRETE SURFACE FINISH FOR STRUCTURES

737.01 OPTION I — HEAVY CEMENT BASE MORTAR

A. Materials

Provide a heavy cement base, packaged in dry powder form, for mixing with water. Provide a plaster mix for plaster gun application and a brush and float mix for brush and float application.

Provide a formulation of acrylic polymers and modifiers in liquid form as an additive with portland cement mixes to ensure adhesion.

B. Proportioning and Consistency

Proportion the bonding agent and water in accordance with the manufacturer's recommendations. Give the Resident Engineer a copy of the recommendations.

737.02 OPTION II — PAINT TYPE SPRAY FINISH

A. Materials

Provide material for paint spray finish that is a textured commercial product designed as a spray finish.

B. Testing and Certification

Brand products not included on the Materials Division approved product list may be qualified by submitting a Type A certification and samples for durability and appearance evaluations. The Department will discontinue product approval if products are used in accordance with the manufacturer's instructions and prove unsatisfactory.

Ensure the manufacturer includes a Type C certification with each shipment of tested products. Ensure materials for spray finish are in accordance with the following tests:

- Freeze-thaw cycle,
- Accelerated weathering,
- Flexibility,
- Fungus growth resistance,
- Abrasion test, and
- Salt spray resistance.

(1) Freeze-Thaw Cycle

Using the mix designed for the structure, cast and cure three concrete slabs at least 4 in × 6 in × 6 in [101.6 mm × 152.4 mm × 152.4 mm]. Apply the surface finish after moist curing the specimens for 14 days, and dry curing them for 24 hr from 60 °F to 80 °F [15.6 °C to 26.7 °C]. Do not use excessive oil on specimen forms. Coat and cure the specimen sides at room temperature for 48 hr. Immerse the specimens in water from 60 °F to 80 °F [15.6 °C to 26.7 °C] for 3 hr and repeat 50 cycles of the following procedures:

- Place the specimens in cold storage at −15 °F [−26.1 °C] for 1 hr.

- Thaw the specimens at temperatures from 60 °F to 80 °F [15.6 °C to 26.7 °C] for at least 1 hr.

Ensure specimens show no defects at the end of 50 cycles of the freeze-thaw test.

(2) Accelerated Weathering

Expose the material to a 5,000 hr test in a twin-arc-weatherometer at an operating temperature of 145 °F [62.8 °C]. Test in 20 min cycles consisting of 17 min of light and 3 min of water spray plus light. At the end of the exposure test, ensure the exposed sample shows no chipping, flaking, or peeling.

(3) Flexibility

When applied to a thin metal plate at a spreading rate from 40 ft²/gal to 50 ft²/gal [0.98 m²/L to 1.22 m²/L], ensure the material bends 180° over a 25.4 mm mandrel without breaking the film.

(4) Fungus Growth Resistance

Provide material that passes a fungus resistance test in accordance with Federal Specification TT-P-29b. Test for an incubation period of at least 21 days, and ensure the material shows no signs of fungal growth.

(5) Abrasion Test

Test for abrasion resistance in accordance with ASTM C 418. Ensure the material lost is no greater than 0.5 cm³/cm².

(6) Salt Spray Resistance

Apply the material to the concrete at a rate of 50 ft²/gal [1.23 m²/L]. Test the material in accordance with ASTM B 117 with the coating exposed to a 5 percent sodium chloride solution for 300 hr and maintained at a temperature from 90 °F ±2 °F [32.2 °C ±1.1 °C]. During the exposure period, ensure the material shows no loss of adhesion or deterioration at the end of the 300 hr.

737.03 ELASTOMERIC COATING SYSTEM

A. General

Provide an elastomeric polyurethane waterproof coating system that forms a waterproof barrier over post-tensioning anchorages or areas shown on the Plans. Provide waterproof coating system components from a single manufacturer. Apply the surface preparation and coating system in accordance with the manufacturer's recommendations.

B. Physical Properties

Provide an elastomeric coating system composed of several coats. Provide an epoxy prime coat if required on the manufacturer's recommendations for waterproofing systems. Provide a polyurethane chemistry that is waterborne aromatic or aromatic. Provide an elastomeric coating system at least 30 mil thick and in accordance with Table 737:1:

Table 737:1
Physical Properties

Property	Test Value	Test Method
Hardness, Shore A	60 – 90	ASTM D 2240
Tensile strength	≥750 psi [5.2 MPa]	ASTM D 412
Elongation >	_400% A	STM D 412
Tear strength	>70 pli [12.35 N/mm]	ASTM C 957
Abrasion resistance, H-18 wheels 1,000 gm/wheel <	_350 mg loss/1,000 revs.	ASTM C 957
Crack bridging, 1,000 cycles	System Passes	ASTM C 957
Elongation recovery	≥94% A	STM C 957

C. System Modifications for Bridge Substructures

Supply the elastomeric coating system with an aliphatic polyurethane top coat. When applied to bridge substructures, match the color to the color scheme shown on the Plans. If the Plans do not show a color scheme, use a color similar to Federal Color Standard No. 595B, Table VIII, Shade No. 36622.

737.04 ANTI-GRAFFITI COATING SYSTEM

A. General

Provide a non sacrificial anti-graffiti coating system that forms a barrier over new or existing concrete surfaces that allows for the removal of graffiti without leaving graffiti shadows or ghosts. Provide anti-graffiti coating system components from a single manufacturer. Apply the surface preparation and coating system in accordance with the manufacturer's recommendations.

B. Physical Properties

(1)Level 1 Coating

Provide a non sacrificial anti-graffiti coating system that forms a barrier over new concrete surfaces that allows for the removal of graffiti in accordance with ASTM D 7089 with a Cleanability Level 2.

(2)Level 2 Coating

Provide a non sacrificial anti-graffiti coating system that forms a barrier over an existing concrete surface that allows for the removal of graffiti in accordance with ASTM D 6578 with a Cleanability Level 2.

737.05 OPAQUE SEALERS AND STAINS

Provide opaque sealer and stain coating systems that are solvent-borne stain-type coatings capable of waterproofing as well as coloring finished concrete. These coatings consist of a blend of acrylic and silicone resins and toning pigments suspended in solution at all times by a chemical suspension agent and solvents. Use laminar silicates, titanium dioxide, inorganic oxides, and other mineral pigments and toning. Use of organic pigments, vegetable or marine oils, paraffinic materials, or stearates in the formulation are not permitted.

Provide a coating system capable of being coated with itself or other solvent-borne coatings without special surface preparation being necessary.

SECTION 738
ELECTRICAL CONDUCTORS

738.01 TRAFFIC SIGNAL WIRE AND CABLE

Provide traffic and signal electrical cable in accordance with IMSA 19-1 or 20-1, size 14 AWG.

Provide shielded loop detector lead-in cable in accordance with IMSA 50-2, size 14 AWG.

Provide loop detector wire in accordance with IMSA 51-5, size 14 AWG.

738.02 BUILDING AND HIGHWAY LIGHTING WIRE AND CABLE

Provide AWG sized, NEC wire, Type XHHW-2 or Type THHN building wire and cable with copper conductors, rated for 600 V.

Provide AWG sized, NEC wire, Type XXHW-2 or Type TTHN underground wire and cable with copper conductors.

Provide AWG sized, NEC wire, Type XHHW-2 or Type THHN aerial wire and cable with a conductor material that is best suited for the service intended.

738.03 COMMUNICATION WIRE AND CABLE

Provide underground communication wire and cables in accordance with IMSA 20-2 or REA-22.

Provide overhead communication wire and cable in accordance with IMSA 20-4.

SECTION 739
PULL BOXES

739.01 PRECAST CONCRETE PULL BOXES

A. Concrete

Provide concrete mixture designed to have a compressive strength of 3,000 psi [20.7 MPa] in accordance with AASHTO T 22.

B. Reinforcement

Provide wire reinforcement in accordance with AASHTO M 32 or AASHTO M 225.

C. Cover

Provide a gray iron casting cover in accordance with Subsection 725.03, “Iron Castings.” Ensure the cover has a non-slip surface and two, ⅜ in [9.5 mm] pent head brass bolts and nuts.

739.02 PRECAST REINFORCED PLASTIC PULL BOXES

A. General

Provide reinforced plastic mortar composed of a borosilicate glass fiber in the form of woven fabric, chopped strand or mat, catalyzed polyester resin, and aggregate.

B. Plastic Material

Provide self-extinguishing plastic materials tested in accordance with ASTM D 635. Ensure the plastic material does not physically change when exposed to weather.

C. Design Characteristics

Provide a cover with an embossed nonskid surface equipped with two, ⅜ in [9.5 mm] pent head brass bolts and nuts. Provide a concrete gray colored box and cover.

Ensure deflections from test loads do not cause the cover to bind or become displaced from the extension.

(1) Cover

Ensure the cover can withstand the following:

- A weight of 5,000 lb [2,268 kg] distributed over a 10 in × 10 in [254 mm × 254 mm] area without puncture or splitting; and
- An impact load of 75 ft•lb [101.6 Ncm] from a 12 lb [5.44 kg] mass with a tup-C nose detail in accordance with ASTM D 2444.

(2) Box Walls

With the cover in place, ensure box walls can withstand a 5,000 lb [2,268 kg] vertical load distributed over a 10 in × 10 in [254 mm × 254 mm] area centered over an exposed edge.

(3) Lateral Loads

Without the cover, ensure lateral loads can withstand 5,000 lb [2,268 kg] distributed over a 10 in × 10 in [254 mm × 254 mm] area of backfill adjacent to the installed box.

SECTION 740
TRAFFIC SIGNAL BACKPLATES

740.01 MATERIALS

Provide vacuum-formed backplates constructed of polycarbonate or Acrylonitrile-Butadiene-Styrene (ABS) sheet material.

Provide polycarbonate sheet material in accordance with ASTM D 638, ASTM D 695, ASTM D 790, and ASTM D 1822.

Provide ABS sheet material in accordance with ASTM D 1788.

740.02 FINISH

Ensure the backplate is black with a hair cell finish on the front and a smooth finish on the back.

CHAPTER 800
TRAFFIC CONTROL FACILITIES

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SECTION 801
PERFORMANCE AND OPERATIONAL TESTS FOR HIGHWAY LIGHTING AND TRAFFIC SIGNALS

801.01 DESCRIPTION

This work consists of providing labor, equipment, appliances, and materials to install and test highway lighting and traffic signal systems.

Ensure the electrical work conforms to NEC except where superseded by the Contract requirements.

801.02 MATERIALS

Within 30 days of receiving notice to proceed, submit to the Resident Engineer a list of materials to be used on the project that are listed on the Department's Traffic Engineering Division Qualified Products List (QPL). For materials not listed on the QPL, submit five copies of a complete materials schedule and proposed equipment, including catalog cuts, diagrams, drawings, and other data, along with a New Product Evaluation Request form to the Resident Engineer for approval. Provide materials and equipment to meet the Contract requirements.

The Resident Engineer may waive the submittal requirements for materials and equipment listed on the Department's Traffic Engineering Division, Qualified Products List.

After completing the traffic signal systems work, deliver the manufacturer's instruction manual for the maintenance, timing, and operation of traffic control equipment to the Resident Engineer. Provide a signal system wiring diagram and a parts list with each controller.

Provide galvanized hardware in accordance with AASHTO M 232, Class C coating.

Provide new, standard, and manufactured electrical and mechanical equipment. Provide the same class of equipment from a single manufacturer. Provide guarantees and warranties in accordance with Subsection 106.11, "Guarantees and Warranties."

801.03 EQUIPMENT

Provide specialized test equipment, tools, electrical diagrams, and labor required to perform tests for highway lighting and traffic signals.

801.04 CONSTRUCTION METHODS

A. General

Determine exact locations of electrical energy supplies in the field.

Make arrangements with the utility provider to complete the service connections.

Notify the Resident Engineer at least 48 hr before testing. The Resident Engineer will notify the city, county, or other agency responsible for supplying the electrical power for the planned testing procedures.

Unless otherwise required by the Contract, provide 60-cycle, single-phase, 480 V electrical supply and circuits for highway lighting. Ensure the lighting electrical supply and circuits are multi-grounded neutral for multiple connections of luminaires, with automatic photoelectric control to turn the highway lights on at dusk and off at dawn. Supply the 480 V lighting circuits from a primary system through a distribution transformer and control equipment.

Provide 60-cycle, single-phase, 120 V electrical supply and circuits for permanent and temporary traffic signals and flashing beacons, unless otherwise required by the Contract.

Provide 60-cycle, single-phase, 480 V electrical supply and ballasts for highway sign lighting.

B. Bonding and Grounding

Provide mechanically and electrically secure conduit, poles, and cabinets to form a continuous system.

Provide at least No. 10 AWG copper wire for bond and ground jumpers.

Provide at least No. 8 AWG copper wire for ground poles, securely attached to the pole and the ground rod, as shown on the Plans.

Provide at least No. 6 AWG copper wire for grounding conduit and neutral grounding conductors at service locations.

C. Electrical Field Testing

Before starting functional testing, test each circuit for continuity and grounds. Ensure the ground rods have a resistance to ground no greater than 25 Ω after installation. With the Resident Engineer present, conduct an insulation resistance test at 500 V (DC) on each circuit between the circuit and the ground. Ensure insulation resistance of at least 10 MΩ on all circuits. The Department will not allow insulation resistance testing using magnetometer detector devices. The Department will not allow splices made in the condulet or junction box adjacent to the magnetometer before testing on the lead-in conductors between the splice and the controller cabinet field terminals.

Submit the written test results to the Resident Engineer.

D. Electrical Functional Tests

Notify the government agency with jurisdiction over the system at least 24 hr before starting functional tests on traffic signal systems.

Do not allow the new and existing traffic signal systems to operate simultaneously.

Continuously operate conventional and high-mast lighting systems and traffic signal systems for 24 hr to determine if system parts function properly. Place the electrical system into service and inspect immediately for defects. Inspect the system during the test period at intervals directed by the Resident Engineer. During the functional test, throw safety switches to verify proper operation as required by the Contract. Switch photoelectric controllers from auto to manual and back to auto

during the night portion of the test to observe the response of the photoelectric controller.

After the 24 hr test period, the Resident Engineer will inspect the complete electrical system to ensure normal operation and to check for proper fixture and equipment installation.

If connected to the permanent power source, perform tests on sign lighting systems, flashing beacons, and electro-mechanical changeable message signs. If not connected to the permanent power source at the time of installation, provide temporary power to each device to demonstrate proper installation and operation for approval by the Resident Engineer.

E. Mechanical Test

After the 24 hr functional test, operate high-mast lighting systems and observe the system at night for six days. Look for defects in the luminaire or lamps. Demonstrate the proper function of lowering devices to the Resident Engineer by completing one lower and raise cycle on each assembly.

F. Defects

Correct defects as directed by the Resident Engineer at no additional cost to the Department.

G. Existing Traffic Signal Equipment

Do not remove, disconnect, or otherwise disable existing signal equipment until the functional test on the new equipment is complete, and approved by the Resident Engineer for continued use.

H. Covering of Signal Indications

Before making the new signal equipment operational, cover signal heads (installed but not lit) with an all-weather bag; do not cover the “walk/don’t walk” indications.

Do not allow the new and existing systems to be visible to traffic at the same time.

801.05 METHOD OF MEASUREMENT — VACANT

801.06 BASIS OF PAYMENT

The Department will consider the costs of functional tests required by the Contract to be included in the contract unit prices for the relevant lighting and traffic pay items.

SECTION 802
ELECTRICAL CONDUIT

802.01 DESCRIPTION

This work consists of providing and installing electrical conduit, junction boxes, fittings, expansion devices, and miscellaneous hardware for electrical conduit.

802.02 MATERIALS

A. Conduits and Fittings

Provide conduits and fittings in accordance with Section 709, “Electrical Conduit.”

B. Junction Boxes

Provide junction boxes with gaskets and covers of the size and type shown on the Plans.

C. Condulets

Provide oversized condulets with exposed conduit systems and a splicing chamber instead of junction boxes, as approved by the Resident Engineer.

The Department will not allow condulets for fused branch circuits.

802.03 EQUIPMENT — VACANT

802.04 CONSTRUCTION METHODS

A. General

Install conduit in accordance with the NEC. Install direct conduit runs with no less than the minimum size shown on the Plans.

The Department will allow the use of larger conduit for the entire length of the run (outlet to outlet), at no additional cost to the Department.

The Department will not allow slip joints or running threads for coupling conduit. If standard couplings are not practical, use threaded-union couplings to couple metal conduit, as approved by the Resident Engineer.

Ream conduit ends to remove burrs and rough edges. Make cuts square so ends will butt together for the full circumference. For metal conduit, tighten couplings until the ends come together; do not leave threads exposed. For nonmetallic conduit use solvent weld connections.

If damage to galvanized conduit exposes bare metal, re-galvanize, metalize, or paint with zinc dust-oxide paint at no additional cost to the Department.

Thread and cap metal and nonmetallic conduit ends with standard pipe caps until wiring starts. After removing caps, install conduit bushings on the threaded ends. Cap conduit ends not terminating in a junction box or electrical enclosure.

Provide factory conduit bends in accordance with the NEC, or bend conduit without crimping or flattening using the longest centerline radius for each installation, not less than six times the conduit inside diameter.

Extend conduit in concrete pole bases, structures, or pedestals no more than 2 in [50 mm] above the footing.

Extend conduit entering pull box sides no more than 2 in [50 mm] inside the box wall and slope the conduit toward the top of the box.

Extend conduit entering the pull box bottom to at least 4 in [100 mm] above the bottom. Locate near the edges of walls. Use nipples to eliminate cutting and threading short conduit runs.

Complete all potentially damaging work before installing conductor in the conduit system.

If incorporating existing underground conduit into a new system, clean with compressed air.

B. Pushed or Bored Conduit

Use pushing or boring methods to place the conduit under pavement. Do not disturb the pavement without approval from the Resident Engineer. Keep pushing or boring pits at least 2 ft [0.6 m] from the edge of surfaced areas.

The Department will not allow the use of water for pushing or boring, if the pavement structure may suffer damage. If leaving pits overnight, cover with planking and mark as directed by the Resident Engineer.

Push only rigid metal conduits. Provide rigid metal or nonmetallic conduits for boring. For rigid, nonmetallic conduit, pre-drill a hole larger than the conduit, and install conduit by hand.

Unless otherwise shown on the Plans, install bored or pushed conduits at least 30 in [0.8 m] deep. Where conduit passes under a surfaced area, cut an “X” in the curb, surface, or both for locating in the future.

C. Trenched Conduit and Backfilling

Install conduit in trenches of the types and sizes shown on the Plans. Excavate trenches deep enough to provide at least 30 in [0.8 m] cover, unless otherwise approved by the Resident Engineer. Clear the trench of hard and abrasive materials before placing conduit.

Do not place conduit before the Resident Engineer inspects the trench.

Excavate immediately before installing the conduit. Store the conduit to not damage or obstruct vehicular or pedestrian traffic, and surface drainage. Excavate trenches to the dimensions shown on the Plans. Dispose of surplus excavated material as approved by the Resident Engineer.

If rock is encountered during trenching, and the minimum cover depth is unattainable, alter the depth or location as approved by the Resident Engineer. Excavate the trench to at least 1 ft [0.3 m] deep.

Backfill trenches with material approved by the Resident Engineer immediately after conduit installation. Deposit the backfill material in uncompacted layers no deeper than 6 in [150 mm]. Install underground utility marking tape as shown on the Plans.

Provide rock-free backfill for the first layer. Compact each layer before placing the next.

Compact backfill to at least 95 percent standard density in accordance with Section 202, "Earthwork."

Reconstruct disturbed surfaced areas, base materials, and sodded areas as approved by the Resident Engineer, at no additional cost to the Department.

If damage occurs to concrete sidewalks or driveways, remove and reconstruct entire slabs unless otherwise approved by the Resident Engineer. Remove pavement in accordance with Section 619, "Removal of Buildings, Structures, and Obstructions, NESHAP Inspection."

D. Exposed Conduit

Use rigid metal conduit on exposed surfaces, unless otherwise shown on the Plans.

Run surface-mounted conduit straight and flush with the surface of the structure or pole. Support the conduit at least every 5 ft [1.50 m], unless otherwise approved by the Resident Engineer. Use galvanized malleable iron conduit clamps and bolts with expansion shield anchor devices approved by the Resident Engineer.

The Department will not allow lag or machine bolt shields and percussion driven anchors in concrete or masonry.

Use QPL-approved supporting devices for conduit attached to structural steel members.

E. Conduit in Concrete Structures

Unless otherwise shown on the Plans, use rigid metal conduit for concrete structures. Where the conduit crosses an expansion joint, install an expansion device of the type and size shown on the Plans.

F. Junction Boxes

Install the sizes and types of junction boxes shown on the Plans.

802.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of each size and type of conduit separately, along the centerline of the conduit from end to end.

802.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) GALVANIZED STEEL ELECTRICAL CONDUIT	Linear Foot [Meter]
(B) POLYVINYL CHLORIDE (PVC) CONDUIT	Linear Foot [Meter]
(C) HIGH DENSITY POLYETHYLENE (HDPE) CONDUIT	Linear Foot [Meter]
(D) ALUMINUM CONDUIT	Linear Foot [Meter]
(E) JUNCTION BOX	Each

The Department will consider the cost of flexible steel conduit, fittings, outlets, entrance caps, pull wires, condulets, expansion devices, excavation, backfilling, and miscellaneous hardware to be included in the contract unit price for the relevant conduit pay item.

SECTION 803
PULL BOXES AND GROUND BOXES

803.01 DESCRIPTION

This work consists of providing and installing underground enclosures.

803.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Precast Concrete Pull Boxes	739.01
Composite/Polymer Concrete Pull Boxes	739.02

Provide ground boxes as shown on the Plans.

803.03 EQUIPMENT — VACANT

803.04 CONSTRUCTION METHODS

Provide underground enclosures as shown on the Plans. Obtain the Resident Engineer's approval to revise enclosure locations to fit field conditions or facilitate conduit system installation.

Use pull boxes to distribute electrical service. Provide ground boxes for communication applications, such as Intelligent Transportation Systems.

A. Installation

Install underground enclosures on a bed of crushed rock as shown on the Plans.

For underground enclosures installed in surfaced areas, make the top of the enclosure flush with the finished surface. For underground enclosures located near curbs as required by the Contract, place adjacent to the back of the curb and flush with the top of the curb.

For underground enclosures in ground, ensure the top of the enclosure is flush with the top of, or no greater than 1 in [25 mm] above, the ground surface. Unless otherwise approved by the Resident Engineer, provide underground enclosures with concrete aprons, at no additional cost to the Department.

Install conduits entering underground enclosures as shown in the Plans and in accordance with Section 802, "Electrical Conduit."

If shown on the Plans, provide underground enclosure extensions of the same material as the enclosure. Attach extensions to the underground enclosure to maintain the depth shown on the Plans without causing assembly separation.

B. Cover and Markings

Mark the covers of pull boxes for lighting conductors with the legend “lighting.” Mark the covers of pull boxes used for traffic signal conductors with the legend “traffic signal.”

Mark ground box covers with the legend “electrical danger danger, ____V.”

For conductor voltages of at least 600 V, add the words “high voltage” to the cover, and equip the conductor cover with a recessed molded lifting eye and recessed hold-down bolts.

Make the letters from 1 in to 3 in [25 mm to 75 mm] tall. Cast the legend with the cover. Ensure the legend is a uniform depth or height, and parallel to one side of the cover.

Provide installations for electrical service with non-metallic covers. Provide installations for use with communication or fiber optic cables with metallic covers.

Provide covers with non-skid surfaces.

C. Ground Rod

Install copper weld ground rods as shown on the Plans.

803.05 METHOD OF MEASUREMENT — VACANT

803.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) PULL BOX	Each
(B) GROUND BOX	Each

The Department will consider the cost of the cover, extension, ground rod, concrete apron, crushed rock, excavation, and backfilling to be included in the contract unit price for *Pull Box* and *Ground Box*.

SECTION 804
CONCRETE FOOTINGS

804.01 DESCRIPTION

This work consists of installing concrete footings for traffic control devices.

804.02 MATERIALS

Provide materials in accordance with the following sections, subsection, and external reference:

Material:	Section, Subsection, or External Reference:
Portland Cement Concrete, Class A	701
Reinforcing Steel	723
Electrical Conduit	709
Anchor Bolts and Nuts	724.02
Galvanizing (Bolts, Nuts, and Washers)	AASHTO M 232

804.03 EQUIPMENT — VACANT

804.04 CONSTRUCTION METHODS

A. Footings

To minimize shimming, construct level concrete footings on firm ground in accordance with Section 509, “Structural Concrete.” Construct footings at the locations shown on the Plans and to the grade directed by the Resident Engineer. If an obstruction prevents the construction at the planned location, construct footings at the location directed by the Resident Engineer.

Erect the pole, post or breakaway base after the foundation reaches 100 percent of the required 28 day compressive strength and ages at least 72 hr. The Resident Engineer may waive this restriction if the pole, post, or breakaway base is set directly in the footing.

Modify footings shown on the Plans based on field conditions and with the approval of the Resident Engineer.

After completing the footing, restore the surrounding area as approved by the Resident Engineer.

B. Anchor Bolts

Use anchor bolts of the size and quantity shown on the Plans. Use a template to locate and secure anchor bolts in the footing. Provide anchor bolts with the top exposed portion plus 6 in [150 mm] galvanized and threaded as shown on the Plans. Supply the anchor bolts with galvanized hex head nuts, flat washers, and lock washers as shown on the Plans.

Do not weld any part of the anchor bolt.

C. Conduits

Install conduits in footings of the quantity, size, and type shown on the Plans. Locate conduit couplings at least 6 in [150 mm] from the face of the footing.

D. Ground Rod

Install copper weld ground rods of the size shown on the Plans.

804.05 METHOD OF MEASUREMENT — VACANT

804.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) STRUCTURAL CONCRETE	Cubic Yard [Cubic Meter]
(B) REINFORCING STEEL	Pound [Kilogram]

The Department will consider the cost of anchor bolts, nuts, washers, ground rod, conduit, excavation, backfilling, and other incidental work to be included in the contract unit price for *Structural Concrete* and *Reinforcing Steel*.

SECTION 805
REMOVAL OF TRAFFIC ITEMS

805.01 DESCRIPTION

This work consists of removing traffic signal and highway lighting items, including, but not limited to, the following:

- Pole assemblies,
- Luminaires,
- Pull boxes,
- Power supplies,
- Signal heads, and
- Controllers.

805.02 MATERIALS — VACANT

805.03 EQUIPMENT — VACANT

805.04 CONSTRUCTION METHODS

If the Contract requires the removal of traffic signals or highway lighting items, disconnect the items from the footing, conduit, and wiring system and store at a location directed by the Resident Engineer.

Do not damage traffic signal equipment during removal and storage. Remove poles and cut anchor bolts and protruding conduit flush with the final ground level. Leave footings, pull boxes, and underground conduit in place. Remove wiring from underground conduit.

Construct concrete footings or other concrete appurtenances to adjust or relocate traffic signals or highway lighting systems, as shown on the Plans.

Before reinstalling removed traffic items, inspect, repair damage, clean, and install a new lamp of the original size and type.

Dispose of materials that cannot be reused with the approval of the Resident Engineer. Provide new materials to complete the installation as shown on the Plans and to make the system operational, at no additional cost to the Department.

After adjusting or resetting the removed items and completing the electrical connections, energize and test the traffic signal or highway lighting system in accordance with Section 801, "Performance and Operational Tests for Highway Lighting and Traffic." Provide acceptable test results to the Resident Engineer for approval.

805.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of relaid cable or conduit in place before removal.

805.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) REMOVAL OF (TRAFFIC ITEMS)	Lump Sum, Each, or Linear Foot [Meter]
(B) RESET OF (TRAFFIC ITEMS)	Lump Sum or Each
(C) RELOCATION OF (TRAFFIC ITEMS)	Linear Foot [Meter]
(D) REMOVE AND RESET (TRAFFIC ITEMS)	Lump Sum or Each

If separate payment for this work is not required by the Contract, the Department will consider the cost to be included in the contract unit price for other relevant items of work.

SECTION 806
POLES AND MAST ARMS

806.01 DESCRIPTION

This work consists of providing and installing poles, mast arms, and pedestal poles for traffic signals and highway lighting.

806.02 MATERIALS

Provide materials in accordance with Section 700, “Materials,” and the latest edition of the AASHTO *Standard Specifications for Structural Supports of Highway Signs, Luminaires, and Traffic Signals*.

806.03 EQUIPMENT — VACANT

806.04 CONSTRUCTION METHODS

A. General

Install high mast poles, as shown on the Plans, in accordance with Section 812, “High Mast Poles.”

Ensure the manufacturer designs the poles and mast arms for a minimum 80 mph [128 km/h] wind velocity.

Ensure the calculated stresses from design loading on poles and arms do not exceed the lesser of, 50,000 psi [344.8 MPa] or 85 percent of ASTM yield strength. Provide certification of the pole material in accordance with ASTM for the operational stress range of the poles. Provide traffic signal steel poles and mast arm materials with at least a 7 gauge thickness. Design traffic signal poles in accordance with the Traffic Engineering Division’s Loading Chart.

Unless the poles are on the Department's Traffic Engineering Division Qualified Product List (QPL), submit manufacturer shop and design drawings, and calculations in accordance with Subsection 105.02, “Plans and Working Drawings.”

The Department will allow mounting of mast arms to the pole before erection. Protect the pole, mast arm, and finish from damage during erection. Repair damaged finish as approved by the Resident Engineer, at no additional cost to the Department.

Level anchor base poles with nuts or shims. For double nut leveling, fill the space between the concrete foundation and the pole base with a non-shrink grout, unless otherwise shown on the Plans.

Install and torque fasteners in accordance with the manufacturer’s recommendations. Cast structural castings in permanent molds.

The Department will not allow double nut leveling for poles with breakaway bases.

B. Poles

Ensure the pole accommodates the mounting height of the luminaire or traffic signal as shown on the Plans. Uniformly taper round or multi-sided poles from bottom to top; pedestal poles do not require taper.

Straighten and center poles on the longitudinal axis.

Unless otherwise required by the Contract, provide each pole with a reinforced hand hole and weatherproof cover. Install a removable pole cap on each shaft, except pedestal poles. Provide metallic poles with a grounding connection inside the base of the shaft, and ground as shown on the Plans.

Provide cast or structural plate anchor bases.

C. Mast Arms

Provide mast arms of the lengths shown on the Plans.

Design luminaire mast arms to support a 50 lb [22.7 kg] luminaire with an effective projected area of 2.5 ft² [0.23 m²]. Provide a smooth raceway for the wiring; each with a slip-fitter tenon.

Design traffic signal mast arms to support the required signal heads, as shown on the Plans.

806.05 METHOD OF MEASUREMENT — VACANT

806.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) TRAFFIC SIGNAL POLE AND MASTARM	Each
(B) TRAFFIC SIGNAL PEDESTAL POLE	Each
(C) HIGHWAY LIGHTING POLE AND MASTARM	Each
(D) HIGHWAY LIGHTING POSTTOP POLE	Each

SECTION 807
BREAKAWAY BASES - HIGHWAY LIGHTING

807.01 DESCRIPTION

This work consists of providing and installing breakaway bases.

807.02 MATERIALS

Provide materials in accordance with the following subsection and external references:

Material:	Subsection or External Reference:
Cast Aluminum	ASTM B 108, Alloy 356 T6
Bolts, Nuts, and Washers, Adapter Plates	724.02
Galvanized Hardware	AASHTO M 232
Galvanized Plates	AASHTO M 111

Provide aluminum breakaway transformer bases cast in a permanent mold. Provide each base with a plastic door approved by the Traffic Engineer Division.

Provide breakaway bases in accordance with the latest edition of the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, and as approved by the FHWA.

807.03 EQUIPMENT — VACANT

807.04 CONSTRUCTION METHODS

Ensure the pole base is no larger than the top flange of the transformer base. The Department will allow slotted anchor bolt holes on the top and bottom flanges of the base.

Provide each base with bolts, nuts, washers, and adapting washers as shown on the Plans to connect the base to the pole and anchor bolts. Install and provide galvanized connecting bolts, nuts, washers, and adaptor plates in accordance with the base manufacturer's recommendations, including bolt torque. Affix an installation and mounting instruction label, indicating AASHTO/FHWA approval and the year approved, inside each breakaway base, opposite the door.

Use shims to level breakaway base poles in accordance with the manufacturer's recommendations. The Department will not allow double nut leveling.

807.05 METHOD OF MEASUREMENT — VACANT

807.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
BREAKAWAY BASE	Each

The Department will consider the cost of hardware, adapter plates, and plastic doors to be included in the contract unit price for *Breakaway Base.*

SECTION 808
PIER-MOUNTED POLE BRACKETS

808.01 DESCRIPTION

This work consists of providing and installing pier-mounted pole brackets.

808.02 MATERIALS

Provide materials in accordance with the following sections, subsection, and external reference:

Material:	Section, Subsection, or External Reference:
Structural Steel	724
Galvanizing	AASHTO M 111
Electrical Conduit	709
Bolts, Nuts, and Washers	724.02

808.03 EQUIPMENT — VACANT

808.04 CONSTRUCTION METHODS

Fabricate, galvanize, and construct the brackets and install on bridge piers as shown on the Plans.

808.05 METHOD OF MEASUREMENT — VACANT

808.06 BASIS OF PAYMENT

The Department will pay for this pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
PIER-MOUNTED POLE BRACKET	Each

SECTION 809
LUMINAIRES

809.01 DESCRIPTION

This work consists of providing and installing roadway and sign lighting luminaires.

809.02 MATERIALS

Provide luminaires with a housing, ballast, reflector, refractor, and lamp of the type and lumen rating shown on the Plans. Submit to the Resident Engineer a list of luminaires to be used on the project that are listed on the Department's Traffic Engineering Division Qualified Products List (QPL). For luminaires not listed on the QPL, submit five copies of a complete materials schedule and proposed equipment, including catalog cuts, diagrams, drawings, and other data, along with a New Product Evaluation Request form, to the Resident Engineer for approval. Fabricate, assemble, and install luminaires as shown on the Plans.

Provide luminaires meeting the Illumination Engineering Society of North America (IESNA) standards for the size and type of luminaire shown on the Plans. For each size and type of luminaire, submit the following to the Resident Engineer:

Manufacturer's photometric test data
Manufacturer certification that IESNA-approved test procedures were used

809.03 EQUIPMENT — VACANT

809.04 CONSTRUCTION METHODS

Install luminaires in accordance with the manufacturer's recommendations and as shown on the Plans.

809.05 METHOD OF MEASUREMENT — VACANT

809.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) ROADWAY LUMINAIRE	Each
(B) UNDERPASS LUMINAIRE	Each
(C) POST TOP LUMINAIRE	Each
(D) OVERHEAD SIGN LUMINAIRE	Each
(E) HIGH MAST LUMINAIRE	Each
(F) NAVIGATIONAL LIGHT	Each

The Department will consider the cost of cut-off visors and other hardware to be included in the contract unit price for the relevant luminaire pay items.

SECTION 810
POWER SUPPLIES

810.01 DESCRIPTION

This work consists of providing and installing permanent and temporary power supply systems.

810.02 MATERIALS

Provide materials in accordance with the following sections, subsection, and external reference:

Material:	Section, Subsection, or External Reference:
Wood Poles	ANSI 05.1
Electrical Conduit	709
Portland Cement Concrete, Class A	701
Reinforcing Steel	723
Conductors	811

For miscellaneous pole line hardware, provide standard material manufactured for pole line construction. Provide hot-dipped galvanized, or otherwise non-corrosive metal parts.

Provide control equipment in accordance with NEMA 3R or 4 and UL Specifications.

Provide a metered, temporary lighting service to power existing and temporary lighting.

810.03 EQUIPMENT — VACANT

810.04 CONSTRUCTION METHODS

Construct power supplies in accordance with the NIST Handbook 81 *Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines*.

Cooperate with the local utility companies to locate, install, and connect power supplies. Contact local "Excavator Alert" organizations before starting trenching or boring operations.

A. Voltage and Construction Specifications

Ensure the voltages for the permanent or temporary service poles are as shown on the Plans.

Construct concrete in accordance with Section 509, "Structural Concrete."

Construct reinforcing steel in accordance with Section 511, "Reinforcing Steel for Structures."

B. Temporary Power Supplies

Arrange for electrical power connections for the temporary service poles as soon as construction allows. Arrange power connections for locations not shown on the Plans through the local utility company, with the approval of the Resident Engineer.

Erect, energize, deactivate, and remove the temporary lighting system at various stages of the traffic control as shown on the Plans or as directed by the Resident Engineer.

Space the temporary lighting on wood poles 150 ft [50 m] apart. Protect the light poles from traffic as approved by the Resident Engineer.

The Department will not allow the use of aerial conductors to connect power to light poles with breakaway bases.

Install the temporary light and service poles. Repair damage from installation, relocation, or removal at no additional cost to the Department.

Maintain all existing lighting systems during construction in accordance with Subsection 105.14, "Maintenance During Construction," at no additional cost to the Department.

If a lighting pole assembly is damaged or knocked down by a third party, repair or replace the damaged lighting pole assembly to its original condition. The Department will pay the additional cost at the contract unit price for pay items necessary to complete the repair or replacement, excluding removal of the light pole and concrete footing.

After completing the lighting system or Project, connect the temporary service poles to the permanent service poles for final acceptance.

Carefully handle items shown on the Plans for removal, resetting, or both. Neatly store the removed items in a location directed by the Resident Engineer.

Removed service poles, light poles, mast arms, luminaires, and temporary lighting equipment become the property of the Department. Stockpile these items at locations shown on the Plans, unless otherwise approved or directed by the Resident Engineer.

Leave the temporary service poles and the temporary lighting systems in place, or remove at the end of the Project, as directed by the Resident Engineer. If temporary service poles or temporary lighting systems provide a safe driving environment, leave in place as approved by the Resident Engineer.

(1)Temporary Lighting on Wood Poles

Supply electrical service to temporarily light traffic control crossovers, points of conflict, and other locations as approved by the Resident Engineer.

(2)Existing Lighting Circuits

Maintain existing lighting systems in operation. If construction disrupts an existing lighting system, use additional temporary lighting on wood poles.

(3)New Permanent Lighting Circuits

Use the temporary lighting service and the temporary service poles to supply electricity to the temporary lighting poles and the new permanent lighting circuits. After Project completion, connect the permanent service pole to the new permanent lighting circuits. Install the permanent electrical service for the new highway lighting systems as shown on the Plans.

810.05 METHOD OF MEASUREMENT

Before payment, provide the Resident Engineer with copies of the utility company's invoice and proof of payment for *Temporary Lighting Service*.

810.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) SERVICE POLE	Each
(B) POLE-MOUNTED TRANSFORMER STATION	Each
(C) PAD-MOUNTED TRANSFORMER STATION	Each
(D) TEMPORARY SERVICE POLE	Each
(E) TEMPORARY LIGHTING SERVICE	Kilowatt-hour
(F) WOOD POLE	Each

The Department or local authority will become will become responsible for continuing temporary lighting system maintenance and operation after project completion and final acceptance.

SECTION 811
ELECTRICAL CONDUCTORS HIGHWAY LIGHTING

811.01 DESCRIPTION

This work consists of providing and installing electrical conductors to transmit and distribute electrical energy.

811.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Building Wire and Cable	738.02
Underground Secondary Distribution Wire and Cable	738.02
Outdoor Aerial Neutral-Supported Secondary Distribution Wire and Cable	738.02

811.03 EQUIPMENT — VACANT

811.04 CONSTRUCTION METHODS

A. Conductors in Conduit

Complete the conduit system before installing the conductors. Provide enough slack in each conductor to allow at least 2 ft [0.6 m] at pole bases and at least 3 ft [0.9 m] at pull boxes.

B. Aerial Conductors

Install aerial conductors in accordance with the National Electric Safety Code and the manufacturer's recommendations for sag and tension. Submit a copy of the cable manufacturer's charts, for each size and type of cable, to the Resident Engineer for approval of aerial conductor.

C. Splices and Taps

Splice or tap the underground and indoor conductors at pull boxes, pole bases, control cabinets, junction boxes, or other weatherproof enclosures. Splice and tap outdoor aerial conductors as shown on the Plans. Do not pull splices into the conduit system. Provide the types of splices and taps required by the Contract.

Seal, waterproof, and insulate insulated conductors in accordance with ANSI C119.1-2006, "Sealed Insulated Underground Connector System Rated 600 Volts." Alternatively, complete Procedure 1 or Procedure 2.

(1) Procedure 1

Make splices and taps using compression connectors. Apply at least three layers of rubber tape in uniform half-lap wrapping, or cover the joint with at least a ⅛ in [3 mm] layer of electrical insulating putty. Place at least three layers of high dielectric, high tensile strength, cold weather plastic tape in uniform, half-lap wrapping over the rubber tape or putty. Coat the layers with insulating paint.

(2) Procedure 2

Use waterproof, self-insulating connections made of compression connectors and epoxy or gel cast splice kits or heat shrinking splice kits.

D. Fuse Holders and Fuses

Make in-line or **Y**-type fuse holders as shown on the Plans. If required by the Contract, provide waterproof and self-insulating fuse holders with a quick disconnect breakaway feature on the load side. Install a **Y**-type fuse holder at the base of each pole or overhead sign structure with the properly sized fuse. If shown on the Plans, provide branch circuits with an in-line fuse holder and fuse.

E. Testing

Test the installed electrical conductors in accordance with Section 801, "Performance and Operational Tests for Highway Lighting and Traffic Signals."

811.05 METHOD OF MEASUREMENT — VACANT

811.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
ELECTRICAL CONDUCTOR	Linear Foot [Meter]

The Department will consider the cost of connectors, fuses, splices, and taps to be included in the contract unit price for *Electrical Conductor*.

SECTION 812
HIGH MAST POLES

812.01 DESCRIPTION

This work consists of providing and installing high mast poles.

812.02 MATERIALS

Before starting high-mast lighting work, submit to the Resident Engineer eight copies of brochures for, and a schedule of, the proposed materials and equipment items for high mast poles. Include brand names, catalogue numbers, descriptions, cuts, diagrams, shop and design drawings, and calculations as required by the Contract.

The Resident Engineer may waive submittal requirements if the materials and equipment are on the Department's Traffic Engineering Division Qualified Products List.

Verify the accuracy of the dimensions and details on the design drawings in accordance with Subsection 105.02, "Plans and Working Drawings."

A. Structural Design

Design high mast pole structures in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*. Apply the following design parameters:

- Design wind velocity: 3 s gust of 90 mph [145 km/h];
- Minimum design life: 50 years with a 1.00 wind importance factor;
- Maximum pole deflection: no greater than 10 percent of the pole height;
- Fatigue category: 1

Provide high mast poles in accordance with Table 812:1.

Table 812:1
Base Plate Thickness for High Mast Poles

Pole Length, *ft [m]*	**Base Plate Thickness,** *in [mm]*
80 – 100 [24.4 – 30.5]	≥2 [50.8]
105 – 120 [32.0 – 36.6]	≥2.5 [63.5]
125 – 150 [38.1 – 45.7]	≥3 [76.2]

The Department may randomly check pole designs.

Ensure the pole manufacturer certifies the following in writing:

- The pole design was coordinated with the manufacturer of the lowering device design;
- The pole design is compatible with the installation of the high mast lowering device and luminaire; and
- The total system will function properly.

B. Fabrication of Steel Shafts

Provide high-strength steel shafts in accordance with Section 812.02.D, "Mechanical Properties." The Department will allow circular, many-sided shafts either the total length shown on the Plans, or in telescoping sections. Provide galvanized poles in telescoping sections only. Provide cold-formed shafts uniformly

tapered from the largest diameter at the base to the smallest diameter at the top without reducing the wall thickness.

For shafts 120 ft [36 m] or shorter, provide no more than five telescoping sections. For shafts longer than 120 ft to 150 ft [36 m to 46 m], provide no more than six telescoping sections.

Provide telescoping sections in one or two pieces. Provide one-piece sections at least 10 ft [3 m] long. Butt-weld the two-piece sections in accordance with Subsection 812.02.C, "Welds."

Ensure the capability of each shaft section to telescope over the next lower section at least 1½ times the diameter of the female end of the joint. Ensure the manufacturer pre-fits and match-marks telescoping sections. Preassemble each telescoping joint for proper fit. Assemble telescoping sections in the field in accordance with the manufacturer's recommendations, as approved by the Resident Engineer.

The Department will not allow racking. Submit to the Resident Engineer the manufacturer's written guarantee that the joints will not settle.

Provide each shaft with a hand hole and a weatherproof cover bolted to a reinforced frame. Ensure the reinforced frame restores the strength lost to create the hand hole. Provide a circuit breaker and winch bracket mounting plate opposite the hand hole.

Provide each shaft with a grounding connection inside the pole near the base. Ensure the pole manufacturer meets the Standard Manufacturing Tolerance for straightness of the pole shaft.

The Department will not allow fabrication of shaft sections using laminated or layered steel plates. Provide shaft sections with a thickness of at least $^{3}/_{16}$ in [4.76 mm] plate or 7 gauge sheet.

C. Welds

Weld in accordance with the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, unless otherwise required by the Contract.

Butt-weld the telescoping shaft sections of single unit poles with backed up 100 percent penetration circumferential transverse welds. Ensure the manufacturer ultrasonically inspects the welds. Grind circumferential transverse welds, except for the base plate connection, from ⅛ in to 0 in [3.18 mm to 0 mm] beyond the outside pole surface. Contour backup material for full, continuous contact with the same material as the shaft.

Provide each shaft with no more than two longitudinal electric welds with at least 60 percent penetration, except for the following areas:

- For longitudinal seam welds within 6 in [150 mm] of circumferential welds, use full-penetration groove welds at butt joints of base plates;
- For longitudinal seam welds on the female section of telescopic field splices, use full-penetration groove welds equal to the minimum splice length plus 6 in [150 mm].

Weld the shaft to the steel base with two continuous welds (one at the top of the base and one at the bottom of the shaft), or one full-penetration butt-weld with a backup strip, if necessary.

The Department will not allow field welds, except for those performed in accordance with Subsection 812.02.B, "Fabrication of Steel Shafts."

Visually inspect and test welds using one of the following methods:

- AWS D1.1 ultrasonic method,
- ASTM E 709 magnetic particle method, or
- ASTM E 94, ASTM E 390 or ASTM E 142-92 radiographics method.

Test and inspect welds in accordance with the AASHTO Specification for the type of weld used. Submit certified results to the Resident Engineer for review. Test 100 percent of field welds.

Remove weld splatter before finishing.

Finish welding before galvanizing.

Ensure weld metal meets the notch-toughness requirements specified for bridge application in AWS D1.1. Perform impact tests in accordance with AWS D1.1, Appendix C for electroslag and electrogas weld metal.

D. Mechanical Properties

Provide high-strength steel for pole shafts with yield strengths of at least 48,000 psi [331 MPa] and meeting the notch-toughness requirements of the Charpy V-notch test for 15 ft•lbs [2.08 kg•m] at 40 °F [4.4 °C]. Submit to the Resident Engineer, 4 copies of the manufacturer's certified chemical and physical properties mill test report covering each heat number used on the project.

Test at least 3 coupons for each heat number after rolled by the steel manufacturer. For samples that do not meet the minimum yield strength, retest new samples with the same heat number. The Resident Engineer may reject steel that fails the second test.

Provide base flanges, brackets, and miscellaneous hardware fabricated from steel plate with yield strengths of at least 36,000 psi [248.2 MPa]. Ensure the base plate meets the notch-toughness requirements of the Charpy V-notch test for 15 ft•lbs [2.08 kg m] at 40 °F [4.4 °C].

(1) Anchor Bolts

Provide each high mast pole with at least 6 anchor bolts.

Ensure the anchor bolts arrive on site before the pole and cage the bolts before installing in the excavated foundation hole.

Provide a template for placing and holding the anchor bolts in the foundation to ensure the pole base will fit properly.

Install galvanized anchor bolts and nuts with galvanized poles in accordance with ASTM A 153-05 (AASHTO M 232) at least the threaded length plus 6 in [150 mm]. Prevent embrittlement in accordance with ASTM A 143-74. Provide certification of compliance with these requirements, if requested by the Resident Engineer.

The Department will not allow welding or tacking the anchor bolts to make the required lengths or to make the anchor cage.

Torque anchor bolts as specified by the pole manufacturer.

Provide two hex nuts and one lock hex nut for each anchor bolt.

(2)Finish

If shown on the Plans, provide galvanized shafts, bases, and miscellaneous brackets in accordance with ASTM A 123-89a (AASHTO M 111-94). Take precautions against embrittlement, warpage, and distortion in accordance with ASTM A 143-74 and ASTM A 384-76. Provide certification of compliance with these requirements, if requested by the Resident Engineer.

Avoid scratching the pole finish. Repair damaged finish in accordance with recommended materials and procedures established by the manufacturer for the pole and the finish, as approved by the Resident Engineer.

812.03 EQUIPMENT — VACANT

812.04 CONSTRUCTION METHODS

Join shafts made of telescoping sections before erection, as directed by the pole manufacturer and approved by the Resident Engineer.

Plumb and verify shafts in at least two directions, 90° apart, with a transit. Plumb shafts at the time directed by the Resident Engineer and within a tolerance of one half the pole top diameter.

Fill the void between the base plate and the top of the foundation with an approved, non-shrinking grout after approval by the Resident Engineer. Provide a drain hole through the grout for moisture inside the pole.

As an alternative to grout, install a heavy gauge galvanized sheet steel formed to fit the hole inside the base plate. Ensure the sheet encloses the void between the base plate and the foundation. Fasten the sheet steel in place to prevent rodents and vandals from entering.

Install the high mast lowering device before erecting the pole.

812.05 METHOD OF MEASUREMENT — VACANT

812.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
HIGH MAST POLE	Each

The Department will consider the cost of accessories, attachments, and testing field welds to be included in the contract unit price for *High Mast Pole*.

SECTION 813
HIGH MAST LOWERING DEVICE

813.01 DESCRIPTION

This work consists of providing and installing a lowering device for high mast pole assemblies.

813.02 MATERIALS

Before starting high-mast lighting work, submit to the Resident Engineer five copies of brochures for, and a schedule of, the proposed materials and equipment replacement parts for high mast lowering devices. Submit to the Resident Engineer five copies of the service and operating manuals. Include brand names, catalogue numbers, descriptions, cuts, diagrams, shop and design drawings (with part numbers and material finishes labeled), and calculations as required by the Contract. Do not include materials otherwise covered by these *Standard Specifications* on the schedule.

The Resident Engineer may waive submittal requirements if the materials and equipment are listed on the Department's Traffic Engineering Division Qualified Products List.

Ensure the lowering device manufacturer has at least 5 years experience manufacturing and installing the device, and is approved by the Design Engineer. The Design Engineer will make final acceptance of the lowering device design.

A. Structural Design

Provide a lowering device that consists of three main sub-assemblies: head frame, lowering ring, and winch assembly. Ensure the material is corrosion-resistant (stainless or galvanized steel, or aluminum).

Ensure fixtures on the lowering devices pass an accelerated vibration test of at least 1 *g*.

Determine the actual loading for the high mast pole design by performing a full-scale wind tunnel test on the complete system, consisting of the lowering device and the luminaires.

Provide a lowering device capable of lowering a ring of luminaires to within 3 ft [1 m] of the pole base to ensure safe and efficient, routine luminaire maintenance.

Provide each pole with a power cable and connectors to energize the entire ring of luminaires while the lowering device is in the lowered position. Provide a weatherproof, twist-lock service receptacle for this cable, rated at 600 V.

Provide equally spaced hoisting cables, attached to the luminaire ring. Provide a method to equalize the tension on the hoisting cables. Provide hoist cables of 7 × 19 construction aircraft cable, $^{3}/_{16}$ in [4.76 mm] diameter, zinc-coated galvanized steel, in accordance with MIL Specification W834420C and Federal Specification RR-W-410d. Provide a winch cable of ¼ in [6.35 mm] diameter, zinc-coated, galvanized steel, using high strength 7 × 19 construction aircraft cable.

In the raised position, ensure minimal free movement in the luminaire ring. Rigidly suspend the luminaire ring from equally spaced points with mechanical latches or with cables in tension as shown on the Plans and approved by the Resident Engineer.

Provide the following luminaire ring suspensions as required by the Contract:

(1)Type I

Provide a positive automatic mechanical latching system not requiring manual or electrical tripping devices to latch or unlatch the system. Ensure the portion of the latching system permanently attached to the top of the pole with no moving parts or parts requiring adjustment after erection of the pole. Provide lowering devices with visual indicators of positive latching. Prevent ice or snow accumulations from impairing the latching system. Ensure the removal of tension from the hoisting and winch cables when the luminaire ring is latched.

(2)Type II

Ensure a positive guide and positioning method for the cables to prevent the luminaire ring from moving. Keep the hoisting cables in constant tension. Provide a method to equalize the stress on each cable and remove tension from the winch and cable assembly when the luminaire ring is in the raised position.

Install guide arms, rollers, or both on the luminaire ring. This assembly will consist of the following:

- A roller contact,
- Spring loaded, cast aluminum arms designed to protect the pole,
- Luminaries, and
- Lamps.

Ensure the centering system keeps the ring luminaire concentric to the pole, prevents the ring from hanging up, prevents damage to the tower shaft finish, and constantly keeps the luminaire ring equidistant from the pole during raising and lowering. Ensure that the centering arms interconnect to prevent the system from jamming on the pole during high winds. Provide stainless steel springs and non-marking rollers.

House self-lubricating pulleys, located at the top of the pole, under a weather-tight cover with coloring similar to the support assembly. Provide at least six hoist cable sheaves at least 6 in [150 mm] in diameter. Machine the cable groove in each sheave with a circular cross-section to match the hoist cable diameter. Provide sheaves in accordance with the requirements of ASTM A 1023.

Ensure lowering device systems are stable and capable of operating in 30 mph [48 km/h] winds.

Provide a lightweight, remotely-controlled, portable motor to power the lowering device winch. Provide a heavy-duty reversible motor with at least 1 hp [750 W], and a stalled torque at least twice the torque required for the lowering device. Provide for manual operation of the lowering device in case of power failure.

Obtain written certification from the lowering device manufacturer that the lowering device design works with the high mast pole and luminaries, and that the

total system functions mechanically and electrically. Ensure the lowering device and fixtures include manufacturer warrantees.

Do not install an electromechanical disconnect in the circuit that supplies power to the luminaires at the top of the pole. Wire the power cable directly to the terminal blocks in the junction box on the luminaire ring.

Attach the power cable to the luminaire ring and ensure support the full weight of the cable in the raised luminaire position. Provide a NEMA 3R aluminum junction box including a weatherproof inlet on the ring exterior for testing the luminaries and lamps at ground level. Provide a factory pre-wired enclosure with the number of 16/3 Type ST cords for the luminaires and main power cord size as recommended by the manufacturer and approved by the Resident Engineer. Attach the power cord to the ring using cable clamps.

B. Materials

(1) Wire Rope Attachments

Obtain approval from the Resident Engineer for wire rope attachments. Install and torque wire rope attachments in accordance with the manufacturer recommendations.

(2) Luminaire Rings and Mast Arms

Provide luminaire ring and mast arms constructed of No. 7 gauge weldable, structural steel with a hot dip galvanized finish.

Provide mast arms with 2 in [50 mm] diameter pipes with slip-fitter connections to the high mast luminaries. Equally space the arms around the ring, unless otherwise shown on the Plans. Provide the number of mast arms as shown on the Plans.

Provide a weatherproof luminaire ring pre-wired to distribute power from the main power cable.

Ensure easy mast arm attachment and removal. Provide one mast arm for each high mast luminaire.

(3) High Mast Support Assembly

Provide a weldable structural-steel high-mast support assembly that attaches to the pole shaft. Devise a pole attachment method in cooperation with the pole manufacturer to prevent the support assembly from rotating on the pole top. Ensure the support assembly houses the pulleys and mechanical latching devices.

(4) Winch Assembly

Provide a self-locking worm gear drive winch assembly with a reduction ratio of 30:1. Place the winch assembly at the base of the pole shaft, adjacent to the hand hole. Equip the winch assembly with a take-up guide to prevent cable overlap. Provide a winch assembly capable of raising and lowering the luminaire ring and luminaires at least 10 ft/min [3 m/min]. Provide a winch containing an inboard and outboard support, designed to operate by hand or mechanically, using a portable motor. Ensure the winch cable is securely attached to the winch drum with at least three wraps around the drum when the luminaire ring is in the lowered position.

(5) Aircraft Obstruction Markers

Unless otherwise required by the Contract, provide luminaire rings with a double FAA-approved red aircraft obstruction marker and a dry transformer, mounted on the ring assembly with a bracket. The Resident Engineer will not accept pipe with conduit lock rings for brackets.

Ensure marker is visible 360° around the pole, and wired to power on and off with the luminaires.

Provide lights equipped with a multiple transfer relay for instant transfer to a reserve lamp if the operating lamp fails. Install the plug-in transfer relay in a weather-tight enclosure.

(6) Lightning Rod and Arrestor

Attach a lightning rod to the lead frame assembly and wire to ground. Ensure that the assembly includes a lightning arrestor at the junction box on the luminaire ring.

(7) Hardware

Provide hardware made of non-corrosive materials or plated to a compatible thickness to the structural parts of the lowering device.

(8) Fasteners

Secure fasteners and pins to prevent loosening by vibration. Provide self-locking nuts, jam nuts, and cotter pins.

(9) Poles

Ground the pole as shown on the Plans.

Provide an assembly that includes a circuit breaker in the base of the pole, sized for the voltage and phasing supplied for the luminaire load. Provide an aluminum or zinc-plated steel cover for the circuit breaker. Provide a pigtail cord and plug from the circuit breaker assembly. Ensure the cord and plug are compatible with the main power cord of the lowering device system.

C. Welding

Weld in accordance with AWS D1.1.

The Department will not allow field welds.

Visually inspect welds and test using the ultrasonic method in accordance with AWS D1.1, the magnetic particle method in accordance with ASTM E 709, or the radiographic method in accordance with ASTM E 94, E 390 or E 142-92. Submit certified test results, if requested by the Resident Engineer.

Complete welding and remove weld splatter before finishing.

D. Finish

Galvanize the high mast lowering device after fabrication in accordance with ASTM A 123-89a (AASHTO M-111-94).

813.03 EQUIPMENT — VACANT

813.04 CONSTRUCTION METHODS

Work with the manufacturer's representative to ensure correct installation of the lowering device. Obtain a written installation and operation manual from the manufacturer of the lowering device. Obtain at least 5 copies per project or one copy per device, whichever is greater.

After installing the lowering device on the tower, but before erecting the tower, request that the Department's Traffic Engineer inspect the fully rigged device. Erect the tower after the Traffic Engineer's inspection and the Resident Engineer's approval.

813.05 METHOD OF MEASUREMENT — VACANT

813.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
HIGH MAST LOWERING DEVICE	Each

The Department will consider the cost of attachments, wiring, circuit breakers, and other accessories to be included in the contract unit price for *High Mast Lowering Device*.

SECTION 825
TRAFFIC SIGNAL CONTROLLER ASSEMBLY

825.01 DESCRIPTION

This work consists of providing and installing a full-actuated traffic controller assembly including cabinet, solid-state full-actuated controller unit, load switches, flasher, conflict monitor, and related documentation.

825.02 MATERIALS

Provide a controller assembly in accordance with NEMA Standards Publication TS-1, *Traffic Control System* (NEMA TS-1).

If shown on the Plans, provide a controller assembly in accordance with NEMA Standards Publication TS 2, *Traffic Controller Assemblies with NTCIP Requirements* (NEMA TS-2).

A. Full-Actuated Traffic Signal Controller

(1) Hardware Design Requirements

Ensure each controller unit has a permanent label on the unit face displaying a unique serial number. Provide solid-state, digitally-timed controller units. Synchronize the controller timing with the 60 HZ power source. Provide controllers with at least the dimensions and characteristics specified in Table 825:1:

Table 825:1
Controller Dimensions and Characteristics

Phases	2 Phase	4 Phase	8 Phase
Load switch positions	4	8	16
Cabinet size (height × width × depth)	41 in × 24 in × 16 in [1.04 m × 0.6 m × 0.41 m]	49 in × 29 in × 17 in [1.24 m × 0.73 m × 0.43 m]	55 in × 38 in × 26 in [1.39 m × 0.96 m × 0.66 m]
Number of detector channels	4	10	16
Number of pre-emption channels	2	4	4
Number of NEMA plus monitor channels	3	6	12

Ensure the unit face displays the following:

- Phases in service (one per ring),
- Phases to be serviced next (one per ring),
- Presence of vehicle call (one per phase),
- Presence of pedestrian call (one per phase),
- Reason for green termination (one per ring),
- Gap-out,
- Maximum time-out,
- Force-off,
- Pedestrian service (one per phase), and
- Max II in effect (one per ring).

The Department will allow steady and flashing indications for phase in service, phase next, and pedestrian service, or other mutually exclusive indications.

Provide a controller that stores and maintains user-programmed entries and timing settings using non-volatile memory. The Department will not allow battery power for memory storage.

Provide circuit components capable of withstanding the environments and voltage conditions described in Part 2 of NEMA TS-1.

Design the controller unit to operate with the logic ground isolated from the alternating current (AC) neutral (common).

Provide a controller unit with the following on the front panel:

- A high-quality keyboard for entering timings and settings (with a lifetime rating of one million operations per key); and
- A direct reading alphanumeric or graphic liquid crystal display (LCD) with back lighting.

Provide an LCD display with the following properties:

- Readable from a distance of 3 ft [1 m], at a 45° angle, in any light conditions;
- An automatic time-out feature, unless the display's continuous life expectancy is 10 years or more;
- An operating temperature range from −30 °F to 160 °F [−34 °C to 75 °C];
- Blank out 10 min after the last keystroke; and
- A display capacity of at least 40 character × 4 lines.

If the Contract requires an LCD contrast adjustment control for visibility at temperature extremes, ensure the contrast control is accessible from the controller unit face and does not require tools to adjust.

Provide one spare set of proprietary components for every ten controller units provided (or portions thereof); at least one set per project.

(2) External Download/Upload Interface

Provide a controller unit with an RS 232 serial port accessible through a DB25S or DB95 connector. Provide the following reserve connector pin assignments:

Table 825:2
Connector Pin Designations

Pin	Designation
1	Frame ground
2	Transmit data
3	Receive data
4	Request to send
5	Clear to send
6	Data set ready
7	Signal ground
8	Data carrier detect
20	Data terminal ready
22	Ring indicator

Ensure the port has a baud rate of at least 2,400 baud and is selectable by keyboard or jumper. Configure the port for an 8 bit word, 1 stop bit, no parity.

(3) Program Requirements

(a) *Programming/Data Entry*

Ensure the controller is programmable (including Time Base Coordinator/ TBC/CBT features) using simple keystrokes aided by full menu displays. The Department will not allow programs and displays that are difficult to program or interpret.

Provide controller units using a programming interface with the following characteristics:

- A menu structure containing a main menu with options for each controller sections on one screen;
- Each option selectable using a numeric entry;
- Each subsequent menu displays a detailed breakdown of the previous menu option;
- Each menu option programmed with a descriptive name (e.g. controller section);
- Entries display and enter in English;
- Toggle entries are set using “yes/no” or “on/off” responses;
- Non-alphanumeric symbols with clear meanings;
- Numeric entries programmed in base 10;
- Each NEMA timing interval is programmable for eight phases and appears in a spreadsheet on the same display screen;
- A copy feature allowing the user to copy all intervals of one programmed phase to selected un-programmed phases (the Department will allow other

versions of the copying functions that meet the functional intent, as reviewed by the Department's Traffic Engineering Division and approved by the Resident Engineer);

- A display scroll feature to show additional information;
- Secure access to unit timing and configuration programmable with at least a four-digit user-selected code (preset to all zeros); and
- Display features available without requiring access to the unit.

The Department will allow internal dip switches to establish codes. Provide a keyboard-entered coded command (series of commands or entries, not a single command or entry) that will set controller and TBC timings and entries to a default or inactive value. Do not place instructions for the access code on the face of the unit. Ensure the coded command allows entry of new values without deleting previous entries.

(b)*Operational Features*

Provide volume density timing in accordance with NEMA TS-1. Ensure the controller unit allows dual-entry operations.

Ensure the following modes are available on a per phase basis:

- Maximum recall,
- Minimum recall,
- Pedestrian recall,
- Soft recall,
- Detector locking and non-locking memory, and
- Phase omit.

Provide a controller unit with the following selectable programmed configurations:

- 8 Phase NEMA, and
- 8 Phase Sequential.

Design the controller unit to provide pedestrian phasing with any phase.

Ensure the controller programs for left turn conditional servicing in the 8 phase NEMA configuration under the following conditions:

- The opposing through movement gapped-out;
- The compatible through movement green continues to extend; or
- The compatible through movement has enough time to service the minimum turn time and the through movement terminating amber and red; if a left turn is re-serviced, ensure the controller terminates the phases when the through phase gap or maximum termination point is reached.

Provide a user-programmed controller with detector assignments. Ensure each detector can call or extend the phases. Provide default detector assignments in accordance with NEMA TS-1.

(c)*TBC/BCT*

Ensure the TBC/BCT selects and coordinates the reversible left-turn sequence operations (dual leading, leading and lagging, or lagging and leading left turns). Ensure operations are transferable from one sequence to another at a preprogrammed time. Ensure transfer occurs at the barrier following phases 1,

2, 5, and 6 or at T(0) as defined in accordance with Subsection 825.02.A(3)(d), "Coordinator Operation."

In addition to operation modes required by the Contract, provide a pedestrian override mode that operates in accordance with the following:

- No pedestrian calls present – ensure normal phase timings programmed for a particular coordination plan are effective for service of the intersection.
- Pedestrian calls present – ensure the programmed pedestrian times service the call and override the normal split times. If the intersection drops out of coordination, ensure the controller returns to coordination after servicing the call without altering the programmed phase sequence.
- Computer controlling the intersection – ensure the computer ignores the pedestrian override mode.
- User-programmable timing entries on a per phase basis. The Department does not require special pedestrian override timings and will allow normal pedestrian timing entries for the pedestrian override timings.
- Individual plan selection of the pedestrian override mode.

Provide at least 36 patterns specifying cycle length, splits, and offsets, including the following:

- At least four cycle length selections, each from 30 s to 200 s, adjustable in one second increments;
- At least three splits per cycle length selection; and
- A unique offset for every cycle per split combination, up to 200 s, adjustable in one second increments.

Ensure additional patterns available using additional cycle lengths, splits per cycle length selection, or offsets per cycle split combination.

(d)*Coordinator Operation*

Ensure the coordinator references a system-wide cycle timer (system cycle timer). T(0) refers to the point in the local cycle timer when the coordinated phase or the leading coordinated phase (if the user selects a pair of coordinated phases) is scheduled for the first time. For early return, T(0) may not be the start of green. If early return to main street green occurs, ensure the pedestrian outputs do not turn on until after any other phases are allowed to be serviced before T(0). The offset is the amount of time the local cycle timer is behind the system cycle timer.

Ensure the following minimum information is available to the user for establishing patterns:

- Basic NEMA controller timing,
- Cycle length (in seconds),
- Phase sequence desired for the particular pattern,
- Seconds or percentage of the cycle that a phase is active, including green, amber, and red times, when there is a constant demand on all input detectors,
- The offset (in seconds) of the first coordinated phase serviced in the sequence from the referenced clock T(0), and

- Pedestrian override mode selection.

Ensure the coordinator performs the following functions for each pattern, using the above list of information:

- Guarantees the coordinated phase(s) programmed time will be serviced in its entirety to coordinate between intersections; the programmed time of the first coordinated phase in the sequence starts at T(0).
- Calculates the force-off point of each phase (the point when green must stop to not violate subsequent phase's programmed time, if calls exist).
- Calculates the start of the permissive window of each phase (the point in the cycle when the previous phase yields to the current phase).
- Calculates the end of the vehicle permissive window of each phase (the point preceding the force off point by the minimum time and the clearance time of the previous phase). The Department requires that vehicle calls, received before the end of vehicle permissive window, be serviced during the current cycle.
- Calculates the end of the pedestrian permissive window of each phase (the point preceding the force off point by the pedestrian walk and clearance times and the clearance time of the previous phase). The Department requires that pedestrian calls, received before the end of pedestrian permissive window, be serviced during the current cycle.
- Guarantees the programmed time of each phase is serviced, if the call occurs before the beginning of the permissive window and the phase does not terminate due to gap out.

The Department will allow percentage inputs for coordination phase times only. Ensure the controller unit tests the plan after entering the information for phase service to verify no plan errors exist (minimum times are violated). If a plan error exists, ensure the controller displays a code indicating the error. If the error remains uncorrected and the erroneous plan is selected, ensure the controller runs in the free operation mode. If pedestrian override is selected, ensure the coordinator ignores errors detected due to pedestrian times violating split times.

Ensure the TBC/BCT is programmable to seek offsets by shortway (lengthening or shortening the cycle by up to 20 percent), and dwell in the coordination phase. Ensure the user can program the longest permissible dwell times.

Ensure the TBC/BCT allows the following features and operations under time-of-day (TOD) control:

- Max II Timing,
- Gap/Ext II Timing,
- Phase Omit,
- Free Operation, and
- Flash Operation.

Ensure the user can make the transfer into and out of flash in a safe manner from any point in the phasing sequence, and can program each phase and overlap to flash yellow or red on the controller front panel. Ensure the flashing operation is programmed to simultaneously flash the load-switch driver outputs.

Where vehicle detection does not exist, ensure the controller unit coordination program is programmable from the front panel to emulate a pre-timed controller by recall or BCT.

When servicing the “walk” violates other phases' permissive windows, unless the call to non-actuated function is active, ensure pedestrian movements for the main street rest in green and “don’t walk”.

Ensure the internal reference synchronous pulse (from which the local offset is calculated) resynchronizes at midnight, or ensure the resynchronization is user programmable with the default set to midnight. Ensure a pulse generates when the TOD clock shows a time that is a multiple of the current cycle length after resynchronization. In case of a power failure, ensure the resynchronization is calculated from the programmed resynchronization time. Ensure the power failure recovery routine accommodates a power failure at midnight. When the TBC operates in the free mode, ensure the current cycle length will generate a synchronous pulse output. Ensure this output does not stop due to commands other than external start (in which case all coordination outputs are false).

For each configuration, ensure the coordinated phase or phase pair is selectable from the individual phases or phase pairs in Table 825:2:

Table 825:2
Configuration of Coordination Phasing

Coordinated Phases	8 Phase NEMA	Quad Sequential	8 Phase Sequential
Individual	2,4,6,8	2,4,6,8	2,4,6,8
Pairs	2 and 6, 4 and 8	2 and 6	—
Note: Do not force compatible pairs to begin simultaneously.			

When establishing its offset from the reference point, ensure the coordinator references the synchronous pulse leading edge, regardless of width. Ensure the pulse width is at least 1 s.

Ensure internal coordination and upload/download programs are simultaneously operable and mutually non-interfering. Program the implementation of revised timing parameters loaded into the timer to occur at controller coordination cycle points that do not alter the selected phase sequence. Ensure the controller continues to operate even if it temporarily drops out of synchronization during the upload/download. Submit to the Resident Engineer a complete description of the upload/download format and protocol with the controller unit to be provided to the maintaining organization.

(e) ***Communication***

Ensure the internal settings are accessible through the RS 232 interface using an external modem. Ensure all functions, including the following, show in real-time on an intersection graphical display on the modem-connected download/upload unit, or other compatible unit:

- Detector actuation,
- Signal indications,
- Gap-out,
- Max-out,
- Minimum green,

- Extensions,
- Preempt, and
- Coordination synchronization status.

Ensure alarms are accessible through the RS 232 port by remote interrogation and by automatic dialing initiated by the controller unit.

Provide software necessary to perform all functions as part of the controller software on CD-ROM. Provide a set of software for every ten controller units. The Department reserves the right to make additional copies of this software.

(4) Clock/Calendar Programming Requirements

Provide a clock/calendar program with the following characteristics:

- Capable of easily setting to the time (hour-minute-second), and the date (year-month-day), including the day of the week;
- Stores a yearly program including dates and times for starting and ending daylight savings time (DST);
- User-programmable dates for DST, fixed and floating holidays, and special events using the keyboard;
- Automatic adjustments for the leap year calendar; and
- Stores operation sequences in the form of the following programs:
  - 1 yearly,
  - 10 weekly,
  - 15 daily, and
  - 30 exceptions.

Ensure the structure and interrelationships of each type of program are in accordance with Table 825:3:

Table 825:3
Clock/Calendar Programming

Program	Entries
Daily	≥10 events per daily program, including the following:
	Time of day cycle (1 – 4)
	Offset (1 – 3)
	Split (1 – 3)
	MUTCD flash (on/off)
	Mode of operation
	Special function 1 (on/off)
	Special function 2 (on/off)
	Left turn sequence (lead-lead/lead-lag/lag-lead)
	Max II gap
	Ext II

Table 825:3
Clock/Calendar Programming

Program	Entries
Weekly	10 weekly programs, including the following:
	Sunday: daily program 1 – 15
	Monday: daily program 1 – 15
	Tuesday: daily program 1 – 15
	Wednesday: daily program 1 – 15
	Thursday: daily program 1 – 15
	Friday: daily program 1 – 15
	Saturday: daily program 1 – 15
	Monday through Friday: daily program 1 – 15
	All week days: daily program 1 – 15
Yearly	≤52 entries, including the following:
	Starting month (1 – 12)
	Starting day of month (1 – 31)
	Weekly program number (1 – 10)
Exception	Including the first 10 as follows:
	New Years Day
	Labor Day
	Martin Luther King Day
	Columbus Day
	Presidents Day
	Veterans Day
	Memorial Day
	Thanksgiving Day
	Independence Day
	Christmas Day

Ensure 30 exception programs are user programmable for fixed and floating exceptions. The Department considers the fixed and floating exception format a day program (as defined in Table 825:3) with an assigned date (fixed – month/day of month; floating – month/week of month/day of week) to override the normally operating program.

Provide a copy feature allowing the transfer of entries between programs within the same program level (daily to daily program, weekly to weekly program, etc.). The Department will allow other programming schemes as reviewed by the Department's Traffic Engineering Division and approved by the Resident Engineer.

(5)Coordination Control Hierarchy

When 120 V (AC) conventional interconnect line inputs or interconnect free input are absent, and the central computer does not have on-line control, ensure the internal TBC controls the coordinated, free, and flash operation of the intersection.

When the interconnect free input signal is present and the computer is not controlling the intersection, ensure the master controller TBC controls the controller unit.

When the central computer brings the intersection on-line using the on-line input, ensure the central computer supersedes the internal time base or external conventional interconnect inputs.

For non-computerized applications with conventional 120 V (AC) interconnect lines, ensure the TBC and cabinet interface are operable as a master for the

conventional wire system and as a local accepting conventional cycle, offset, split, free/flash, and on-line commands from the interconnect line.

(6) Preemption Programming Requirements

Provide an internal preemptor that is user programmable from the front panel for railroad or fire run preemption sequences.

Ensure phases are selectable so a limited signal sequence is operational during preempt (PE). Ensure the user can add phases, not in the intersection sequence, to the special limited sequence without requiring additional external logic.

Provide at least the following intervals:

Table 825:4
Controller Intervals – Durations and Increments

Interval [a]	Duration, *s*	Increment, *s*
0. Preempt delay (Emergency vehicle preempt)	0 – 99	1
1. P.E. Minimum green	0 – 9	1
2. P.E. yellow	3 – 9.9	0.1
3. P.E. Red clearance	0 – 9.9	0.1
4. Track green	0 – 99	1
5. Track yellow	0 – 9.9	0.1
6. Track red	0 – 9.9	0.1
7. Minimum P.E. duration (Flash or Limited cycle)	0 – 99	1
8. Return yellow (Solid display) (Yellow limited after limited cycle green)	0 – 9.9	0.1
9. Return red clearance (Red after Flash P.E.)	0 – 9.9	0.1

[a]Terminology may vary but the meaning must be clear.

Ensure the user can program additional, unspecified intervals to zero. If using three letter abbreviations or interval numbers on the display, define them on the front panel. While in preemption, ensure the display identifies the timed intervals as preempt intervals. The Department will allow the use of yellow and red clearance from the phase timings in place of the specified clearance intervals, as long as all other preemption requirements are met.

Ensure the phases serviced after the preempt sequence are programmable using the front panel keyboard.

Ensure the preempt sequences are selectable using external inputs. Assign preempt priority with No. 1 as the highest. If the controller receives a higher priority PE input during a sequence, ensure the controller unit immediately clears to the next all-red interval before entering the new sequence.

Reserve preempt 1 for a priority railroad preempt. If more than two preempts exist, ensure the user can delete the priority overrides except the railroad preempt. If a non-priority preempt activates during another preempt cycle, ensure the in-progress preempt completes its cycle. If the second preempt input is active when the first finishes, ensure the controller unit goes to all-red flash or the programmed point in the non-priority preempt. When preempt inputs are removed, ensure the controller unit proceeds through the normal sequence to return red clearance (Interval 9).

Once the controller unit enters the PE minimum green following preempt delay (Interval 1), ensure the sequence continues to completion, even if the call is

dropped. If the call returns or remains through the minimum preempt (Interval 7), ensure the controller unit remains in the minimum preempt until the call is dropped.

Ensure the controller unit is programmable to be in flash or limited sequence during Interval 7. If flash is programmed, ensure the phases flash yellow or red, as programmed form the front panel. Implement flash by simultaneously flashing the appropriate load-switch driver outputs, not by setting the voltage monitor output to false. When selecting limited sequence, ensure all phases are programmable even if not normally used in the intersection sequence.

In the event of a power interruption as defined in NEMA TS-1, and the preempt command is present when power returns, ensure the controller unit powers up in all-red flash operation and remains there until the preempt command is removed.

Ensure overlap phases start and end with the parent phases in accordance with NEMA TS-1. If the preempt occurs during yellow or red displays between parent phases, ensure the overlap phase displays yellow for at least 3 s and red clearance for at least 1 s.

Ensure "Don't Walk" displays throughout the preempt sequence unless a limited cycle runs during the preempt duration (Intervals 2 through 9). During a limited cycle (Interval 7), the Department will allow pedestrian heads programmed to dark.

Ensure preempt routines have priority over all functions, except emergency and conflict flash.

Ensure the signal from the conflict monitor stop times the preempt cycle until removed or reset.

All intervals are sequential.

The Department defines the logic of each interval as follows:

(a)*Preempt Delay*

Ensure preempt delay starts immediately upon receipt of the preempt command. Ensure the preempt delay does not affect the normal operation of the controller until the delay time out occurs. Use this interval for emergency vehicle preemption delay. Ensure the interval is omitted if zero time is set.

(b)*PE Minimum Green*

When the PE minimum green interval becomes active, ensure any vehicle signals displaying green does not terminate until the programmed time lapses. Ensure "Walk/Walk" indications change to "Don't Walk" immediately at the interval end. Ensure the interval is omitted if zero time is set.

(c)*PE Yellow Clearance*

Ensure green signals not programmed as track or fire lane signals, change from green to yellow, and red signals do not change. Ensure signals displaying yellow at the start of PE yellow clearance remain yellow and display for at least 3 s. Ensure "Walk/Walk" indications change to "Don't Walk" immediately at the interval start. Ensure yellow signals programmed as track or fire lane signals remain yellow, and green and red signals do not change.

(d)*PE Red Clearance*

Ensure yellow signals change from yellow to red, and red and green signals do not change.

(e)*Track Green*

Ensure signals programmed as track (or fire lane) signals change to or remain green and all other signals change to or remain red. Ensure Intervals 4, 5, and 6 are user programmable to zero during emergency vehicle preempts.

(f) *Track Yellow*

Ensure the track yellow interval is the yellow interval for the track (or fire lane) signals. Ensure all other signals remain red.

(g)*Track Red*

Ensure the track red interval provides all-red time for track or fire lane clearance.

(h)*Minimum PE Duration*

Ensure the preempt sequence does not end until the preempt input signal is removed, and the minimum duration time expires. Ensure each signal is user programmable for red, red flash, yellow flash, or green using the keyboard. As an alternative, ensure a limited cycle is programmable for railroad preempts.

(i) *Return Yellow Clearance*

Ensure return yellow clearance provides a solid yellow clearance for green or flashing yellow indications; red and flashing red indications display solid red; and the interval skips if programmed to zero.

(j) *Return Red Clearance*

Ensure the return red clearance is an all-red clearance in preparation for return to the normal cycle. Ensure return phases are user programmable using the keyboard.

B. Cabinet Requirements

(1)Design Requirements

Provide cabinets with the following characteristics:

- Completely weatherproof, to prevent entry of water;
- Constructed of unpainted sheet aluminum at least ⅛ in [3 mm] thick;
- Contains no wood, wood fiber products, or flammable materials;
- Neat and uniform welds;
- Un-welded seams sealed with clear or aluminum weather-seal compound;
- Vertical shelf support channels, with single continuous slots (not fixed notches or holes), to allow for shelf adjustments;
- Sufficient shelf space to accommodate the following:
  - A controller unit 12 in [0.3 m] high,
  - A 12-channel NEMA conflict monitor, and
  - The number of NEMA loop-detector amplifiers specified in Table 825:1, “Controller Dimensions and Characteristics.”

Equip the cabinet with the following:

- A commercially-available, thermostatically-controlled fan with a capacity meeting NEMA requirements, with at least 2 CFS [0.05 CMS];
- An adjustable thermostat with a range from 70 °F to 110 °F [20 °C to 43 °C]; and
- An air intake and exhaust vent.

Securely mount a filter to the air intake vent so air entering the cabinet passes through the filter. Ensure the air intake vent is large enough to use the entire filter. Provide the minimum filter dimensions recommended by the manufacturer for each cabinet size defined in Table 825:1, "Controller Dimensions and Characteristics." Place a screen over the air intake and exhaust vent. Provide a screen with openings no greater than 0.012 in² [8 mm²]. Ensure the exhaust vent is large enough to prevent back pressure on the fan.

Provide each cabinet with a unique serial number of at least ¼ in [6 mm] high numbers. Stamp the serial number on the upper right-side wall of the cabinet near the front, or engrave on a metal Mylar plate and attach to the cabinet with epoxy or aluminum rivets. Mount a ground fault circuit interruption type, duplex receptacle to the lower front right side wall or on the door, and wire it to the load side of the 20 A circuit breaker.

(2) Back Panel

Provide back panels with the following characteristics:

- Designed to accept the minimum load switches as shown on the Plans;
- Hinged at the bottom, folding down and out from the top and allowing access for maintenance of all components (load switches, relays, etc.); and
- Allows access to the back of the back panel in less than 2 min using standard tools.

The Department will not allow printed-circuit back panels or components mounted behind the panel, except transient suppression devices for relay coils. Number or identify wire termination points on the back of the back panel to correspond with the labeling on the panel face.

Bring outputs from the controller to the load switches, and outputs from the detectors to the controller, through posted binder head screw terminals with removable shorting bars. Support load switches and flashers with brackets designed to accept all NEMA load switches and flashers and prevent vibration from dislodging them from the back panel sockets. Bring load switch outputs through posted binder head screw terminals. Connect field wiring for signal heads at this terminal strip on the back panel. If the Contract requires, provide additional load switches for phasing.

(3) Detector Panel

Mount a loop detector panel on the left side of the cabinet. Ensure the panel provides the following:

- Connections between loops at the street and detector amplifiers,
- Pedestrian call isolation, and
- Connections between detector amplifiers and the controller unit.

Provide a three position detector test switch per detector in the cabinet.

Bring inputs from the loops through posted binder head screw terminals, and outputs from the detectors to the controller through posted binder head screw terminals with removable shorting bars. Equip detector harnesses for shelf mounted units with an MS3106A-18-1S connector, and wire the harness in accordance with Table 825:6:

Table 825:6
Detector Harness Wiring

PIN number	Function
A	AC common
B	Controller unit logic ground
C	120 V (AC)
D	Loop
E	Loop
F	Controller detector call input
G	Spare
H	Ground bus
I	Controller detector call input
J	120 V (AC) output from green load switch for this phase

Provide an on-off-momentary toggle switch for each vehicle and pedestrian phase that allows the user to disconnect the detector input for that phase from the controller unit, or place a call to the controller. Ensure the momentary position places a call to the controller, the on position connects the detector to the controller unit, and the off position disconnects the detector from the controller unit.

If using a detector rack, provide a detector panel, loop amplifiers, and associated wiring in accordance with Section 828, "Vehicle Loop Detector and Loop Detector Wire."

(4) Cabinet Door

Provide a cabinet with one door in front. Attach the door to the cabinet using three hinges with unremovable stainless steel pins or a full length piano hinge with stainless steel pins spot welded at the top of the hinge. Provide stainless steel pins in accordance with ASTM A320 B8F. Mount the hinges to allow removal from the door or cabinet only when the door is open. Ensure the bottom of the door opening extends at least to the bottom level of the back panel.

Fit the cabinet door with a Number 2 Corbin lock with a three point latch, at least a ¾ in [19 mm] diameter shaft, and a cast aluminum or stainless steel handle that is lockable in the closed position with a padlock. Provide a lock and latch designed so the handle will not release until the lock releases. Provide one key for each cabinet. Install the lock clear of the handle arc.

Provide a gasket at least ⅜ in [9 mm] thick as a permanent dust and weather resistant seal in the channel cabinet door facing. Provide a nonabsorbent gasket material that maintains resiliency after long term exposure to the outdoor environment. The Department will allow an **L**-bracket instead of the channel if the gasket fits snugly against the bracket and provides a permanent dust and weather resistant seal around the entire door.

Provide a locking auxiliary police door in the cabinet door allowing access to a panel containing a signal shutdown switch, flash switch, and a manual-automatic switch. Provide a standard ¼ in [6 mm] two-conductor phone jack to accept a

manual push button telephone. Equip the police door with a gasket of the same specifications as the main cabinet door, and provide one brass key per auxiliary door.

Rivet a 12 in × 17 in [0.30 m × 0.43 m] heavy-gauge vinyl-plastic pouch to the inside of the cabinet door. Ensure the pouch can accommodate a copy of the cabinet wiring diagram, controller manual, and accessory documentation.

(5) Wiring

Provide neat wiring in the cabinets, routed so that opening and closing the door, or raising and lowering the back panel does not cause twists or crimps. Provide wiring harnesses that are braided, sheathed in nylon mesh sleeving, or of PVC or polyethylene insulated jacketed cable. Provide PVC jacketed cable for wiring leading to the cabinet door and jacketed cable for loop detector harnesses.

Provide the following sizes of stranded copper conductor wire:

- At least No. 22 AWG in the cabinet;
- At least No. 10 AWG between the main power circuit breakers and the signal power bus; and
- At least No. 16 AWG for wires carrying individual signal lamp current.

Provide all wires and insulation rated to at least 600 V, and ensure AC service lines can carry the maximum circuit current.

Provide white conductors for AC common, and green conductors for equipment grounding. The Department will not allow these colors to be used for any other conductor.

Provide a 50 A barrier terminal block with at least three binder head screw terminals and one compression fitting (designed to accept up to No. 4 AWG stranded wire) for connecting the AC power lines. Isolate AC wiring in the path from the terminal block to the transient surge suppression device and bundle separately from all other wiring in the cabinet.

Provide permanent terminal identification as shown on the Plans, in accordance with the cabinet wiring diagram, and the following:

- As close to the terminal strip as possible;
- Not on any part easily removable from the terminal block panel;
- Not obstructed by cabinet equipment;
- On both sides of the panel for through-panel solder lugs or other connectors;
- A number and function designation for each controller input and output function at each terminal point in the cabinet;
- A number for each load switch socket;
- For each flash transfer and power relay base;
- A function designation for each harness in the cabinet on the connector end;
- For the flasher socket; and
- For other sockets in the cabinet.

Make all NEMA controller unit and conflict monitor connector pinouts, except for load switch inputs to the conflict monitor, available on binder head screw terminals on the back panel.

Provide a controller unit harness (A, B, C, or any combination of the three plugs) long enough to reach any point 15 in [0.40 m] above the timer shelf. Provide a conflict monitor harness, and any auxiliary harnesses required by the Contract, long enough to reach 24 in [0.60 m] from the conflict monitor shelf.

Provide copper ground buses for the power supply neutral (common) and chassis ground. Jumper the AC neutral and chassis ground buses together with at least No. 10 AWG wire. Isolate the logic ground from the AC neutral, and terminate it on a logic ground bus that accepts 20 No. 20 AWG stranded wires.

Equip the circuit breakers with solderless connectors installed on the right side wall or the lower right hand side back panel inside the cabinet. Ensure the breakers are easily accessible and positioned so the rating markings are visible. These circuit breakers are in addition to auxiliary fuses required by the Contract to protect component parts.

Protect the load side of the main circuit breaker with a lightning surge suppressor (EDCO ACP-340, or an equivalent reviewed by the Department's Traffic Engineering Division and approved by the Resident Engineer). Connect the suppressor ground connection to the cabinet, and the suppressor to the line filter in accordance with manufacturer recommendations. Provide at least No. 10 AWG wire to connect the suppressor, line filter, and load switch bus.

Install a relampable fluorescent light, with a switch, in the cabinet. Ensure the light turns on when the cabinet door opens, and off when the cabinet door closes.

Place transient suppression devices on the coil side of all relays in the cabinet. Provide direct-current relay coils with at least a reversed biased diode across the coil. Equip each AC relay with a metal oxide varistor, or equivalent suppression device, across coils. The Department will allow Resistor Capacitor (RC) networks.

Except where soldered, provide wires with lugs, or other fittings approved by the Resident Engineer, to attach binding posts.

Ensure the outgoing traffic control signal circuits are the same polarity as the line side of the power source.

Provide a switch on the cabinet door inside face and label it “Auto-Flash.” When the switch is in the “Flash” position, ensure that calls for flashing operation do not remove the power from the controller unit and allow normal operation while the intersection is in flashing operation. When the switch is in the “Auto” position, ensure the operation is in an automatic mode with the signals on. Provide a three-position switch, near the “Auto-Flash” switch, to stop the controller unit and auxiliary equipment and label it “Stop Timing”. Label the top position “Automatic Operation”, the middle position “Stop Time Off”, and the bottom position “Stop Time On”. Provide a controller power on/off switch.

Wire the cabinet so that activation of the conflict monitor causes the controller unit, and any auxiliary equipment, to stop timing. Wire conflict and manual flash for all red.

Ensure the red enable and remote reset from the conflict monitor can be terminated on the back panel face.

C. Conflict Monitor

Provide NEMA Plus conflict monitors in accordance with NEMA TS-1 with the number of channels shown on the Plans. Provide additional channels as shown on the Plans.

D. Solid-State Load Switch

Provide solid-state load switches with the following characteristics:

- Solid-state construction;
- Meets Section 5 of NEMA TS-1;
- “Triple-Signal Load Switches” type; and
- Indicator light for each circuit that illuminates when a “true” input occurs.

E. Two-Circuit Solid-State Flasher

Provide two-circuit solid-state flashers with the following characteristics:

- Solid-state construction;
- Contains no electromechanical devices;
- Meets Section 8 of NEMA TS-1;
- Voltage range from 95 V to 135 V (AC);
- Nominal voltage of 120 V (AC);
- Constructed of easily replaceable components;
- Operating frequency from 57 Hz to 63 Hz;
- Designed to operate at ambient temperatures from −30 °F to 160 °F [−34 °C to 74 °C]; and
- Type III unit (dual circuit rated at 15 A per circuit).

F. LED Traffic Signal Battery Backup System

Provide a battery backup system in accordance with the latest NEMA 3R or 4 requirements. Obtain the following from the equipment manufacturer and submit to the Resident Engineer upon request:

- Certification showing that the equipment model has been tested and approved in accordance with NEMA;
- Service warrant;
- Instruction books;
- Service manuals;
- List of generic part numbers for service personnel; and
- Complete installation instructions.

(1) General Equipment

Ensure the system provides power for normal signal operation, flash operation, and combination mode.

Provide a system designed for outdoor applications meeting the traffic industry environmental standard and compatible with NEMA TS-1 and TS-2 controllers and cabinets.

Provide a system that includes cables, wiring harnesses, battery cables, and components for operation.

(2) System Equipment

Provide equipment for LED traffic signal battery backup systems in accordance with Table 825:6:

Table 825:6
Equipment Properties for LED Traffic Signal Battery Backup

Property	Requirement
Output power	≥1,200 VA
Active output power	≥875 W
Output/Input voltage	120 V (AC), 60 Hz
Output waveform, pure sine wave	<5% THD
Input current	12 A – 15 A
Input voltage variation	92 V – 135 V (AC)
Typical efficiency	>95%
Maximum charge current	6 A
Operating temperatures	−30 °F – 165 °F [−34 °C – 74 °C]
Typical transfer time	2 ms – 4 ms
Audible noise at 1 m	<55 dbA
Lightning/Surge protection	Passing ANSI/IEEE C62.41/C62.45 Cat A and B
Typical battery recharge time	90% in 4 hr
Warranty	36 months on components
Computer interface port	RS-232

Protect the unit with automatic electronic short circuit or overload shutdown, automatic over temperature shutdown, and voltage adjustment that activates due to input voltage variation. Provide an LED indicator for “online”, “on battery”, “low battery overload”, and “fault”.

(3) Battery System

Provide sealed, absorbed glass mat or gel, 12 V batteries.

Ensure the number of batteries and amp-hour ratings are capable of operating the battery backup system in full time signal operation at 875 W for at least 3 hr.

Provide batteries with interconnect wiring, corrosion-resistant mounting trays, and brackets.

Provide a regulated, temperature compensated battery charging system.

Provide batteries with 3-year full-replacement warranties.

(4) Battery Cabinet

Ensure the battery cabinet is mountable on the controller cabinet side. Provide a cabinet of ⅛ in [3.17 mm] thick aluminum, Type 5052-H32 housing, with a natural aluminum finish, sturdy aluminum shelves, and lockable door.

G. Documentation

Submit the following documentation with each cabinet:

- Three accurate and legible cabinet wiring diagrams; and
- One manual for the controller, conflict monitor, load switch, flasher, and detector units.

825.03 EQUIPMENT — VACANT

825.04 CONSTRUCTION METHODS

Install vehicle-actuated solid-state traffic signal controllers at locations shown on the Plans and in accordance with the manufacturer's recommendations.

825.05 METHOD OF MEASUREMENT — VACANT

825.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
TRAFFIC SIGNAL CONTROLLER ASSEMBLY	Each

The Department will consider the cost of additional load switches and conflict monitor channels to be included in the contract unit price for the *Traffic Signal Controller Assembly*.

SECTION 827
SOLID-STATE FLASHING CONTROLLER

827.01 DESCRIPTION

This work consists of providing, installing, and programming (initial) solid-state flashing controllers and solid-state time clocks.

827.02 MATERIALS

Provide the following types of flashing controller as shown on the Plans:

- Type I - Provide a flashing controller in accordance with Subsection 827.02.A, "Controller."
- Type II - Provide a flashing controller, including a solid-state time clock, in accordance with Subsection 827.02.A, "Controller," and Subsection 827.02.B, "Time Clock."

A. Controller

Provide a solid-state, NEMA two-circuit Type III, 15 A flashing controller.

B. Time Clock

Provide a solid-state single-circuit time clock, except for the relay output. Ensure availability of components to the Department for servicing 5 years after expiration of the manufacturer's warranty. Alternatively, ensure availability of the components from industrial electronics suppliers.

Provide an integral keyboard capable of setting the time, date, day of week, and the relay output operation. Provide a keypad with marked key functions. Ensure all data for programming the unit and reviewing the stored program is clearly displayed without using auxiliary devices.

Provide a system capable of automatically changing between daylight savings time and standard time, once programmed. Ensure a hardware change, a software change, or both can override the automatic changes.

Ensure the display verifies data before it is entered into the program. Ensure the programmer can correct data before its entry. Ensure the system allows alteration of data before entry. Provide for alteration of individual program steps without disturbing other program steps.

Provide operating instructions with each time switch. The Department defines a program step as the time and day(s) of the week when the output turns on or off. When instructed to turn the output on or off, ensure the system sets the instruction time to the minute and ensure the change occurs at the zero second of that minute. Provide a time switch capable of initiating at least six program steps. Ensure the time switch can execute five separate skip plans programmed at least 1 year in advance.

Use the integral keyboard to program skip plans. To program each plan, enter the beginning and ending dates for the time switch output deactivation. Ensure the time switch can skip durations from 1 day to 6 months. Ensure a skip plan can begin in 1 calendar year and end in the next consecutive year. Ensure the system allows entering one-day skips 6 days before the day to be skipped. After the one-day skip, ensure the time switch automatically resets and resumes normal operation.

The Department will not require chronological entry of skip plan programs.

Ensure review of the skip plan program without affecting the normal operation of the time switch. Ensure the display includes the skip plan number, the beginning date, and the ending date.

Provide a backup system to maintain timekeeping and the program for at least 48 hr at 77 °F [25 °C] that automatically goes online when the 115 V alternating current (AC) power source fails. When the line power resumes, ensure the unit automatically resumes normal operation and recharges the backup system. Provide a capacitive charging system. The Department will not allow batteries for the charging system.

If an AC power outage erases the time switch program, ensure the unit displays a program loss indication. Provide a display with a discrete LED indicator and ensure the display can be reset from the integral keyboard.

When the time switch operates on the backup system, ensure the display blanks and the output disables to conserve power. Ensure the unit displays the time, day of week, date, and the output relay condition. When using the 12 hr time format, ensure the unit displays “am/pm.” Provide a unit capable of switching to an alternate time display that includes seconds. Ensure a keystroke switches the display between the normal and alternate modes.

Provide for program review on the clock memory, integral with the input. Ensure the program review does not affect the current time switch operation.

Ensure the capability for mounting the time switch back panel to a backplate. Ensure that mounting holes provide a clearance for at least a No. 10 screw.

Provide a time switch no larger than 4 in [100 mm] wide × 7⅜ in [190 mm] high × 3⅛ in [80 mm] deep. Provide a cover for the unit to protect the time switch from dust. Ensure easy removal of the cover to allow access to the field wiring terminals. A rain-tight cover is not necessary.

Provide a terminal block capable of accommodating wire sizes from No. 20 AWG to No. 12 AWG to interface to the power line and the controlled device.

Ensure that the time switch operates on 115 V (AC), 60 Hz power source, from 95 V to 135 V (AC) and from −30 °F to 160 °F [−1 °C to 71 °C].

Ensure that timing synchronizes with the power line. Provide a backup power source to maintain the timing when commercial power fails. When using the backup power, ensure timing remains accurate within 3 sec per 24 hr period throughout the entire temperature range. Ensure changeovers between 115 V (AC) and the backup system do not alter the time.

Provide a keyboard for system programming. Ensure the time set accurately to 1 s.

C. Cabinet

Provide a weatherproof, aluminum alloy cabinet of at least 14 in [355 mm] high × 10 in [254 mm] long × 5 in [127 mm] wide, to enclose (with ample space) the flashing controller and associated equipment of the type regularly supplied by the manufacturer and approved by the Resident Engineer.

Provide a hinged door that allows access to the cabinet interior. Seal and weatherproof the door with neoprene gasket material. Provide a standard police lock and two keys.

Provide identifiable terminals, connected to terminal boards, accessible without removing equipment from the cabinet.

Provide a surge protector (EDCO SPA-100, or an equivalent approved by the Department's Traffic Engineering Division), with each flashing controller.

Provide a circuit breaker in accordance with NEC.

827.03 EQUIPMENT — VACANT

827.04 CONSTRUCTION METHODS

Place and wire the Type I or Type II controller unit as required by the Contract.

827.05 METHOD OF MEASUREMENT — VACANT

827.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
SOLID STATE FLASHING CONTROLLER	Each

The Department will consider the solid state time clock and the cabinet included in the contract unit price for *Solid State Flashing Controller*.

Unless otherwise required by the Contract, the Department will pay for sign posts in accordance with Section 851, “Galvanized Steel Sign Posts” and sign post footings in accordance with Section 804, “Concrete Footings.”

SECTION 828
VEHICLE LOOP DETECTOR AND LOOP DETECTOR WIRE

828.01 DESCRIPTION

This work consists of providing and installing a solid state digital inductive vehicle loop detector and loops.

828.02 MATERIALS

Provide and install the following materials in accordance with the latest edition of NEMA TS-1 or TS-2.

A. Detector Loop Wire

Provide detector loop wire embedded in the pavement in accordance with Subsection 738.01, "Traffic Signal Wire and Cable."

B. Shelf Mounted Detector Unit

Provide a self-contained, self-tuning, solid state digital detector that automatically compensates for temperature variations and environmental conditions.

(1) Mechanical Requirements

Provide a detector unit and power supply enclosed in a sheet-metal housing with a protective paint finish. Ensure that the case allows access to the interior assembly and allows parts testing and servicing. Supply each detector unit with a connecting cable. Insert a multi-terminal plug into the plug receptacle on the face panel of the detector to make an electrical connection from the detector to the incoming and outgoing circuits. Ensure detector replacement without disconnecting and reconnecting the individual wires.

(2) Output Delay and Extend

Supply the loop detector unit with programmable delay and extend output features.

(a) *Delay Output*

Provide a delay circuit variable to at least 20 s in 1 s increments for delayed output. Ensure vehicle detection delay for the time period selected to prevent detector output until vehicle presence in the loop for the selected length of time. Ensure the vehicle delay timing resets each time the vehicle vacates the loop. Ensure the delay circuit immediately disables in the presence of 120 V (AC) on Pin J of the MS 3106A-18 1P connector for this channel.

(b) *Extend Output*

Provide a variable extend circuit for carryover output to at least 15 s in 0.25 s increments. Ensure detector actuation extends after the vehicle leaves the loop. Ensure the timing circuit resets the after the extension expires. Do not disable the extend circuit in the presence of 120 V (AC) at Pin J of the connector.

Provide digital timing. Ensure use of pins, thumbwheels, or dip switches for programming settings. The Resident Engineer will not require delay and extend features to function simultaneously, unless otherwise shown on the Plans.

Provide external programming capability on the face of the unit.

(3) Operating Requirements

Design the detector so environmental metal objects near the loop do not affect operation. Ensure the lead-in cable is located in a common conduit with signal and interconnect cables without interfering with detector operation.

Ensure the detector operates in temperatures from −30 °F to 160 °F [−34 °C to 71 °C] with an online voltage of single phase 120 V (AC) 60 cycle. Accommodate online voltage variation of 15 percent without affecting the operation or life of detector equipment.

Provide the detector unit with a tuning range of loop inductance from 40 µH to 700 µH. Ensure the detector detects vehicles traveling up to 100 mph [160 km/h]. Ensure the detector detects vehicles that pass over any part of the loop. Ensure the detector returns to its original condition after a power failure.

(4) Electrical Requirements

Provide solid state detector circuitry. Provide a printed circuit board in accordance with Section 825, "Traffic Signal Controller Assembly." Provide facilities on the front panel for adjusting the detector. Provide for a simplified loop tuning procedure without a test apparatus or traffic. Provide a detector unit with switches on the front to independently select the pulse or presence operating mode. Provide each detector channel with a surge protector (EDCO SRA-16C-1, or an equivalent approved by the Department's Traffic Engineering Division). Provide the detector with a multi-conductor color coded harness and MS connector. On the front panel, install a fuse (replaceable without tools) for each detector unit. Permanently ground each detector unit internally. Provide an indicator light on the front panel to show vehicle detection.

C. Card Rack Detector Unit

Provide two channel, self-tuning, solid state, digital card rack detector units that automatically compensate for temperature variations and environmental conditions in accordance with NEMA TS-2 and Subsection 828.02.B, "Shelf Mounted Detector Unit."

D. Card Rack Assembly

Provide a card rack, cross-wired for two or four channel operations, that will accommodate at least eight detector units.

Provide an aluminum detector card rack frame with modular slots allowing the PCB edge connectors to plug into the rear while sliding between top and bottom card guides for each module. Provide mounting flanges turned outward. To allow the card rack to swing out, provide slack in the wiring and hinge on one side and fasten with thumb screw connectors on the other side.

E. Power Supply

Provide a 24 V (DC) power supply that delivers at least 3.6 A. For a shelf-mounted power supply, ensure the front panel of the power supply provides power on LED, a

power on-off switch, a fuse for the 120 V (AC) input line, and a connector. Provide a connector with a metallic shell internally connected to the chassis ground that is compatible with an MS-3106A-18-1SW cable connector.

Provide connector PIN terminations in accordance with Table 828:1:

Table 828:1
Connector PIN Terminations

PIN	Function
A	AC neutral
B	Reserved
C	120 V (AC) line
D	Reserved
E	24 V (DC) output
F	Reserved
G	Logic ground
H	Chassis ground
I	Reserved
J	Reserved

F. Vehicle Loop Wire Sealant

Provide and install loop wire sealant for installing vehicle detector loops in asphalt and concrete pavement as shown on the Plans.

(1) General Requirements

Provide a one-part polyurethane sealant for asphalt and concrete pavement. Ensure that the sealant allows traffic to travel over the filled slot immediately after application without tracking. Provide sealant that will not shrink in volume.

(2) Physical Properties

Provide sealant with a shelf life of at least 12 months. Provide sealant with uncured and cured properties specified in Table 828:2, Table 828:3, and Table 828:4:

(a) *Uncured (Wet) Sealant*

Provide uncured (wet) sealant with the following properties:

Table 828:2
Physical Properties of Uncured Sealant

Property	Requirement	Test
Standard weight	717.87 lb/cycle ± 1 lb [1,210 kg/m^3 ± 0.45 kg]	ASTM E 201
Total solids by weight, 18 hr at 200 °F [94 °C]	75% – 86% by weight	ASTM D 1353
Viscosity, no. 6 spindle at 20 rpm, 77 °F [25 °C], 50% relative humidity	0.00073 psi•s – 0.0123 psi•s [5 Pa•s – 85 Pa•s]	Brookfield RVF
Curing time, 50% relative humidity	Touch: ≤24 hr	ASTM D 1640
4 mil [1,000 µm] film, 77 °F [25 °C]	Complete ≤36 hr	—

(b) *Cured Sealant*

Provide cured sealant with the properties specified in Table 828:3:

Table 828:3 Physical Properties of Cured Sealant		
Property	**Requirement**	**Test**
Hardness (Indentation)	65 – 85	ASTM D2240 Model 1700, 25C, 50% relative humidity
Tensile strength, Die C pulled at 20 IPM	≥125 psi [862 kPa]	ASTM D412
Elongation, Die C pulled at 20 IPM	≥200%	ASTM D412
Adhesion, canvas to concrete	15 lb/in [0.3 kg/mm] wide	ASTM D903
Application temperature	41 °F – 131 °F [5 °C – 55° C]	—
Service temperature	−40 °F – 150 °F [−40 °C – 65 °C]	—

(c) ***Resistance***

Provide cured sealant with the chemical resistances specified in Table 828:4:

Table 828:4 Chemical Resistance of Cured Sealant		
Property	**Result**	**Test**
Deicing	No effect	ASTM D 471
Gasoline	Slight swell	ASTM D 471
Hydraulic brake fluid	No effect	ASTM D 471
Motor oil	No effect	ASTM D 471
Sodium chloride 5%	No effect	ASTM D 471
Conduct the ASTM tests from 70 °F to 77 °F [18 °C to 25 °C] for 22 hr		

(3) Application of Sealant

Apply the sealant as shown on the Plans. The Department may test to ensure compliance. If a sample fails, remove and replace with new sealant as approved by the Resident Engineer.

828.03 EQUIPMENT — VACANT

828.04 CONSTRUCTION METHODS

Locate the loop detection system as shown on the Plans. Mark and maintain the detection system locations on the roadway for approval of the Resident Engineer.

Cut the induction loop slot and corner cuts to the dimensions shown on the Plans. Use compressed air to clean and dry the slot.

Wind loop wires in the same direction. Provide loop wire in a continuous length to the pull box, and connect to the lead-in cable. Use a blunt wood instrument to place the wire into the slot without damaging the insulation.

Make all connections between loop wire and lead-in cable in the pull box. Solder the connection with a 60/40 alloy, rosin core solder. Avoid damaging the wire and cable insulation while soldering.

Place a water-tight connector sealing packet over each completed connection. If no lead-in cable is necessary, directly connect the loop wire to the terminal block in the base of the traffic signal pole.

After placing the loop wire and backer rod in the slot, check the circuitry, and seal the slot with a sealer required by the Contract.

828.05 METHOD OF MEASUREMENT — VACANT

828.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) VEHICLE LOOP DETECTOR	Each
(B) LOOP DETECTOR WIRE	Each or Linear Foot [Meter]

SECTION 830
PEDESTRIAN PUSH BUTTON

830.01 DESCRIPTION

This work consists of providing and installing pedestrian push buttons and signs on traffic signal installations.

830.02 MATERIALS

Provide phenolic-enclosed precision snap-acting single-pole, single-throw pedestrian push button switches with screw terminals rated at 5 A at 125 V alternating current in accordance with Americans with Disabilities Act (ADA) Section 14.2.5.

Provide materials for pedestrian information signs as shown on the Plans.

830.03 EQUIPMENT — VACANT

830.04 CONSTRUCTION METHODS

Install the pedestrian push button in accordance with ADA requirements. Design pedestrian push buttons to prevent tampering and electrical shock.

Attach the pedestrian push button and sign to a traffic signal pole or steel pipe as shown on the Plans. Shape the housing to fit the curvature of the pole or pipe. Secure the housing to provide a rigid installation.

830.05 METHOD OF MEASUREMENT — VACANT

830.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
PEDESTRIAN PUSH BUTTON	Each

The Department will consider the cost of signs and hardware to be included in the contract unit price for *Pedestrian Push Button*.

SECTION 831
TRAFFIC SIGNAL HEADS

831.01 DESCRIPTION

This work consists of providing and installing vehicular and pedestrian traffic signal heads and lamps on supports.

831.02 MATERIALS

Provide vehicular traffic signal heads and component parts that consist of polycarbonate or die-cast aluminum in accordance with the ITE Standard for Adjustable Face Vehicle Traffic Control Signal Heads (VTCSH). Provide pedestrian traffic signal heads in accordance with the ITE Standard Adjustable Face Pedestrian Signal Head Standard.

Provide LED lamps in accordance with the ITE Standard for Vehicle Traffic Control Signal Heads, unless otherwise shown on the Plans. Provide LED colors in accordance with the chromaticity requirements of the VTCSH standard, Section 8.04 and Figure 1. Provide LED lamps approved by the Department's Traffic Engineering Division or listed on the Department's Traffic Engineering Division Qualified Products List. Ensure pedestrian symbols are fully illuminated LEDs. The Department will not allow outline symbols. Provide pedestrian countdown if shown on the Plans.

If shown on the Plans, provide incandescent lamps in accordance with the ITE Standard for Traffic Signal Lamp. For 8 in [200 mm] vehicular traffic signal heads or 12 in [300 mm] pedestrian traffic signal heads, provide 60 W, 590 lm, 120 V, clear traffic signal incandescent lamps with a life rating of at least 8,000 hr. For 12 in [300 mm] vehicular traffic signal heads or 20 in [508 mm] pedestrian traffic signal heads, provide 150 W, 1,950 lm, 130 V, clear traffic signal incandescent lamps with a life rating of at least 8,000 hr. Provide glass lenses and specular alzak aluminum reflectors in traffic signal heads with incandescent lamps.

If the Contract requires polycarbonate traffic signal housings, provide ultraviolet stabilized, pre-colored opaque yellow and injection-molded housings with black doors and visors, unless otherwise shown on the Plans.

Apply three coats of paint, inside and outside, to die cast aluminum doors, visors, and signal housings before assembly.

A. First Coat – Primer

Ensure the first coat consists of oxide baking primer in accordance with the performance specifications of Federal Specifications TT-P-636.

B. Second Coat – Grey Enamel

Ensure the second coat consists of medium grey alkyd urea exterior baking enamel in accordance with Federal Specifications TT-E-489.

C. Third Coat – Yellow Enamel

Ensure the third coat consists of highway yellow alkyd urea exterior synthetic baking enamel, with minimum gloss reflectance in accordance with the performance specifications of Federal Specifications TT-E-489, Enamel Heat Resisting Glyceryl Phthalate, Type 4, Instrument Black.

831.03 EQUIPMENT — VACANT

831.04 CONSTRUCTION METHODS

Make signal heads weather-tight.

Ensure signal heads consist of at least one adjustable signal section with LED or lamps fastened together. Ensure each signal section is self-contained and consists of an optical unit with housing, housing door, visor, and glass lenses, unless otherwise shown on the Plans.

Provide signal heads with brackets and fittings for mounting on the type of signal support shown on the Plans. Ensure signal heads capable of positioning to control the movement of one direction of vehicular or pedestrian traffic.

831.05 METHOD OF MEASUREMENT — VACANT

831.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
TRAFFIC SIGNAL HEADS	Each

The Department will consider the cost of lamps, wiring, visors, and hardware to be included in the contract unit price for *Traffic Signal Heads*.

SECTION 832
OPTICALLY-PROGRAMMED ADJUSTABLE TRAFFIC SIGNAL HEADS

832.01 DESCRIPTION

This work consists of providing and installing optically-programmed adjustable traffic signal heads and lamps on supports.

832.02 MATERIALS

Provide optically-programmed adjustable traffic signals capable of allowing optical determination of the visibility zone of the indication. Ensure the signal does not require hoods or louvers. Provide for projected indications selectively visible or veiled within 15° of the optical axis. Ensure the indications emanate from a single section. Ensure external illumination does not provide indications. Prevent one light unit from illuminating a second unit.

A. Optical System

Provide a lamp with the following characteristics:

- 75 W,
- 120 V (AC),
- Three prong,
- Sealed beam,
- With an integral reflector with stippled cover, and
- With an average life rating of at least 6,000 hr.

Provide a lamp collar, including specular inner surface, that couples the lamp to the diffusing element. The diffusing element may be discrete or integral with the convex surface of the optical limiter.

Provide an optical limiter made of heat-resistant glass with an accessible imaging surface at focus on the optical axis for objects from 900 ft to 1,200 ft [275 m to 365 m] away. Provide an optical limiter that allows the application of a veiling mask, determined by the desired visibility zone.

For the objective lens, provide a high resolution planar incremental lens, hermetically sealed within a flat laminant of weather resistant acrylic or an equivalent approved by the Resident Engineer. Ensure the lens has a symmetrical outline and can rotate 90° about the axis without displacing the primary image. Provide an optical system that accommodates projection from a single section of diverse selected indicia to separate portions of the roadway so one indication is visible at a time.

Provide the projected indication in accordance with ITE chromaticity standards.

B. Electrical

For the lamp fixture, provide a separately accessible housing and integral lamp support, with indexed ceramic socket, and self-aligning, quick release lamp retainer. Electrically connect the case and lamp housing with an interlock assembly, which disconnects from the lamp holder when opened. In each signal section, include a covered terminal block for clip or screw attachment of lead wires. Interconnect

sections with concealed copper No. 18 AWG, stranded and coded wires, to enable field connection.

C. Photo Controls

In each signal section, include an integral way to regulate its intensity between limits as a function of background illumination. Ensure that the lamp intensity is at least 97 percent of uncontrolled intensity at 10,760 lx, and reduces from 13 percent to 17 percent of maximum at less than 11 lx. Ensure response is proportional and instantaneous when illumination increases to 10,760 lx, and damped for decreases from 10,760 lx.

Provide an intensity controller with an integrated, directional light sensing and regulating device interposed between the lamp and line wires. Ensure that the intensity controller is compatible with 60 Hz input and is responsive from 105 V to 135 V. The Contractor may phase-control the output for a controller with terminal impedance of 1,200 Ω open circuit and a corresponding holding current.

832.03 EQUIPMENT — VACANT

832.04 CONSTRUCTION METHODS

Provide die cast aluminum parts in accordance with ITE alloy and tensile requirements and with a chromate preparatory treatment. Finish the exterior of the signal case, lamp housing, and mounting flanges with a high quality prime baked enamel and finish paint. Make the lens holder and case interior optical flat black. Predrill the signal case and lens holder for backplates and visors. Use stainless steel hinges and latch pins. Seal access openings with weather resistant rubber gaskets.

Mount the signal to standard 1½ in [38 mm] fittings as a single section, as a multiple section face, or combined with other signals. Provide the signal section with an adjustable connection enabling incremental tilting from 0° to 20° below horizontal while maintaining a common vertical axis through couplers and mounting. Ensure that the mounting attachment allows external adjustment in 5° increments about the mounting axis. Provide a mountable signal capable of being serviced with standard tools. Ensure that attachments fasten to mounting surfaces without affecting water and light integrity of the signal.

Install, direct, and veil the signal in accordance with manufacturer's instructions. Mask signal sections with manufacturer-recommended materials.

832.05 METHOD OF MEASUREMENT — VACANT

832.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
OPTICALLY-PROGRAMMED ADJUSTABLE TRAFFIC SIGNAL HEADS	Each

The Department will consider the cost of masking, wiring, and hardware to be included in the contract unit price for *Optically Programmed Adjustable Traffic Signal Heads*.

SECTION 833
TRAFFIC SIGNAL BACKPLATES

833.01 DESCRIPTION

This work consists of providing and installing backplates to traffic signal heads.

833.02 MATERIALS

Provide backplates in accordance with Section 740, "Traffic Signal Backplates."

833.03 EQUIPMENT — VACANT

833.04 CONSTRUCTION METHODS

Provide one piece backplates. The Department will allow the use of two or three piece backplates for S-19 signal heads.

Secure the backplate to the traffic signal heads with non-corrosive machine screws, washers, and lock nuts as shown on the Plans.

833.05 METHOD OF MEASUREMENT — VACANT

833.06 BASIS OF PAYMENT

The Department will pay for each item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
BACKPLATES	Each

SECTION 834
ELECTRICAL CONDUCTORS FOR TRAFFIC SIGNALS

834.01 DESCRIPTION

This work consists of providing and installing electrical conductors for traffic signal systems.

834.02 MATERIALS

Provide materials in accordance with the following subsections:

Material:	Subsection:
Traffic Signal Wire and Cables	738.01
Shielded Loop Detector Lead-In Cable	738.01

834.03 EQUIPMENT — VACANT

834.04 CONSTRUCTION METHODS

Avoid damaging the conductor and the insulation during installation. Replace damaged conductors at no additional cost to the Department.

A. Traffic Signal Electrical Cable

Install traffic signal electrical cable from the heads on each traffic signal pole to the traffic signal controller. Place the electrical cable in conduit from the traffic signal pole to the controller. Provide electrical cable with the number of conductors and at least one spare conductor as shown on the Plans.

B. Shielded Loop Detector Lead-In Cables

Place the shielded loop detector lead-in cables in conduit from each loop detector pull box to the traffic signal controllers. At each loop detector pull box, splice the loop wire or the sensing element lead to the loop detector lead-in cable with a waterproof, self-insulating connection using soldered connections and epoxy or gel cast splice kits as shown on the Plans.

C. Underground Conductors in Conduit

Complete the conduit system before installing the conductors. Provide slack in each conductor at the pole bases, pull boxes, and cabinets, as approved by the Resident Engineer.

D. Underground Splices

The Department will allow splices in the traffic signal conductors at the pole bases, terminal block, or controller cabinet.

E. Testing

Test the installed traffic signal and detector lead-in conductors in accordance with Section 801, “Performance and Operational Tests for Highway Lighting and Traffic Signals.”

834.05 METHOD OF MEASUREMENT — VACANT

834.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) TRAFFIC SIGNAL ELECTRICAL CABLE	Linear Foot [Meter]
(B) SHIELDED LOOP DETECTOR LEAD-IN CABLE	Linear Foot [Meter]

The Department will consider the cost of connectors, splices, and incidentals to the traffic signal system to be included in the contract unit price for *Traffic Signal Electrical Cable* and *Shielded Loop Detector Lead-In Cable*..

SECTION 836
REGULATORY OR WARNING SIGN ASSEMBLY

836.01 DESCRIPTION

This work consists of providing and installing regulatory or warning sign assemblies with flashing beacons.

836.02 MATERIALS

Provide regulatory or warning sign assemblies that consist of a sheet aluminum sign with the message, traffic signal heads, solid-state flashing controller, time clock, sign post, foundation, wiring and conduit as shown on the Plans.

A. Sign

Provide the sign material in accordance with Section 850, “Signs.”

B. Solid State Flashing Controller and Time Clock

Provide the solid-state flasher controller and time clocks as shown on the Plans and in accordance with Section 827, “Solid-State Flashing Controller.”

C. Flashing Beacons

Provide flashing beacons with traffic signal heads and lamps as shown on the Plans and in accordance with Section 831, “Traffic Signal Heads.”

D. Sign Post, Footing, and Mounting Hardware

Provide the sign posts and foundations as shown on the Plans and in accordance with Section 850, “Signs.” Provide galvanized, aluminum, or stainless steel mounting hardware.

E. Aluminum Base

Provide FHWA-approved cast aluminum bases.

836.03 EQUIPMENT — VACANT

836.04 CONSTRUCTION METHODS

Install and connect the regulatory or warning sign assembly to a power supply as shown on the Plans.

836.05 METHODS OF MEASUREMENT — VACANT

836.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
REGULATORY OR WARNING SIGN ASSEMBLY	Each

The Department considers the cost of wiring and connecting the regulatory or warning sign assembly to power to be included in the contract unit price for *Regulatory or Warning Sign Assembly*.

SECTION 849
RAILROAD-HIGHWAY CROSSBUCK SIGNS

849.01 DESCRIPTION

This work consists of providing and erecting railroad-highway crossbuck signs with posts.

849.02 MATERIALS

Provide materials as shown on the Plans. Submit to the Resident Engineer a Type D certification in accordance with Subsection 106.04, “Material Certifications.”

849.03 EQUIPMENT — VACANT

849.04 CONSTRUCTION METHODS

A. Making Signs

Provide the signs and posts as shown on the Plans.

B. Setting Signs

Set the sign posts in compacted soil holes with the top of the sign set to the elevation as shown on the Plans or as directed by the Resident Engineer. Ensure the sign faces oncoming traffic. Adjust the sign to provide visibility as approved by the Resident Engineer.

Backfill the holes with Class A concrete as shown on the Plans. Rod and consolidate the concrete to obtain density. Temporarily support the sign in a plumb position for at least 24 hr before removing the supports.

C. Sign Locations

Place crossbuck signs in accordance with MUTCD for Streets and Highways, or as directed by the Resident Engineer.

849.05 METHOD OF MEASUREMENT — VACANT

849.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
RAILROAD-HIGHWAY CROSSBUCK SIGNS	Each

The Department will consider the cost of posts and footings to be included in the contract unit price for *Railroad-Highway Crossbuck Signs*.

SECTION 850
SIGNS

850.01 DESCRIPTION

This work consists of providing and erecting signs, including sheet aluminum and extruded aluminum panel signs with a retroreflective or non-retroreflective sheeting background, and steel or aluminum sign bracket arms, bolts, and fittings.

850.02 MATERIALS

Provide materials in accordance with Section 719, “Signs.”

Provide signs with Type III high intensity retroreflective sheeting unless otherwise shown on the Plans. Provide extruded panel signs with Type III high intensity retroreflective sheeting for the background with Type VIII retroreflective sheeting for legends and borders. Provide durable, transparent or opaque, high intensity colored electronic cuttable film with pressure sensitive adhesive and removable liner for Interstate shields for both extruded aluminum signs and route assembly signs. Obtain the Resident Engineer’s approval of shop drawings before starting the manufacture of special signs.

850.03 EQUIPMENT — VACANT

850.04 CONSTRUCTION METHODS

A. Cleaning

Clean sheet aluminum and extruded aluminum panel signs before applying sheeting adhesive and sheeting.

B. Application of Sheeting

Pre-perforate Class 2 adhesive coated sheeting. Use mechanical equipment to apply sheeting to treated base panels as follows:

(1) Continuous Roll Application

Continuously apply the sheeting with Class 1 adhesive coating over the entire surface of the sign. Prevent air pockets or bubbles. Ensure the retroreflective sheeting for extruded panel signs extends ¼ in [6.35 mm] over and adheres to each side of the panel. For sheeting on extruded panels, ensure no more than one splice per panel.

(2) Color Match

During sign fabrication, match the color of sign faces with at least two pieces or panels of retroreflective sheeting to provide uniform appearance and brilliance, at night and during the day.

The Resident Engineer will reject signs with non-uniform shading and contrast between adjacent widths of applied sheeting.

(3) Splices

At splices, overlap Class 1 adhesive coated sheeting at least $^{3}/_{16}$ in [4.76 mm]. Butt splice Class 2 adhesive coated sheeting and ensure a gap not exceeding $^{1}/_{64}$ in [0.397 mm]. Only use butt splices on screen processed sign faces with transparent colored ink. For sheet metal signs with heights no greater than 24 in [0.61 m], the Department will not allow retroreflective sheeting splices. For sheet metal signs at least 36 in [0.91 m] high, the Department will allow one horizontal or one vertical retroreflective sheeting splice.

C. Finishing Signs

After applying the retroreflective sheeting background, use the silk screen process to apply messages and borders on sheet metal signs. Use a cutout legend, if required by the Contract.

Seal sign face splices and edges with materials supplied and recommended by the sheeting manufacturer. Use stick-on copy for legends, symbols, and borders on extruded panel signs. Ensure finished signs with a smooth and uniform light surface with clear and sharp letters and numbers.

Protect sheet signs from moisture during shipment or storage.

D. Sign Locations and Positions

Erect signs with sign faces in a vertical position and horizontally angled away from the direction of travel, as shown on the Plans. Prevent specular reflection from erected signs. Adjust sign positioning to eliminate or minimize specular reflection at no additional cost to the Department.

Align the lower edge of extruded panel signs on overhead trusses along the centerline of the lower horizontal chord member. After installation, the Resident Engineer will inspect the signs at night.

850.05 METHOD OF MEASUREMENT

The Resident Engineer will measure signs by the area of the vertical front face with no deduction for rounded corners.

850.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) SHEET ALUMINUM SIGNS	Square Foot [Square Meter]
(B) EXTRUDED ALUMINUM PANEL SIGNS	Square Foot [Square Meter]
(C) MASTARM MOUNTED SIGNS	Square Foot [Square Meter]
(D) SPECIAL SIGNS	Each or Square Foot [Square Meter]

SECTION 851
GALVANIZED STEEL SIGN POSTS

851.01 DESCRIPTION

This work consists of providing and constructing galvanized steel sign posts and footings.

851.02 MATERIALS

Provide materials in accordance with Section 721, “Galvanized Steel Sign Posts.”

851.03 EQUIPMENT — VACANT

851.04 CONSTRUCTION METHODS

If necessary, field cut steel posts and place the cut end in the concrete foundation. Re-galvanize, metalize, or paint steel post parts, if damage reveals bare metal. Use zinc dust-oxide paint, approved by the Resident Engineer.

The Department will not allow the use of welded splices in round pipe or wide flange beam posts.

851.05 METHOD OF MEASUREMENT — VACANT

851.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) GALVANIZED STEEL WIDE FLANGE BEAM POSTS	Linear Foot [Meter]
(B) GALVANIZED STEEL PIPE POSTS	Linear Foot [Meter]
(C) SQUARE TUBE POST	Linear Foot [Meter]
(D) FLANGE CHANNEL POSTS	Linear Foot [Meter]

If the Contract requires breakaway sign posts, the Department will consider the cost of breakaway design elements to be included in the contract unit price for the relevant post pay items.

Unless otherwise required by the Contract, the Department will pay for sign post footings in accordance with Section 804, “Concrete Footings.”

SECTION 852
OVERHEAD SIGN STRUCTURES

852.01 DESCRIPTION

This work consists of providing and constructing overhead sign structures on prepared footings.

852.02 MATERIALS

Provide materials for overhead sign structures in accordance with Section 720, “Overhead Sign Structures.”

Provide materials for concrete footings in accordance with Section 804, “Concrete Footings.”

852.03 EQUIPMENT — VACANT

852.04 CONSTRUCTION METHODS

A. Design

To design overhead sign structures, use general data in accordance with the AASHTO *Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*, as shown on the Plans.

Submit shop drawings to the Resident Engineer for approval before construction.

B. Welding

Qualify procedures, welders, and welding in accordance with Subsection 720.03, “Welding Requirement,” and AASHTO/ANSI/AWS D 1.1.

C. Fabrication

Provide overhead sign structures free of sharp edges, irregularities, misfits, or structural deficiencies, as approved by the Resident Engineer. Complete overhead sign structures as shown on the Plans.

D. Shipping and Erection

Deliver upright supports and truss structures to the project immediately before the erection of the complete structure, including signs. Attach fixtures and other components after erection of the complete structure.

Protect the surfaces of the structures to prevent damage during transportation and erection.

The Resident Engineer will reject damaged structures that cannot be re-galvanized or metalized in accordance with AWS C2.2-52T-Recommended Practices for Metalizing.

E. Electrical Requirements

Provide electrical equipment, materials, and installation methods in accordance with Section 801, “Performance and Operational Tests for Highway Lighting and Traffic Signals.”

If there is no electrical power at the site, provide temporary power to demonstrate that fixtures and equipment are installed in accordance with Section 801, “Performance and Operational Tests for Highway Lighting and Traffic Signals.”

852.05 METHOD OF MEASUREMENT — VACANT

852.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) ALUMINUM OVERHEAD SIGN STRUCTURE	Each or Linear Foot [Meter]
(B) GALVANIZED STEEL OVERHEAD SIGN STRUCTURE	Each or Linear Foot [Meter]
(C) OVERHEAD SIGN STRUCTURE, MONOTUBE TYPE A	Each
(D) OVERHEAD SIGN STRUCTURE, MONOTUBE TYPE B	Each
(E) OVERHEAD SIGN STRUCTURE, MONOTUBE TYPE C	Each
(F) ALUMINUM OVERHEAD SIGN STRUCTURES-BRIDGE MOUNTED	Each
(G) GALVANIZED STEEL OVERHEAD SIGN STRUCTURES-BRIDGE MOUNTED	Each
(H) OVERHEAD SIGN STRUCTURES, WALKWAY, AND HANDRAIL	Linear Foot [Meter]
(I) UPRIGHTS FOR OVERHEAD SIGN STRUCTURE	Each
(J) TESTING OF ALUMINUM WELDS	Lump Sum

Pay Item:	**Pay Unit:**
(K) REPLACE ALUMINUM TUBING IN OVERHEAD SIGN STRUCTURE	Pound [Kilogram]
(L) REPAIR OVERHEAD SIGN STRUCTURE	Each

The Department will pay for the following items separately in accordance with Section 802, “Electrical Conduit”; Section 803, “Pull Boxes and Ground Boxes”; Section 804, “Concrete Footings”; Section 809, “Luminaires”; and as shown on the Plans:

- Internal walkway and hand rail,
- External walkway and hand rail,
- Sign lights,
- Electrical conduit,
- Wiring,
- Pull boxes, and
- Reinforcing steel in footings and concrete footings.

SECTION 853
DELINEATORS

853.01 DESCRIPTION

This work consists of providing and installing delineators and posts.

853.02 MATERIALS

Provide materials in accordance with Section 710, “Delineators.”

853.03 EQUIPMENT — VACANT

853.04 CONSTRUCTION METHODS

Install delineator units on the posts at the heights shown on the Plans or directed by the Resident Engineer. Drive or set posts to the line and grade shown on the Plans.

If driving posts, ensure the posts are plumb and firm in the ground, spaced as shown on the Plans. Use a Resident Engineer approved driving cap for driven posts. Do not damage the tops of posts during driving operations. Remove and replace damaged posts as directed by the Resident Engineer, at no additional cost to the Department.

If setting posts, dig the post holes to the depth and spacing shown on the Plans.

Backfill post holes with Resident Engineer approved material in layers no greater than 6 in [150 mm] deep. Compact each layer and preserve the alignment of the posts.

Provide bolts and fasteners of the type, length, diameter, and material shown on the Plans, or an equivalent approved by the Resident Engineer.

At bridges, fasten the delineators to the bridge handrail posts or parapet wall using brackets and fasteners for the various types as shown on the Plans.

853.05 METHOD OF MEASUREMENT

The Resident Engineer will divide and code *Delineators* for measurement and payment in accordance with Table 853:1:

Table 853:1
Delineators

Type 1 Monodirectional			Type 2 Bidirectional		
Code	**No. of Reflectors**	**Reflector Placement**	**Code**	**No. of Reflectors**	**Reflector Placement**
1	1	—	1	2	One on each side mounted back to back
2	2	vertically	2	4	Two on each side vertically mounted back to back
3	3	vertically	3	6	Three on each side vertically mounted back to back

Provide reflectors of the color shown on the Plans or directed by the Engineer.

853.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
DELINEATORS	Each

The Department will consider the cost of post mounting brackets and hardware to be included in the contract unit price for *Delineators*.

SECTION 854
TRAFFIC STRIPE (PAINT)

854.01 DESCRIPTION

This work consists of providing and placing a white or yellow paint stripe with beads applied by the drop-on method.

854.02 MATERIALS

Provide materials in accordance with Subsection 711.05, “Glass Beads for Traffic Paint, Thermoplastic, and Multi-polymer” and Subsection 711.06, “Traffic Stripe Paint – Acrylic Waterborne.”

854.03 EQUIPMENT

Use a paint machine capable of applying an even, clean-cut line with minimal drifting paint. Ensure the cutoff mechanism on the paint machine is capable of making a clean-cut end section without dripping or stringing fine lines of paint.

Use a bead dispenser with an automatic cutoff control synchronized with the cutoff of the striping material.

854.04 CONSTRUCTION METHODS

Clean the pavement area of foreign material to ensure maximum adhesion of paint.

Apply the material to the pavement at a wet film thickness of 15 mils [0.381 mm]. Evenly distribute 6 lb of beads per gallon of wet paint [719 kg per cubic meter], unless otherwise directed by the Resident Engineer. Use an automatic bead dispenser attached to the striping machine to immediately and uniformly dispense the beads on the completed paint line.

Do not apply the traffic stripe paint on wet pavement or at air temperatures below 40 °F [5 °C], and falling. Apply traffic stripe paint when air temperature is 45 °F [7 °C], and rising.

854.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of traffic stripe using a 4 in [100 mm] standard width. For traffic stripes narrower or wider than 4 in [100 mm], the Resident Engineer will make a proportional adjustment based on the 4 in [100 mm] standard width.

The Resident Engineer will measure arrows, words, and symbols by each unit. The Resident Engineer will count arrows by each head.

854.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) TRAFFIC STRIPE PAINT	Linear Foot [Meter]
(B) TRAFFIC STRIPE PAINT (ARROW, WORDS, OR SYMBOLS)	Each

SECTION 855
TRAFFIC STRIPE (PLASTIC)

855.01 DESCRIPTION

This work consists of providing and placing reflectorized plastic pavement markings on asphalt concrete (AC) and portland cement concrete (PCC) pavement surfaces.

855.02 MATERIALS

Provide plastic pavement markings materials in accordance with Section 711, “Traffic Stripe,” except yellow thermoplastic material. Provide lead-free yellow thermoplastic material.

Provide matte, non-retroreflective black contrast markings for PCC surfaces.

Provide glass beads in accordance with Subsection 711.05, "Glass Beads for Traffic Paint, Thermoplastic,and Multi-polymer."

855.03 EQUIPMENT

A Extruded Application (Thermoplastic)

Apply the material to the pavement using the extrusion method; one side of the shaping die is the pavement surface and the other three sides are formed by equipment for heating and controlling the material flow.

Prevent extrusion of the material above the pavement surface.

Ensure the equipment parts coming in contact with the material are accessible for cleaning and maintenance. Prevent parts between the main reservoir and the shaping die from clogging. Ensure mixing and conveying parts, including the shaping die, maintain the material at the plastic temperature. Extrude plastic stripes with continuously uniform dimensions. Use equipment designed to produce a uniform film thickness from 90 mil to 188 mil [2.38 mm to 4.76 mm].

Ensure the shaping die includes a remotely controlled cut-off device to provide clean, square stripe ends, and to apply skip lines.

The Department will not allow the use of pans, aprons, and similar appliances that the die overruns.

B. Mechanical Application (Preformed Plastic Tape)

Install preformed pavement line markings with a mechanical applicator that accurately and uniformly places pavement lines. Equip the mechanical applicator with a film cut-off device and measuring devices that automatically and accumulatively measure the length of each stripe within a 2 percent tolerance.

855.04 CONSTRUCTION METHODS

A. Surface Preparation

Remove foreign material from the road surface before applying the plastic marking material. Ensure the pavement surface is dry.

For new PCC pavement, sandblast the pavement surface at stripe locations to remove curing compound. Sandblast at least 7 days after placing the new PCC pavement, unless otherwise directed by the Resident Engineer.

Remove existing stripes at the direction of the Resident Engineer.

On AC and PCC surfaces older than 12 months, or with existing or removed pavement markings, apply a 50/50 blend of a two-part epoxy primer sealer to the area to be striped. Use a primer sealer compatible with the plastic striping material and the pavement surface.

On PCC and AC surfaces older than 12 months, apply a liquid seal coat to the area to be striped. Use a seal coat compatible with the plastic striping material and the pavement surface.

Correct pavement markings that are non-uniform or not visible as directed by the Resident Engineer, at no additional cost to the Department.

Obtain written approval from the Resident Engineer before placing plastic pavement markings over longitudinal joints.

Use abrasive blasting or grinding to remove existing, temporary, or permanent traffic markings until at least 95 percent of the underlying pavement is visible, unless otherwise specified by the manufacturer. Minimize interference between temporary pavement markings and the permanent dual-component pavement marking materials.

When applying dual component markings to new PCC pavement, use a high-pressure water jet, sandblasting, or other method approved by the Resident Engineer, to remove existing curing compound. Remove the curing compound at least 1 in [25 mm] beyond the width of the marking. After removing the curing compound, sweep and use a high-pressure air spray.

B. Application of Markings

(1) Hot-Applied Plastic Pavement Markings

Use the extrusion method for hot applied pavement markings. Ensure the lines have sharp edges, uniform thickness, good adhesion, and uniform high reflectance. In accordance with the manufacturer recommendations, melt the compound and install at temperatures from 400 °F to 450 °F [204 °C to 232 °C], measured at the pavement surface.

Apply hot thermoplastic markings on clean, dry pavement with a surface temperature of at least 55 °F [13 °C] and rising, and wind chill temperature of at least 45 °F [7 °C].

The Department defines the drying time for pavement markings as the minimum elapsed time after application when the stripe retains its shape and reflectivity, and traffic will not damage the stripe. The Department defines minimum drying times in accordance with the following, at a maximum relative humidity of 70 percent and air temperature of 50 °F [10 °C]:

- For stripes 188 mil [4.76 mm] thick, 2 min; and
- For stripes 90 mil [2.38 mm] thick, 1 min.

Mix and apply thermoplastic pavement marking material to ensure that stripes retain the original characteristics of the bond to the surface, resistance to distortions by traffic or climate, and resistance to discoloration.

Ensure the thickness of the dry thermoplastic material in accordance with Table 855:1:

Table 855:1
Specified Line Thickness

Description	Standard line thickness, *mil [mm]*	Thin line thickness, [a] *mil [mm]*
Lane and stop lines	120 – 188 [3 – 4.8]	70 – 125 [1.8 – 3.2]
Edge, gore, and diagonal lines	90 – 188 [2.4 – 4.8]	70 – 125 [1.8 – 3.2]
Words, arrows, and symbols	120 – 188 [3 – 4.8]	70 – 125 [1.8 – 3.2]

[a] For roadways with less than 5,000 ADT, use a 4 in stripe only, no words or symbols.

(2) Cold-Applied Plastic Pavement Markings

For preformed pavement markings of reflectorized plastic material cold-applied to the pavement surface, coat with a factory-applied, pressure-sensitive adhesive.

Apply the material to the AC and PCC surfaces in accordance with the manufacturer recommendations when the surface temperature is at least 65 °F [18 °C] and rising. If applying the markings at surface temperatures from 65 °F to 50 °F [18 °C to 10 °C], apply the markings in accordance with the manufacturer recommendations, other special instructions, or both.

Do not use heat, solvents, or extra adhesives to apply the reflectorized plastic markings, except for surface sealers on PCC surfaces as required by the Contract.

(3) Inlaid Installation of Preformed Plastic Tape

For the inlaid method, apply the markings on newly-placed, compacted AC pavement, when the pavement temperature is from 125 °F to 155 °F [52 °C to 68 °C].

Use a mechanical roller to inlay the markings into the AC surface. Ensure the mechanical roller inlays the marking to a depth from 65 percent to 80 percent of the plastic tape thickness.

If any of the following occurs during inlaying operations, repair or replace the inlaid markings as approved by the Resident Engineer at no additional cost to the Department:

- Distortion of the markings,
- Failure to provide a uniform appearance, or
- Improper installation of the markings.

Place the markings in the finished surface of installed AC pavement before the end of each work day.

C. Application of Glass Beads

Apply large glass beads at a coverage rate of at least 10 lb per 100 ft² [4.5 kg per 10 m²] before applying standard beads. Apply standard glass beads at a coverage rate of at least 10 lb per 100 ft² [4.5 kg per 10 m²]. For transverse and hand-machine applied markings, use a single drop of large glass beads at a rate of at least 10 lb per 100 ft² [4.5 kg per 10 m²].

D. Performance Period

Ensure markings and replacement markings meet the Contract requirements for at least 30 calendar days. Within 30 days of notification by the Resident Engineer, remove and replace non-compliant pavement markings at no additional cost to the Department.

E. Retroreflectivity

Measure stripes with a portable reflectometer that uses 30 m geometry in accordance with ASTM E 1710 and the manufacturer recommendations. Ensure the manufacturer calibrates the reflectometer annually. Keep the annual calibration certification with the reflectometer.

(1) Minimum Retroreflectivity

Ensure longitudinal markings meet the minimum retroreflectivity values in accordance with Table 855:2:

Table 855:2
Minimum Retroreflectivity

White		Yellow	
mcd/m²/lx	Contract unit price adjustment	mcd/m²/lx	Contract unit price adjustment
≥400	100%	≥225	100%
350 – 399	75%	200 – 224	75%
200 – 349	50%	150 – 199	50%
<200	Remove and replace	<150	Remove and replace

(2) Measurement

Measure retroreflectivity of markings within 10 calendar days of placement, after removing loose beads.

Measure marking retroreflectivity in the direction of traffic, except the Department will allow yellow skip lines to be measured in either direction of traffic. One measurement (multiple readings) will represent each 2,500 ft [762 m] lot of single-color longitudinal stripe. The Department will not allow readings for adjacent lots to be taken closer than 1,000 ft [305 m] from each other.

For solid longitudinal stripes, one measurement represents the average of five readings per lot, taken at 3 ft [1 m] intervals along a randomly selected 15 ft [4.5 m] section of solid stripe.

For longitudinal skip stripes, one measurement represents the average of six readings per lot, two readings taken from each of three adjacent skip stripes. The Department will not allow readings taken within the first or last 1 ft [0.3 m] of skip stripes.

For non-compliant measurements, the Resident Engineer will require additional measurements to determine the extent of non-compliance.

The Department will not require measurements for the following:

- Stop bars, crosswalks, gores, words, and symbols;
- Longitudinal striping installed using hand line machines;
- County roads or city streets, unless otherwise required by the Contract; and
- Projects less than 1 mi [1.6 km] long.

Obtain the Resident Engineer's approval in writing before using a mobile retroreflectometer system as an alternate measurement method.

(3)Acceptance

Submit final retroreflectivity measurements to the Resident Engineer for acceptance. Include the date and time of reflectometer calibration, location (GPS coordinates), line color, and date of each measurement. The Department will consider unmeasured stripes non-compliant. The Resident Engineer will provide notification of non-compliance with the minimum retroreflectivity values. Remove and replace non-compliant stripe sections at no additional cost to the Department.

For quality assurance, the Department will measure retroreflectivity with a Delta Light & Optics, Model LTL X portable reflectometer. If the Department and the Contractor measurements differ by greater than 10 percent, the Department will use its measurements for acceptance.

The Resident Engineer may accept striping quantities less than 2,500 ft [762 m] by visual inspection.

855.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of traffic stripe for 4 in [100 mm], 6 in [152.4 mm], 8 in [203.2 mm], and 24 in [609.6 mm] stripe.

The Resident Engineer will count arrows by each head.

855.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) TRAFFIC STRIPE (PLASTIC)(4" WIDE)	Linear Foot [Meter]
(A) TRAFFIC STRIPE (PLASTIC)(6" WIDE)	Linear Foot [Meter]
(A) TRAFFIC STRIPE (PLASTIC)(8" WIDE)	Linear Foot [Meter]
(A) TRAFFIC STRIPE (PLASTIC)(24" WIDE)	Linear Foot [Meter]
(B) TRAFFIC STRIPE (PLASTIC)(Arrows)	Each
(B) TRAFFIC STRIPE (PLASTIC)(Words)	Each
(B) TRAFFIC STRIPE (PLASTIC)(Symbols)	Each

The Department considers the cost of preparing the pavement surface and retroreflectivity measurements (including the measurement submittals) to be included in the contract unit price for the relevant pay item.

The Department will pay for the replacement of pavement markings damaged by snow and ice removal.

The Department will pay for stripe removal in accordance with Section 857, "Construction Zone Pavement Markings."

SECTION 856
TRAFFIC STRIPE (MULTI-POLYMER)

856.01 DESCRIPTION

This work consists of providing and placing reflectorized and non-reflectorized multi-polymer pavement markings on asphalt concrete (AC) and portland cement concrete (PCC) pavement surfaces.

856.02 MATERIALS

A. Physical Properties of the Mixed Compound

Provide a multi-polymer resin material free of heavy metals (as defined by the EPA) approved by the Resident Engineer.

When heating to the application temperature, ensure the material does not exude toxic fumes.

Formulate and test the materials to ensure performance as a pavement marking material with glass beads applied to the surface.

When properly applied with the required gradations and bead applications, ensure the multi-polymer resin compound cures to a no-track condition within 45 min (at 70 °F [20 °C] or greater) or within 240 min (at 40 °F [4.4 °C]), tested in accordance with ASTM D 711.

Provide materials in accordance with the Table 856:1, Table 856:2, and Table 856:3:

Table 856:1
Color Requirements

Federal 595 Color		Chromaticity Coordinates								Brightness (Y)
		1		2		3		4		
		x	y	x	y	x	y	x	y	
White	17855	0.302	0.344	0.325	0.344	0.302	0.320	0.325	0.320	80 min
Yellow	33538	0.543	0.472	0.475	0.472	0.543	0.425	0.475	0.425	60 min – 70 min

Table 856:2
Multi-Polymer Traffic Stripe Properties

Property	Test Procedure	Description
Abrasion Resistance	ASTM C 501	Evaluate using a Taber Abrader with a 2.2 lb [1,000 g] load and CS-17 wheels for 1,000 cycles. Calculate the wear index and ensure the index for the dual component material is 80 mg or less. Perform the test on cured samples applied, without glass beads, at a film thickness from 0.0195 in to 0.0205 in [0.495 mm to 0.520 mm] to code S-16 stainless steel plates. Allow the samples to cure at room temperature (from 73 °F to 77 °F]) from 24 hr to 72 hr before performing the tests.

Table 856:2
Multi-Polymer Traffic Stripe Properties

Property	Test Procedure	Description
Hardness	ASTM D 2240	Ensure the multi-polymer paint pavement markings material has a Shore D Hardness from 75 to 95. Allow the samples to cure at room temperature (from 73 °F to 77 °F) from 24 hr to 72 hr before performing the indicated tests.
Adhesion to Concrete	ACI 503, Appendix A.1	Ensure the multi-polymer marking material has a higher degree of adhesion to the specified concrete (at least 4,000 psi) surface, so there is 100 percent concrete failure in the test performance. Allow the samples to cure at room temperature (from 73 °F to 77 °F) from 24 hr to 72 hr before performing the indicated tests.
Yellowness Index	ASTM D 1925	Ensure the white material has a yellowness index no greater than 30. Base the index on a sample cured at room temperature (from 73 °F to 77 °F) for 72 hr and exposed in the QUV chamber for 72 hr.

Table 856:3
Material Requirements

Tests	Requirements
Density (Gallon Weight)	±0.10 lb/gal [12 kg/m³]
Viscosity (Krebs-Stormer)	±7 KU
Viscosity (Cone & Plate)	±0.5 P
Grind	Not less than the standard
% Non-Volatile Matter	±1.0%
% Pigment (white)	±3.0%
% Volume Non-Volatile Matter	±3.0%
Infrared Spectrum	Analyze Component A and Component B to verify for control purposes that submitted materials are identical to materials originally approved by the Resident Engineer. The Resident Engineer will reject materials that deviate from the original sample.

B. Multi-Polymer Composition

Provide a two-component (Compound A and Compound B) multi-polymer resin material, 100 percent solids system with a volumetric mixing ratio of 2:1 (A:B) in accordance with Table 856:4:

Table 856:4
Multi-Polymer Composition

Pigment Composition	Percent by Weight
White:	
Titanium Dioxide Rutile (94% minimum purity, ASTM D 476, Type III	18.0 – 25.0
Multi-Polymer Resin	75.0 – 82.0

Table 856:4
Multi-Polymer Composition

Pigment Composition	Percent by Weight
Yellow:	
Organic Non-Lead Yellow	7.0 – 8.0
Titanium Dioxide (ASTM D 476, Type III)	14.0 – 17.0
Multi-Polymer Resin	77.0 – 79.0

Ensure that the pigment composition only consists of titanium dioxide.

(1) Multi-Polymer Content (Component A)

Test the multi-polymer content of the multi-polymer resin in accordance with ASTM D 1652 and calculate the weight per multi-polymer equivalent (WPE) for both white and yellow markings. Determine the multi-polymer content on a pigment free basis. Ensure the multi-polymer content meets the target value provided by the manufacturer, reviewed by the Department's Material Division, and approved by the Resident Engineer. The Resident Engineer will apply a tolerance of ±50 WPE to the target value to establish the acceptance range.

(2) Amine Value (Component B)

Determine the amine value of the curing agent in accordance with ASTM D 2074. Ensure the total amine value meets a target value provided by the manufacturer, reviewed by the Department's Material Division, and approved by the Resident Engineer. The Resident Engineer will apply a tolerance of ±50 WPE to the target value to establish the acceptance range.

C. Sampling and Certification

If directed by the Resident Engineer, submit the following from manufacturer:

- Certified test results;
- A 1 qt sample representing each batch of multi-polymer resin material; or
- Both.

Obtain Resident Engineer approval of the multi-polymer components before use in accordance with the following:

- Documentation of acceptable performance from other state DOT’s field performance of 50,000 ADT for the past 5 years in accordance with this specification.
- Submit a written explanation of changes to the formulation, as well as physical or chemical properties of the approved multi-polymer resin, to the Resident Engineer at least 30 days in advance of its use, for re-evaluation and approval. Include MSDS with submitted documentation.

D. Non-Reflectorized Contrast or Shadow Markings

Ensure the marking material used for the contrast or shadow marking conforms to the same formulation, material, and pre-approved sampling requirements, except for the following items:

- Color pigments used,
- Color requirements listed, and
- If drop-on glass beads must be replaced with a black, color-fast, anti-skid material.

E. Glass Beads

Provide double-drop glass beads in accordance with Subsection 711.05, "Glass Beads for Traffic Paint."

856.03 EQUIPMENT

Use equipment that sprays the multi-polymer materials in the manufacturer recommended proportions. Mount the equipment on a truck capable of applying uniformly dimensioned markings as required by the Contract.

Provide equipment with an automatic bead dispenser that continuously mixes and agitates the pavement marking material.

Provide equipment capable of placing at least 40,000 ft [12,190 m] of the following types of markings per day to the alignment, spacing, and thickness shown on the Plans:

- Solid or skipped stripes 4 in to 6 in [100 m to 150 mm] wide;
- Markings other than solid or skipped lines; and
- A centerline and no-passing barrier stripe configuration consisting of one skip stripe with two solid stripes, simultaneously.

Ensure the equipment places markings with clean edges of uniform cross section and thicknesses, with square ends, and with an approximate stripe-to-gap ratio of 1:3.

Ensure the equipment uniformly and instantly places the beads on the markings. When placing beads on two adjacent stripes, ensure each stripe has an equivalent bead coverage rate and embedment.

Provide equipment that heats and places each component within the component mix tolerances in accordance with the manufacturer recommendations.

856.04 CONSTRUCTION METHODS

A. Surface Preparation

Remove foreign material from the road surface before applying the dual component material. Ensure the pavement surface is dry.

Use abrasive blasting or grinding to remove existing, temporary, or permanent traffic markings until at least 95 percent of the underlying pavement is visible, unless otherwise specified by the manufacturer. Minimize interference between temporary pavement markings and the permanent dual-component pavement marking materials.

When applying dual component markings to new PCC pavement, use a high-pressure water jet, sandblasting, or other method approved by the Resident Engineer, to remove existing curing compound. Remove the curing compound at least 1 in [25 mm] beyond the width of the marking. After removing the curing compound, sweep and use a high-pressure air spray.

B. Pavement Temperature and Condition

Apply dual component pavement markings to new AC and PCC pavement surfaces at least 30 calendar days after paving, and under the following conditions:

- On a dry roadway (no standing water or significant dampness)
- At a pavement surface temperature of at least 40 °F [4.4 °C] and rising; and
- At wind chill temperature of at least 35 °F [1.7 °C].

Measure the pavement surface temperatures 30 min before beginning striping installation. If critical temperatures exist, as determined by the Resident Engineer, measure the pavement surface temperature every 1 hr to 2 hr, or at shorter intervals as directed by the Resident Engineer, until the end of the day. Measure the pavement surface temperature with a standard surface temperature or infrared non-contact thermometer.

C. Application

Apply large glass beads at a coverage rate of at least 8 lb per 100 ft² [3.6 kg per 10 m²] before applying standard beads. Apply standard glass beads at a coverage rate of at least 8 lb per 100 ft² [3.6 kg per 10 m²]. For hand-machine applied markings, apply a single drop of standard glass beads at a coverage rate of at least 8 lb per 100 ft² [3.6 kg per 10 m²].

Alternatively, apply a non-reflectorized contrast marking, of the same dimensions as the white skip lines shown on the Plans, immediately after each upstream white skip line.

D. Performance Period

Ensure markings and replacement markings meet the Contract requirements for at least 30 calendar days. Within 30 calendar days of notification by the Resident Engineer, remove and replace non-compliant pavement markings at no additional cost to the Department.

E. Retroreflectivity

Measure stripes with a portable reflectometer that uses 30 m geometry in accordance with ASTM E 1710 and the manufacturer recommendations. Ensure the manufacturer calibrates the reflectometer annually. Keep the annual calibration certification with the reflectometer.

(1) Minimum Retroreflectivity

Ensure longitudinal markings on PCC pavement surfaces meet the minimum retroreflectivity values in accordance with Table 856:6:

(2) Measurement

Measure retroreflectivity of markings within 10 calendar days of placement, after removing loose beads. Take the reading at least 72 hr after application to allow the binder to cure.

Measure marking retroreflectivity in the direction of traffic, except the Department will allow yellow skip stripes to be measured in either direction of travel. One measurement (multiple readings) will represent each 2,500 ft [762 m] lot of single-color longitudinal stripe. The Department will not allow readings for adjacent lots to be taken closer than 1,000 ft [305 m] from each other.

For solid longitudinal stripes, one measurement represents the average of five readings per lot, taken at 3 ft [1 m] intervals along a randomly selected 15 ft [4.5 m] section of solid stripe.

For longitudinal skip stripes, one measurement represents the average of six readings per lot, two readings taken from each of three adjacent skip stripes. The Department will not allow readings taken within the first or last 1 ft [0.3 m] of skip stripes.

For non-compliant measurements, the Resident Engineer will require additional measurements to determine the extent of non-compliance.

The Department will not require measurements of the following:

- Stop-bars, crosswalks, gores, words, symbols;
- Longitudinal striping installed using hand line machines;
- County roads or city streets, unless otherwise required by the Contract; and
- Projects no greater than 1 mi [1.6 km] long.

Obtain the Resident Engineer's approval in writing before using a mobile retroreflectometer system as an alternative measurement method.

(3)Acceptance

Submit final retroreflectivity measurements to the Resident Engineer for acceptance. Include the date and time of reflectometer calibration, location (GPS coordinates), line color, and date of each measurement. The Department will consider unmeasured stripes non-compliant. The Resident Engineer will provide notification of non-compliance with the minimum retroreflectivity values. Remove and replace non-compliant stripe sections at no additional cost to the Department.

For quality assurance, the Department will measure retroreflectivity with a Delta Light & Optics, Model LTL X portable reflectometer. If the Department and the Contractor measurements differ by greater than 10 percent, the Department will use its measurements for acceptance.

The Resident Engineer may accept striping quantities less than 2,500 ft [762 m] by visual inspection.

Table 856:6
Minimum Retroreflectivity

White		Yellow	
mcd/m²/lx	**Pay Adjustment**	**mcd/m²/lx**	**Pay Adjustment**
≥400	100%	≥250	100%
350 – 399	75%	225 – 249	75%
200 – 349	50%	175 – 224	50%
<200	Remove and replace	<175	Remove and replace

856.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of traffic stripe using a 4 in [100 mm] standard width. For traffic stripes narrower or wider than 4 in [100 mm], the Resident Engineer will make a proportional adjustment based on the 4 in [100 mm] standard width.

The Resident Engineer will count arrows by each head.

856.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) TRAFFIC STRIPE (MULTI-POLYMER) (4" WIDE)	Linear Foot [Meter]
(A) TRAFFIC STRIPE (MULTI-POLYMER) (6" WIDE)	Linear Foot [Meter]
(A) TRAFFIC STRIPE (MULTI-POLYMER) (8" WIDE)	Linear Foot [Meter]

Pay Item:	**Pay Unit:**
(A) TRAFFIC STRIPE (MULTI-POLYMER) (24" WIDE)	Linear Foot [Meter]
(B) TRAFFIC STRIPE (MULTI-POLYMER) (SYMBOLS, WORDS, ETC.)	Each

The Department will consider the cost of preparing the pavement surface and retroreflectivity measurements (including the measurement submittals) to be included in the contract unit price for the relevant pay item.

The Department will pay for the replacement of pavement markings damaged by snow and ice removal.

The Department will pay for stripe removal in accordance with Section 857, “Construction Zone Pavement Markings.”

SECTION 857
CONSTRUCTION ZONE PAVEMENT MARKINGS

857.01 DESCRIPTION

This work consists of providing and placing pavement markings on detours and roadways accessed by traffic during construction.

857.02 MATERIALS

Provide paint, removable pavement marking tape, or other construction zone pavement marking material as shown on the Plans, or as directed by the Resident Engineer.

Provide traffic stripe materials in accordance with Section 711, “Traffic Stripe.”

857.03 EQUIPMENT

Apply pavement markings in accordance with the manufacturer’s recommendations. Use a paint machine and a bead dispenser in accordance with Subsection 854.03, “Equipment,” to apply the painted construction traffic stripe.

Use equipment for removing pavement markings that will not damage the pavement surface or pavement material texture.

857.04 CONSTRUCTION METHODS

A. General

Install removable pavement marking tape and pavement markings in accordance with the manufacturer’s recommendations, or as approved by the Resident Engineer. At the time of marking application, ensure a dry pavement surface, an atmospheric temperature above 50 °F [10 °C], and a wind chill factor above 40 °F [4 °C]. Remove dirt, debris, loose particles, curing compound, and heavy oil residues from the road surface application areas immediately before installing pavement markings.

Ensure uniform and visible removable pavement marking tape and pavement markers for traffic control. Correct pavement markings not uniform or clearly visible as approved by the Resident Engineer, at no additional cost to the Department.

B. Detours

Complete pavement markings on detours, including lane and edge lines, before opening the detour to traffic. If the Resident Engineer directs maintenance, restoration of pavement markers, or re-striping of detours, begin these operations within 24 hr of notification from the Resident Engineer; weather permitting.

C. Stage Construction

When resurfacing roadways in successive stages, place pavement markings before opening the new roadway stage to traffic as shown on the Plans or as directed by the Resident Engineer.

D. Removal

If detour or permanent pavement markings conflict with the permanent pavement markings of the next traffic control phase, remove as approved by the Resident Engineer before switching traffic. Place temporary pavement markings before removing existing markings from roadways open to traffic. Remove temporary pavement markings before installing final striping.

When additional pavement marking is necessary due to overlays, redirection of traffic, restoration, or Resident Engineer direction, start the striping operation within 24 hr of notification from the Resident Engineer.

Remove the removable pavement marking and adhesive, as directed by the Resident Engineer. Install additional pavement markings according to traffic conditions, as approved by the Resident Engineer. Immediately dispose of removed pavement marking tape and pavement markers.

Remove pavement markings without damaging the pavement surface or pavement material texture.

The Department will not allow painting over or blotting out the existing pavement markings. When the removal operation deposits sand or other material on the pavement, remove as the work progresses. If blast cleaning within 10 ft [3 m] of a lane carrying traffic, remove the residue immediately using a vacuum attachment operated concurrently with the blast cleaning operation, or other methods approved by the Resident Engineer.

Repair pavement damage as directed by the Resident Engineer at no additional cost to the Department.

857.05 METHOD OF MEASUREMENT

The Resident Engineer will measure the length of stripes and each unit of arrows and words.

857.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) CONSTRUCTION TRAFFIC STRIPE (PAINT)	Linear Foot [Meter]
(B) CONSTRUCTION TRAFFIC STRIPE (PAINT) (ARROWS, WORDS, SYMBOLS)	Each
(C) REMOVABLE PAVEMENT MARKING TAPE	Each or Linear Foot [Meter]
(D) NON-REMOVABLE PAVEMENT MARKING TAPE	Each or Linear Foot [Meter]
(E) CONSTRUCTION ZONE PAVEMENT MARKERS	Each
(F) PAVEMENT MARKING REMOVAL	Each or Linear Foot [Meter]

The Department will consider the cost of restoring pavement markers, re-striping, and maintaining pavement markings to be included in the contract unit price for the relevant pay items.

The Department will consider the cost of placement and removal of removable pavement marking tape and construction zone pavement markers to be included in the contract unit price for *Removable Pavement Marking Tape* and *Construction Zone Pavement Markers*.

SECTION 858
PAVEMENT MARKERS

858.01 DESCRIPTION

This work consists of providing and installing pavement markers.

858.02 MATERIALS

Provide materials in accordance with Section 736, “Pavement Markers.”

Provide retro-reflective markers with neutral or colored marker bodies that match the reflector face.

For bi-directional markers, ensure the marker body color is neutral or split to match the reflective face. Provide pavement markers in accordance with the color codes specified in Table 858:1:

Table 858:1
Pavement Markers Color Code

Class	Color Code
A	Crystal/Crystal
B	Amber
C	Crystal/Red
D	Amber/Amber

For Class C markers, provide reflector units affixed to the castings with an adhesive material molded to the reflective unit as an integral part.

Provide marker housing colors matching the existing traffic stripe colors.

858.03 EQUIPMENT

Use equipment to mix and apply epoxy resin adhesive in accordance with AASHTO M 237.

858.04 CONSTRUCTION METHODS

Ensure the marker attachment areas on the highway surface are free of material that may affect the adhesion of the marker to the pavement surface. For markers on PCC pavement, sand blast or wire buff the marker attachment area immediately before placing the maker. Immediately before attaching the reflector unit, apply a coat of primer from the same manufacturer to the casting at the reflector unit attachment point.

Follow the installation procedure recommended by the marker manufacturer. Affix the markers to the highway surface ensuring traffic does not displace markers.

Correct pavement markers that are not uniform or clearly visible (day or night), as directed by the Resident Engineer, at no additional cost to the Department.

Place retro-reflective pavement markers at the locations shown on the Plans. Ensure the color of reflected light as shown on the Plans or as directed by the Resident Engineer.

For roadways open to public travel during work, operate the equipment and store materials and supplies to minimize hazards or inconveniences to the traveling public.

Repair pavement or facilities damaged by equipment operation at no additional cost to the Department.

858.05 METHOD OF MEASUREMENT

The Resident Engineer will measure *Pavement Markers* separately by counting individual marker classes and types.

The Resident Engineer will divide pavement markers into classes and types for measurement and payment in accordance with Table 858:2:

Table 858:2
Pavement Marker Classes

Class A Retroflective		Class B Non-Retroreflective Ceramic	Class C Retroreflective, All Weather	
Type	**Direction**	**Type**	**Type**	**Direction**
Type 1	Mono-directional	Yellow	Type 1	Mono-directional
Type 2	Bi-directional	White	Type 2	Bi-directional

858.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) PAVEMENT MARKERS	Each
(B) REMOVE AND RESET PAVEMENT MARKERS	Each

SECTION 870
SAND-FILLED IMPACT ATTENUATION MODULES

870.01 DESCRIPTION

This work consists of providing and placing sand-filled impact attenuation modules.

Module. One free-standing, frangible unit within the impact attenuation system.

870.02 MATERIALS

A. General

Provide sand-filled impact attenuation modules that meet the test requirements, procedures, and results in accordance with NCHRP 350 report Test Level III approved by the FHWA.

Ensure each module consists of a barrel, a lid, and sand material. Provide high density thermoplastic (polyethylene or polypropylene) barrels and lids that shatter on impact.

Provide modules designed to distribute the sand mass without spontaneous rupture of the outer container or collapse of the inner core.

Provide a yellow outer container, unless otherwise shown on the Plans, in accordance with the standard highway color code requirement in the MUTCD.

As a replacement supply, provide the number of additional modules of each capacity as shown on the Plans. These unassembled modules will become the property of the Department. Deliver to the nearest Department warehouse approved by the Resident Engineer.

B. Barrels

Provide yellow barrels molded in one or multiple parts that resist ultraviolet (UV) weathering degradation. Provide barrels capable of supporting and containing 200 lb [90 kg], 400 lb [180 kg], 700 lb [320 kg], 1,400 lb [640 kg], and 2,100 lb [960 kg] of sand at the heights required by the Contract without leaking.

C. Lids

Provide a polyethylene lid from ⅛ in to ⅜ in [3 mm to 9 mm] thick that resists deterioration from UV rays. Ensure the lid clamps or press-fits over the outer container to seal the module.

D. Sand

Ensure the sand mass and sieve analysis for each module meets the manufacturer's recommendations and contains no greater than 2 percent moisture by dry weight of the aggregate at the time of placement.

E. Certification

For each lot or module shipment, submit to the Resident Engineer a Type D Certification in accordance with Subsection 106.04, "Material Certifications."

870.03 EQUIPMENT — VACANT

870.04 CONSTRUCTION METHODS

Place the modules in the configuration for each location as shown on the Plans. Paint the outline of the base of each module on the surface of the pavement or apron. Within the outline, paint the weight of the sand mixture for each module using 4 in [100 mm] high numbers.

To prevent modules on sloped surfaces greater than 5 percent from moving or overturning, attach a half-ring block or other leveling device to the pavement or apron surface under the module.

While placing each module in the final position, fill within 10 lb [4.5 kg] of the sand mass required by the Contract. Fill the module with sand to the heights required by the Contract.

After filling the module, place and fit the lid. For non-self-securing lids, drill four holes, with ¼ in [7 mm] diameters, through the perimeter of the lid and outer container at equidistant points around the module perimeter. Secure the lid with four pop rivets.

870.05 METHOD OF MEASUREMENT

A. Permanent Installations

Provide new materials. The Resident Engineer will measure modules, including component parts, by the unit as shown on the Plans. The Resident Engineer will measure delivered replacement modules by the unit as shown on the Plans.

B. Temporary Installations

For modules temporarily used in construction work zones, the Resident Engineer will not measure the installed replacement modules.

Maintain enough sand-filled replacement modules to provide replacement of 35 percent of the total modules in use on the Project.

Upon Project completion, retain ownership of sand-filled impact attenuation modules used for temporary installations, unless otherwise shown on the Plans.

C. Removal of Existing Installations

Remove and dispose of existing modules not used during construction or not remaining in place after Project completion.

870.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) SANDFILLED IMPACT ATTENUATION MODULE	Each or Sign Day
(B) REPLACEMENT IMPACT ATTENUATION MODULE	Each
(C) REMOVAL OF EXISTING IMPACT ATTENUATION MODULE	Each

The Department will consider the cost of sand and paint to be included in the contract unit price for *Sandfilled Impact Attenuation Module*.

The Department will consider the cost of maintaining replacement modules in stock to be included in the contract unit price for *Sandfilled Impact Attenuation Module*.

SECTION 876
TRUCK MOUNTED IMPACT ATTENUATORS

876.01 DESCRIPTION

The work consists of providing, installing, operating, maintaining, and relocating truck-mounted impact attenuators. This work also consists of providing, stockpiling, and moving repair packages.

876.02 MATERIALS

Provide truck-mounted impact attenuators with the following components:

- Crushable cartridge encased in a shell,
- Backup and support assembly to attach the backup to the truck, and
- Truck with a gross vehicle weight from 15,000 lb to 35,000 lb [6,800 kg to 15,800 kg].

Provide a truck chassis to mount the impact attenuator with a clearance from 11 in to 13 in [280 mm to 330 mm] between the bottom of the shell and the roadway.

Provide truck-mounted attenuators in accordance with the test requirements, procedures, and results in NCHRP 350 report Test Level III approved by the FHWA. Submit certified test results meeting the test and performance criteria in accordance with NCHRP 350.

Provide the truck-mounted impact attenuator cartridge with a standard trailer lighting system. Provide a 90° tilt system with a mechanical locking device to secure the truck-mounted attenuator cartridge in the 90° position.

876.03 EQUIPMENT — VACANT

876.04 CONSTRUCTION METHODS

Do not park truck-mounted impact attenuators against rigid objects, except as a temporary safety measure until installation of a permanent crash attenuator. Use this method for no longer than 72 hr or as shown on the Plans.

Install the attenuator on the truck in accordance with the manufacturer's recommendations. During truck-mounted attenuator operations, stockpile the truck-mounted impact attenuator replacement packages on the project or at another local site approved by the Resident Engineer. If repairing the truck-mounted impact attenuator, ensure traffic safety through the construction area or suspend construction activities.

Immediately repair or replace damaged truck-mounted attenuators.

876.05 METHOD OF MEASUREMENT — VACANT

The Resident Engineer will measure *Truck-Mounted Attenuator* by the maximum number in use at any one time during the Project.

876.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) TRUCK MOUNTED ATTENUATOR	Each or Sign Day
(B) TRUCK MOUNTED IMPACT ATTEN. REPLACEMENT PACKAGE	Each

The Department assumes ownership of *Truck-Mounted Attenuators*, paid for on an each basis.

The Contractor retains ownership of *Truck-Mounted Attenuators*, paid for on a sign day basis, unless otherwise shown on the Plans.

SECTION 877
PORTABLE LONGITUDINAL BARRIER

877.01 DESCRIPTION

This work consists of providing, placing, and relocating portable longitudinal barriers.

877.02 MATERIALS

Provide materials in accordance with the following sections:

Material:	Section:
Portland Cement Concrete, Class A	701
White Concrete	701.14
Reinforcing Steel	723

Provide portable longitudinal barriers in accordance with the current test requirements, procedures, and results in NCHRP 350 report Test Level III, approved by FHWA. Submit certified test results meeting the test and performance criteria in accordance with NCHRP 350 guidelines.

Submit alternative designs for approval by the Resident Engineer before starting the manufacture of barriers. The Resident Engineer will consider alternative and special design features influencing the casting of a section, and attachments or holes that facilitate the handling and lifting of a section. Ensure alternative designs meet the exterior dimensions as shown on the Plans.

877.03 EQUIPMENT

Use a transfer and transport vehicle for placing, resetting, and removing the portable longitudinal barriers on the Project as required by the Contract.

877.04 CONSTRUCTION METHODS

Before casting the portable longitudinal barrier, notify the Resident Engineer of the casting site and start date. Mix, place, finish, and cure the longitudinal barriers in accordance with Subsection 627.04, "Construction Methods."

Submit written certification indicating barrier fabrication in accordance with the Specifications before delivering portable longitudinal barriers to the Project.

Prevent damage to longitudinal barrier sections and hinges during fabrication, storage, handling, and placement. Repair minor chipping, spalling, and scars as directed by the Resident Engineer. Make repairs or replace damaged sections and hinges at no additional cost to the Department.

Finish surfaces supporting the portable longitudinal barrier units to provide a full and uniform bearing over the entire bearing area. Correct bearing defects as approved by the Resident Engineer. Connect or join units as shown on the Plans. Align joint units horizontally and vertically to present a uniform appearance.

When the Project no longer requires portable longitudinal barriers to protect the work site or traveling public, remove the barriers and hardware from the Project and deliver to the Department storage facility shown on the Plans, or otherwise to the Contractor's yard. At the storage facility, stockpile the barrier sections and store hardware in sturdy containers marked for future use.

877.05 METHOD OF MEASUREMENT — VACANT

877.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) PORTABLE LONGITUDINAL BARRIER	Linear Foot [Meter]
(B) DELIVER PORTABLE LONGITUDINAL BARRIER	Linear Foot [Meter]
(C) RELOCATION OF PORT. LONGITUDINAL BARRIER	Linear Foot [Meter]

The Department will consider the cost of purchasing and delivering new barrier to the Project in the contract unit price for *Portable Longitudinal Barrier*. The Department will pay for *Portable Longitudinal Barrier* on its first functional use, on its storage as shown on the Plans, or on its storage directed by the Resident Engineer. After installation of the portable longitudinal barrier in its first functional location, the Department will own the barrier.

The Department will pay for other moves of the new barrier in accordance with *Deliver Portable Longitudinal Barrier* or *Relocation of Portable Longitudinal Barrier*.

The Department will pay (80 percent of the contract unit price) for *Deliver Portable Longitudinal Barrier* upon delivery and placement of the Contractor-owned portable longitudinal barrier to the project in its first functional location, as shown on the Plans. The Department will pay the final installment (20 percent of the contract unit price) for *Deliver Portable Longitudinal Barrier* after removal of the barrier from its last functional location on the Project.

For *Relocation of Portable Longitudinal Barrier*, the Department will pay the Contract unit price after the barrier is moved from one functional location to another functional location on the Project, as shown on the Plans. The Department will pay the last payment for *Relocation of Portable Longitudinal Barrier* when the barrier is moved to its last functional location.

SECTION 878
MODULAR GLARE SCREEN

878.01 DESCRIPTION

This work consists of providing and installing modular glare screen units on concrete median barriers.

878.02 MATERIALS

Provide 10 ft [3 m] long modular glare screen units with glare screen blades, a flexible base rail, mounting brackets with hardware, and an anchor bolt system.

Provide modular glare screen blades and base rail manufactured from frangible or flexible light-weight material. Provide modular glare screen in accordance with Table 878:1:

Table 878:1
Modular Glare Screen Blade Properties

Property	Measurement
Weight	≤0.9 lb/ft [1.30 kg/m]
Width	4½ in – 6 in [115 mm – 150 mm]
Specific gravity	0.90 – 1.70
Tensile strength	≥2,900 psi [20,000 kPa]

Provide green modular glare screen blades similar to Federal Standard Number 595-34227.

A. Base Rail

Provide base rail in accordance with Table 878:2:

Table 878:2
Base Rail Properties

Property	Measurement
Weight	≤1.4 lb/ft [2.00 kg/m]
Width	4½ in [115 mm] – 6 in [150 mm]
Rail tensile strength	≥2,900 psi [20,000 kPa]

B. Weatherability

Provide glare screen blades and base rails that retain mechanical properties from −40 °F to 150 °F [−40 °C to 65 °C] and show minimum degradation after 3,000 hr in a weatherometer.

C. Certification

Submit to the Resident Engineer a Type D materials certification in accordance with Section 106.04, “Material Certifications.”

878.03 EQUIPMENT — VACANT

878.04 CONSTRUCTION METHODS

Install unit component parts as shown on the Plans and in accordance with the manufacturer's recommendations.

Fasten each base rail section to the barrier wall in at least three locations. Ensure the connections have a pullout strength of at least 2,900 psi [20,000 kPa] and a shear strength of at least 2,900 psi [20,000 kPa].

878.05 METHOD OF MEASUREMENT — VACANT

878.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) MODULAR GLARE SCREEN (PERMANENT)	Each or Linear Foot [Meter]
(B) MODULAR GLARE SCREEN (TEMPORARY)	Sign Day

SECTION 880
CONSTRUCTION SIGNING AND TRAFFIC CONTROL

880.01 DESCRIPTION

This work consists of providing and erecting signs, lights, barricades, and other devices.

880.02 MATERIALS

A. General

Provide materials for construction signing and traffic control in accordance with NCHRP 350 report Test Level III, approved by FHWA.

B. Construction Signing and Traffic Control Materials

(1) Arrow Display

Provide each arrow display with a circuitry control unit, a mounting frame, and a sign panel with yellow sealed beam lamps attached in accordance with MUTCD Section 6F-3.

Provide non-reflective black finish for panel faces exposed to oncoming traffic.

Provide a control unit to display higher intensity during the day and lower intensity at night. Ensure lamps display the same light intensity for a given setting. The Department will only allow the substitution of larger panels for smaller panels.

Provide a mounting frame to support the sign panel so the bottom edge of the panel is at least 7 ft [2.1 m] above the roadway surface when displayed to

oncoming traffic. Mount arrow displays so the panel rotates on a horizontal axis to hide it from the view of oncoming traffic when not in use. Mount mobile arrow displays on pneumatic-tired vehicles.

Provide a power source with a separate auxiliary power source that can be immediately available to operate flashing lights. Provide a self-contained battery or electric generator power source on mobile arrow displays.

Provide arrow displays with a solid-state electronic circuitry control unit with four modes that contain switching controls for operator selection in accordance with Table 880:1:

Table 880:1
Arrow Display Controls

Mode	Display
Pass Right	Flashing arrow
Pass Left	Flashing arrow
Pass either side	The apex of the outermost chevrons point to the nearest panel edge
Caution	At least four lamps in a pattern not indicating a direction

(2) Construction Signs and Barricades

Provide metal, wood, or plastic supports and sign blanks. Provide two supporting legs for each sign 10 ft² [1 m²] or larger. Provide wide-angle flat-top retroreflective sheeting for signs and barricades in accordance with Type IV-A sheeting, unless otherwise shown on the Plans.

Construct sign messages and symbols in accordance with MUTCD and as shown on the Plans.

Mark and immediately replace construction signs not in accordance with Subsection 719.04, “Retroreflective Sheeting.”

(3) Construction Signs 32.3 ft² [3 m²] and Larger

Provide aluminum or galvanized steel to construct signs. If ground mounting, provide and install breakaway signs in accordance with GMS-1, FGS-1, FGS-2, and SPA-1. The Resident Engineer will approve installation locations before construction begins. The Department will not require reinforcing steel in the sign footings. Place signs on existing overhead signs if shown on the Plans.

Retroreflectorize signs as required by the Contract. Provide signs of the designs and colors shown on the Plans.

(4) Vertical Panels

Provide vertical panels in accordance with MUTCD Section 6F-5. Place Type IV-A reflectorized sheeting on both sides of each vertical panel.

(5) Warning Lights

Provide warning lights in accordance with MUTCD Section 6F-7OF.

(6) Cones

Provide cones in accordance with MUTCD Section 6F-5.

(7)Surveillance of Traffic Control

Provide an ATSSA or Department-certified observer to maintain traffic control devices in position for work zones at the construction site 24 hr a day, seven days a week when traffic is directed away from the normal traffic lanes or when directed by the Resident Engineer. Provide the observer with a cell phone.

(8)Traffic Surveillance, Police

Make arrangements through the Oklahoma Highway Patrol, Chief's office to provide one officially marked Oklahoma Highway Patrol car and one law enforcement officer capable of issuing traffic citations. Ensure the Oklahoma Highway Patrol insures, licenses, bonds, and approves the officer for this work. Ensure the duty hours of the officer and vehicle match the Contractor's working hours.

(9)Flagger

If required by the Contract, provide two flaggers per sign day. Provide lighting to illuminate the flagger stations at night.

(10)Plastic Drums

Provide two-piece breakaway drums in accordance with the MUTCD. Obtain a "Certificate of Crashworthiness" from the manufacturer, stating that the drums, with conventional barricade warning lights, are in accordance with the NCHRP 350, Category I device requirements. Use the drums as channelizing devices for construction and maintenance operations.

Provide plastic drums at least 36 in [900 mm] high and at least 18 in [450 mm] wide. Ensure the upper body of the un-reflectorized drum weighs at least 9.5 lb [4.31 kg] and the base weighs at least 40 lb [18.14 kg].

Provide drums constructed of impact resistant, low density polyethylene with a density of 0.925 and a melt index of 0.3. Provide bright orange polyethylene that resists color fading. Ensure the material will maintain structural integrity in temperatures from -58 °F to 120 °F [14 °C to 50 °C]. Ensure sheeting surfaces are 100 percent flame treated to maximize adhesion of reflective sheeting to the drum body.

Provide weather tight drums designed to accept horizontal, circumferential bands of reflectorized sheeting, 4 in to 6 in [100 mm to 150 mm] wide. Provide drums with a D-shaped configuration at the base attachment point to minimize rolling after impact. Provide drums with enclosed tops and drains to prevent water accumulation. Ensure that stacking the drums will not damage the reflective surface. Ensure each drum allows the attachment of two Type A or Type C conventional barricade warning lights. Provide warning lights capable of remaining attached during repeated impacts at speeds of at least 55 mph [88 km/h] and in accordance with NCHRP 350.

Provide drum base sections with the following characteristics:

- No taller than 4 in [100 mm];
- An integral component of the plastic drum;
- At least 45 percent post consumer or post industrial rubber;
- 40 lb [18 kg];

- A vertical profile no greater than 3 in [75 mm];
- Attachable and detachable by one person without tools; and
- Capable of withstanding 60 mph [100 km/h] winds, turbulence created by vehicles, and repeated movements during construction and maintenance operations.

Ensure the top portion of the unit deforms and breaks away from the base and ballast upon vehicular impact. Ensure the ballast remains in place, allowing the vehicle to pass over it.

Drums shall have alternating fluorescent orange and white horizontal circumferential stripes of retro-reflectorized sheeting. There shall be a minimum of two fluorescent orange and two white stripes beginning with a fluorescent orange stripe at the top of the drum. If there are non-reflectorized spaces between the horizontal orange and white stripes, they shall be no more than 2 in [50 mm] wide. All non-reflectorized portions of the drum shall be orange.

Reflective sheeting shall meet the requirements of the latest ASTM D4956 for Type X Reboundable sheeting.

(11)Tube Channelizers

Provide orange tube channelizers, at least 27 in [700 mm] high and at least 2 in [50 mm] wide when facing traffic. Ensure the channelizers do not damage vehicles upon impact.

For nighttime use, equip each tube channelizer with two 3 in [75 mm] wide white bands with retroreflectivity at least that of Type IV sheeting. Place the white bands no greater than 2 in [50 mm] from the top of the tube and no greater than 6 in [150 mm] apart.

(12)Sampling and Testing

Submit to the Resident Engineer a Type D certification in accordance with Subsection 106.04, “Materials Certifications.”

880.03 EQUIPMENT — VACANT

880.04 CONSTRUCTION METHODS

Perform construction traffic control as directed by the Resident Engineer in accordance with MUTCD Chapter VI and as shown on the Plans.

Place signs, lights, and barricades on portable or fixed supports as required by the Contract.

Monitor and maintain the condition of devices. Immediately replace damaged signs or devices as directed by the Resident Engineer. If directed by the Resident Engineer, clean the sign or device.

Coordinate with Department personnel to conduct nighttime traffic control device reviews at the beginning of the Project, in conjunction with major changes to traffic signing, and at monthly intervals. Record the date and result of the nighttime inspection in the contractor signing log.

Immediately remove or cover unnecessary traffic control devices as approved by the Resident Engineer.

Light the flagger stations at night and ensure the lighting does not impede the vision of passing drivers.

The Resident Engineer will give written notice of unacceptable conditions to facilitate prompt maintenance and changes in construction traffic control devices. Correct the specified devices within 24 hr of notice.

Continue providing construction traffic control and maintain the log of devices until completion and acceptance at no additional cost to the Department.

880.05 METHOD OF MEASUREMENT

A. Per Pay Item

If Plans show itemized pay items for construction traffic control devices, the Resident Engineer will measure each device used for construction traffic control per calendar day. For non-working periods, the Resident Engineer will use the sign log from the previous and successive working days to measure payment for devices. The Resident Engineer will measure one calendar day for devices used at multiple locations in one day.

Maintain a log of devices used for construction traffic control per calendar day. Update the log daily throughout the project to confirm the addition or deletion of individual devices. Submit the log to the Resident Engineer before each pay period.

The Department will not allow unnecessary devices to remain in place for more than 5 days unless covered as directed by the Resident Engineer. The Resident Engineer will not measure unnecessary devices left in place. After 5 calendar days, the Resident Engineer will deduct the contract unit price of the relevant pay item every day the unnecessary device remains in place and uncovered. If an unnecessary device remains in place and uncovered for more than 30 calendar days, the device will become the property of the Department.

B. Lump Sum Item

If additional days are necessary, the Resident Engineer will calculate a daily rate by dividing the lump sum contract unit price for *Construction Traffic Control* by the number of calendar days in the contract time. The Resident Engineer will calculate the additional compensation by multiplying the daily rate by the number of additional days.

If the Contractor fails to make corrections to devices as directed by the Resident Engineer within 24 hr, the Resident Engineer will assess a daily charge equal to half of the daily rate calculated in the previous paragraph. The Resident Engineer may assess the daily charge for each additional 24 hr until the devices are corrected. The Department will deduct this amount, as a non-recoverable charge, from the next progress payment.

880.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) ARROW DISPLAY (TYPE)	Sign Day
(B) CONSTRUCTION SIGNS (SIZE)	Sign Day

Pay Item:	**Pay Unit:**
(C) CONSTRUCTION BARRICADES	Sign Day
(D) VERTICAL PANELS	Sign Day
(E) WARNING LIGHTS (TYPE)	Sign Day
(F) DRUMS	Sign Day
(G) TUBE CHANNELIZERS	Sign Day
(H) CONES (SIZE)	Sign Day
(I) FLAGGER	Sign Day
(J) CONSTRUCTION TRAFFIC CONTROL	Lump Sum
(K) SURVEILLANCE OF TRAFFIC CONTROL	Sign Day
(L) TRAFFIC SURVEILLANCE, POLICE	Hour

If the Contract includes a lump sum pay item for *Construction Traffic Control*, the Department will consider the cost of installing and removing all construction traffic control to be included in the contract unit price for *Construction Traffic Control*. The Department will pay for *Construction Traffic Control* as a percentage equal to the project percent complete. The Department will pay for amounts of *Construction Traffic Control* remaining on the date of completion in the next estimate.

The Department will pay for *Surveillance of Traffic Control*, *Traffic Surveillance, Police,* and *Arrow Display* separate from the other construction traffic control pay items.

If the Resident Engineer requires additional signing for safety, differing site conditions which require additional work and calendar days, or uncontrollable third party delays that require the extension of contract time, the Department will pay for such by prorating the price bid for lump sum traffic control. The amount determined by multiplying the rate per day for construction traffic control by the number of additional days allowed by the Resident Engineer will be the amount added by change order, and shall be full compensation for the additional work or third party delay.

Unless otherwise shown on the Plans or Special Provisions, construction traffic control devices remain the property of the Contractor upon project completion.

The Department will consider the cost of incidental items for detours and other traffic control systems to be included in the contract unit price for other relevant pay items.

The Department will consider the cost of providing two flaggers and lighting the flagger stations at night to be included in the contract unit price for *Flagger*.

The Department will not pay for construction traffic control for time extensions due to unusually severe weather.

The Department will not pay for devices on liquidated damage days.

If the Resident Engineer suspends contract time for public safety in accordance with Subsection 108.07, “Administration and Extension of Contract Time,” the Department will pay for construction traffic control during the period of suspension.

SECTION 882
CHANGEABLE MESSAGE SIGN

882.01 DESCRIPTION

This work consists of providing, maintaining, and using a trailer-mounted changeable message sign or remote-controlled changeable message sign.

882.02 MATERIALS

Provide an internally-illuminated variable-message sign including the following characteristics:

- A magnetically operated matrix, LED, fiber optic, or lamp matrix message board,
- A solar and battery power supply,
- Hardware for connection to a 110 V power source,
- An on-board computer, and
- A computer-operated interface.

Mount on a towable, heavy duty trailer.

Provide a sign capable of three lines of text or symbols, each with seven rows and 40 columns of LED pixel display elements. Provide solid state LEDs and LED energize/de-energize circuitry, directly embedded in the display element panel. Ensure each line consists of eight separate, interchangeable display element panels with seven rows and five columns of display elements. Provide display element panels with an evenly installed horizontal matrix, with 3 in between individual characters. Ensure each display element panel measures 18 in [457 mm] high by 13 in [330 mm] wide, with no separate driver boards required to drive the LEDs. Provide a separate wiring harness to power each LED pixel on the display element panels.

Provide sign display elements consisting of wide-angle LEDs that allow 30° legibility of the sign message. Ensure LEDs rated for at least a 100,000 hr life. Ensure the display elements operate at temperatures from −20 °F to 140 °F [−29 °C to 60 °C].

Ensure clear sign legibility from 1,000 ft [305 m].

Provide an onboard computer to control the sign. Ensure the sign automatically changes to a pre-selected default message upon failure, and it remains on display until the problem is corrected.

Equip the remote-controlled changeable message sign unit with a cellular telephone and a security system that prevents unauthorized sign access, but allows access through a password or code unique to that sign. If the password or code is not entered within 60 s of initial telephone contact, terminate the call. Control the remote-controlled changeable message sign with a touch tone modem decoder.

Provide a sign capable of storing up to 199 preprogrammed messages, and displaying any of the messages with a call through the trailer-mounted terminal for the changeable message signs and the remote-controlled changeable message signs. Ensure the sign retains the messages during power failure. Ensure sign operation if the sign keyboard controller is disconnected.

Provide a solar recharged battery pack as the primary power supply.

Provide a solar power supply consisting of solar cell modules installed in a rigid mount at the top of the sign case, and wired to the battery pack through a 30 A solar regulator. Ensure the solar regulator capable of 30 consecutive 24 hr days of operation, starting with a fully charged 12 V battery pack without sun under normal weather conditions. Include a temperature- compensated, voltage-regulated 110 V (AC) battery trickle charger, accessible from a standard plug-in convenience receptacle mounted in the side of the pedestal. Ensure a 110 V (AC) battery trickle charger capable of recharging the battery pack within 24 hr to 48 hr. Ensure the temperature-compensated voltage-regulated trickle charger automatically charges the batteries when 110 V (AC) is applied to the convenience receptacle. Do not require the operator to configure the charging system after plugging in the 110 V (AC) power source.

Provide four 12 V D-size batteries, deep cycle rated for solar power systems.

Ensure the lamp matrix, LED, or fiber optic sign equipped with a top-mounted photocell for automatic sign-dimming during night use.

Provide a trailer rated for 3,500 lb [1,588 kg] including an axle and springs rated for 3,500 lb [1,588 kg]. Ensure each trailer includes hydraulic surge brakes rated for 6,000 lb [2,722 kg], with a 2 in [50 mm] ball hitch.

Provide a trailer consisting of a frame and tongue constructed of square tube. Ensure the frame is at least 3 in by 3 in [76 mm by 76 mm] and $^{3}/_{16}$ in [4.8 mm] thick; and the tongue at least a 3 in by 3 in [76 mm by 76 mm] and ¼ in [6.4 mm] thick. Weld the tongue and trailer in accordance with AWS standards. Use ASTM 500 grade B alloy. Ensure the trailer is 196 in [4,978 mm] long by 79.5 in [2.019 mm] wide. Provide 15 in [381 mm], five lug wheels with holes for inserting a heavy chain to prevent vandalism. Provide size P205-75-15 rating B tires.

Provide the trailer with four leveling jacks, one at each corner, making the trailer and sign assembly capable of withstanding 104 mph [167 km/h] wind gusts.

882.03 EQUIPMENT — VACANT

882.04 CONSTRUCTION METHODS.

Provide, place, operate, maintain, and relocate the sign as shown on the Plans.

882.05 METHOD OF MEASUREMENT — VACANT

882.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	**Pay Unit:**
(A) CHANGEABLE MESSAGE SIGN	Each or Sign Day
(B) REMOTE CONTROLLED CHANGEABLE MESSAGE SIGN	Each or Sign Day

The Department will consider the cost of the cellular telephone and telephone charges required for the remote-controlled sign to be included in the contract unit price for *Remote-Controlled Changeable Message Sign*. The cellular phone will become the property of the Department.

If the Contract includes an each pay item for *Changeable Message Sign* or *Remote Controlled Changeable Message Sign*, the portable changeable message signs will become the property of the Department upon completion of the Project.

If the Contract includes a sign day pay item for *Changeable Message Sign* or *Remote Controlled Changeable Message Sign*, the portable changeable message signs will become the property of the Contractor upon completion of the Project.

The Department will consider the cost of providing, placing at a location approved by the Resident Engineer, maintaining, and operating one changeable message sign for 1 day to be included in the contract unit price for the relevant pay item.

SECTION 884
BRIDGE GUARDRAIL RETROFITS

884.01 DESCRIPTION

This work consists of providing and installing bridge guardrail retrofits.

884.02 MATERIALS

Provide materials in accordance with the following sections and subsections

Material:	Section or Subsection:
Portland Cement Concrete	701
Reinforcing Steel	723
Metal Guard Rail	732.01
Aluminum Alloy Tubes for Railings	732.03
Cast Aluminum Alloy Bridge Railing Post	732.03
Pipe Railing	732.04

884.03 EQUIPMENT — VACANT

884.04 CONSTRUCTION METHODS

Install bridge guardrail retrofits as shown on the Plans.

884.05 METHOD OF MEASUREMENT — VACANT

884.06 BASIS OF PAYMENT

The Department will pay for each pay item at the contract unit price per the specified pay unit as follows:

Pay Item:	Pay Unit:
(A) BRIDGE GUARDRAIL RETROFIT	Linear Foot [Meter]
(B) BRIDGE PARAPET RETROFIT	Linear Foot [Meter]
(C) REMOVE BRIDGE RAIL AND POSTS	Linear Foot [Meter]

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