Contract Number: 2016-260-07-06-YSS

Hidalgo County Precinct No.1

SPECIFICATIONS AND FORMS OF CONTRACT, BOND, AND PROPOSAL
FOR

Paving and Drainage Improvements for Colonia Noreste Subdivision

RECONSTRUCTION OF ROADWAY AND REGRADE OF ROADSIDE DITCHES
WITHIN COLONIA NORESTE SUBDIVISION.
HIDALGO COUNTY, TEXAS

THE COUNTY OF HIDALGO TEXAS

FILED
AT 1:00 O'CLOCK P M
AUG 30 2016
ARTURO GUAJARDO JR, COUNTY CLERK
HIDALGO COUNTY, TEXAS
BY _____ DEPUTY

Prepared for:

Hidalgo County Precinct 1

HIDALGO COUNTY OFFICIALS

RAMON GARCIA, COUNTY JUDGE
A.C. CUELLAR JR, COMMISSIONER, PCT 1
EDUARDO CANTU, COMMISSIONER, PCT 2
JOE M. FLORES, COMMISSIONER, PCT 3
JOSEPH PALACIOS, COMMISSIONER, PCT 4

Prepared by:

TEDSI INFRASTRUCTURE GROUP
TEDSI
TBPE Firm No. 1640
Consulting Engineers
1201 East Expressway 83 ♦ Mission, Texas 78572
Tel: (956) 424-7898
Fax: (956) 424-7022

PROJECT MANAGER: MARK D. CORBITT, P.E.

August 2016

TABLE OF CONTENTS

Description	Page	
TABLE OF CONTENTS	i	
NOTICE TO BIDDERS / REQUEST FOR BIDS	1	
BIDDER'S DOCUMENTS:		
INSTRUCTION TO BIDDERS	2 - 7	
BID PROPOSAL FORM	8 – 10	
BIDDER'S ACKNOWLEDGEMENT	11	
PROJECT REQUIREMENTS ACKNOWLEDGEMENT	12	
BID BOND FORM	13 - 14	
INSURANCE REQUIREMENTS ACKNOWLEDGEMENT	15	
NON-COLLUSION AFFIDAVIT OF PRIME BIDDER	16	
CONFLICT OF INTEREST QUESTIONNAIRE	17-18	
CONTRACT REQUIREMENTS:		
CONTRACT	19-20	
CONTRACT – PART I: CONTRACT AWARD FORMS AND CERTIFICATIONS	21	
I.1 NON-COLLUSION AFFIDAVIT OF CONTRACTOR	22	
I.2 PERFORMANCE BOND	23 -24	
I.3 PAYMENT BOND	25 -26	
I.4 CONTRACTOR'S CERTIFICATE OF INSURANCE	27	
I.5 SALES TAX AND LOCAL SALES TAX EXEMPTION CERTIFICATE	28	
I.6 AFFIDAVIT AND WAIVER OF LIEN – CONTRACTOR	29	
I.7 RELEASE AND WAIVER OF CLAIMS BY SUBCONTRACTORS AND PRODUCT VENDORS	30	
I.8 CONTRACTOR'S AFFIDAVIT AS TO STATUS OF LIEN	31	
I.9 WAGE RATES (GENERAL DECISION NUMBER: TX160008 01/08/2016)	32	32-1 thru 32-4
CONTRACT – PART II: GENERAL CONDITIONS	33	
II.1 STANDARD GENERAL CONDITIONS OF THE CONTRACT	34:	00700-1 thru 00700-47
II.2 SUPPLEMENTARY GENERAL CONDITIONS	35	
II.3 GOVERNING SPECIFICATIONS	36-38	
II.4 GENERAL NOTES	39	
CONTRACT – PART III: CONTRACT DRAWINGS	40	

REQUEST FOR SEALED BIDS
(RFB)

TO SUPPLY HIDALGO COUNTY with sealed bids for the following Construction Project:

Request for Sealed Bids (RFB)	2016-260-07-06-YSS	-HIDALGO COUNTY PRECINCT NO. 1- "Paving and Drainage Improvements for Colonia Noreste Subdivision"

PROCUREMENT PACKETS. Interested contractors may obtain bid packets at project engineer's office: TEDSI Infrastructure Group Inc., 1201 E Expressway 83, Mission, TX 78572, Ph. 956-424-7898 for the amount of **$100.00 each.** General and or Prime Contractors submitting bids and or proposals to the County of Hidalgo shall be **non-refundable**.
The PDF version of bid packets may be obtained via email may **at no cost** by emailing your request to the Project Engineer at the following address: dsolis@tedsi.com .

PRE-BID CONFERENCE is scheduled for **Wednesday, June 29, 2016 at 2:00 P.M.** at HIDALGO COUNTY PURCHASING DEPARTMENT CONFERENCE ROOM: -2802 S. Business Hwy 281, Edinburg, TX 78539

A BIDDER'S BOND from a reliable surety company licensed to operate in the State of Texas or certified Cashier's Check, payable without recourse to the County of Hidalgo, for the amount of not less than **5%** of the total bid shall accompany the bid as guaranty that, if awarded the contract, the bidder will enter into a contract with the County of Hidalgo. A Payment Bond is required in the amount of one hundred percent (100%) of the Contract Amount, if the contract exceeds $25,000. A Performance Bond is required in the amount of one hundred percent (100%) of the Contract Amount, if the contract exceeds $100,000.

UPON SUBMITTING SEALED BID, bidders are required to properly identify (handwritten, typed or printed) sealed envelope and or packet with Bidders' name and address on the upper left hand corner of the sealed envelope and or package, and **Bid No. and project name** on the lower left hand corner of sealed envelope and or packet. **OVERNIGHT MAIL MUST ALSO BE PROPERLY LABELED ON THE OUTSIDE OF EXPRESS ENVELOPE OR PACKAGE.**

The sealed bid must contain one (1) original and three (3) copies of bid and must be clearly identified and addressed for delivery to:

Martha L. Salazar, CPPB, Hidalgo County Purchasing Agent
Hidalgo County Purchasing Department

US Postal Mail Courier Address: Hidalgo County New Administration Building, 2812 S. Business Hwy 281, Edinburg, TX 78539
Physical Location: Hidalgo County New Administration Building, 2802 S. Business Hwy. 281 (Southeast of Canton Rd & Business Hwy 281) Edinburg, TX

BIDS ACCEPTANCE: Sealed bids will be accepted until **9:30 A.M. on Wednesday, July 06, 2016** at which time they will be opened in the Hidalgo County Purchasing Department Conference Room at **Physical Location: 2802 S. Business Hwy 281, Hidalgo County New Administration Building, Edinburg, Texas 78539.** NO FACSIMILES OR LATE ARRIVALS WILL BE ACCEPTED. ANY BID RECEIVED AFTER THAT TIME WILL NOT BE OPENED AND WILL BE RETURNED.

Attention is called to the fact that not less than, the most current federally determined prevailing **(Davis-Bacon and Related Acts)** wage rate, as issued and contained in the contract documents, must be paid on this project. In addition the successful bidder must ensure that employees and applicants for employment are not discriminated against because of race, color, religion, sex, age, disability or national origin.

BIDS MAY BE HELD by the County of Hidalgo for a period not to exceed ninety (90) days from the date of the opening of bids for the purpose of reviewing the bids and investigating the qualifications of bidders, prior to awarding of the contract.

Typed-written RFI's shall be sent to Engineer. Please follow with a call to confirm receipt of RFI. RFI's will not be answered by phone. NO HAND WRITTEN RFI'S will be answered. All inquiries shall be forwarded by **June 30, 2016 at 5:00pm.** Inquiries beyond this date will not be responded. Contact project engineer for copies of Addenda.

BY ORDER OF THE COMMISSIONERS COURT OF HIDALGO COUNTY, TEXAS ON THIS THE 14TH DAY OF JUNE, 2016.
MARTHA L. SALAZAR, CPPB
HIDALGO COUNTY PURCHASING AGENT

REPORT ROAD HAZARDS@ 1-866-HCR-SAFE OR 1-866-427-7233

INSTRUCTIONS TO BIDDERS

LEGAL NOTICE **BID NO: 2016-260-07-06-YSS**

1. Sealed bids will be received for **"PAVING AND DRAINAGE IMPROVEMENTS FOR COLONIA NORESTE SUBDIVISION"** in accordance with the specifications attached as Exhibit "A" hereto. Bids should address all specifications set forth. Bidders may suggest substitutions of features which they feel would be in the best interest of Hidalgo County. Strong rationale must be presented for any deviation from the specifications. Hidalgo County reserves the right to reject the deviation and its effect on the overall bid.

2. One (1) original and Three (3) copies of all bids are required with the bidders name and return address clearly typed/printed on upper left hand corner and the proper notation clearly typed/printed on the lower left hand corner of the envelope and/or package: **BID Number: 2016-260-07-06-YSS – PAVING AND DRAINAGE IMPROVEMENTS FOR COLONIA NORESTE SUBDIVISION** and in Hidalgo County Purchasing Department Office at 2802 S. Business Hwy 281, Edinburg, Texas **on or before 9:30 a.m. C.T., on Wednesday, July 6, 2016.** NO FACSIMILES OR LATE ARRIVALS WILL BE ACCEPTED. ANY RFB RECEIVED AFTER THAT TIME WILL NOT BE OPENED AND WILL BE RETURNED. OVERNIGHT MAIL MUST ALSO BE PROPERLY LABELED ON THE OUTSIDE OF EXPRESS ENVELOPE OR PACKAGE WITH REFERENCE TO BID NUMBER AND PROJECT NAME. Hidalgo County reserves the right to refuse and reject any/all RFB's and to waive any/all formalities or technicalities, or to accept the RFB considered the best and most advantageous to Hidalgo County.

3. **Hidalgo County** reserves the right to: **A.** separate and accept, or eliminate any item(s) listed under this bid that it deems necessary to accommodate budgetary and/or operational requirements; **B.** reject any or all bids submitted and further reserves the right to design the evaluation criteria to be used in selecting the lowest and best bid for approval; and **C.** award the bid to one bidder or to multiple bidders if the County determines it is in its best interest to do so."

4. The Bidder shall not substitute items named in the bid without the express written consent of Hidalgo County. Failure of the delivered item(s) to perform as specified, or failure to meet the stated delivery schedule shall release Hidalgo County from all obligations to the contracting party with regard to the item(s) in question. In such event, County may elect to award the contract to the next-lowest responsible bidder, or to reject all bids and re-advertise.

5. For work to be performed at a County owned or operated location, each bidder shall, in its sole discretion, visit the job site before preparing the bid and thoroughly familiarize himself/herself with existing conditions. Bidder should take field dimensions and note all circumstances which affect the dollar amount of the bid.

6. Descriptive specifications are referenced in this document to indicate the general kind

and quality of equipment desired by Hidalgo County. Due to various styles and models of equipment, bidders are required to include illustrations, specifications, explanation of warranties, and service data with their bid including catalogue numbers and any necessary references.

7. No bid may be withdrawn within thirty (30) days from the scheduled time to open bids.

8. Proposed prices are to remain firm for a minimum of ninety (90) days after bid opening.

9. Any interpretations, amendments, corrections or changes to this bid document must be in a written addendum and signed by the County or designee. Addenda will be mailed to all who are known to have received a copy of the Request for Bids. Bidders shall acknowledge receipt of all addenda as a part of their bid.

10. County reserves the right to accept or reject any or all bids.

11. Costs are to be net F.O.B., County Prepaid.

12. County is exempt from Federal Excise Tax, State Tax and Local Tax. Do not include tax in cost figure. If it is determined that tax was included in the cost figures it will not be included in the tabulation of any awards. Tax exemption certificates will be furnished upon request.

13. Funds for this procurement have been provided through the County budget for this fiscal year only. County, on an annual basis, has the right to reconsider a contract during the budget process for ensuing years if financial resources of County are insufficient to meet the liabilities of said contract. The award of a bid or contract hereunder will not be construed to create a debt of the County which is payable out of funds beyond the current fiscal year.

14. Upon award and prior to execution of a contract, Sole Proprietorships are required to submit a copy of their social security cards to the Hidalgo County in order to establish an account with the County. All awarded vendors must submit a completed W-9 and a copy o their Federal ID Number Certificate.

15. DELIVERY INSTRUCTIONS:
    - No deliveries accepted after 3:00 P.M., Monday-Friday.
    - At least seventy two (72) hours prior notice of delivery must be given to Martha Salazar.
    - If you need additional information call the office listed below:

Hidalgo County Purchasing Department
Martha L. Salazar, CPPB
(956) 318-2626

INSTRUCTIONS TO BIDDERS

16. BILLING AND PAYMENT INSTRUCTIONS:

. Invoices must include:

a) Name and address of successful bidder
b) Name and address of receiving department or official
c) Purchase Order Number (if any)
d) Notation - **"PAVING AND DRAINAGE IMPROVEMENTS FOR COLONIA NORESTE SUBDIVISION"** Descriptive information as to the items or services delivered, including product code, item number, quantity, etc.

. Discount payments will be considered when offered.

. Contact person for Billing and Payment questions:

Hidalgo County Purchasing Department
2802 S. Business Hwy 281
Edinburg TX 78539
Attn: Martha Salazar

17. Schedule of Events

Bid Opening, 9:30 AM C.T.	July 6, 2016
Award of Contract	_____, 2016
Commence Work or Deliver Products	_____, 2016

18. Bid or Performance Bond and Debarment Certification; Payment Under Contract:

. If the contract proposed is for the construction of public works or is for a contract for goods & services exceeding $100,000, all bidders shall furnish a good and sufficient bid bond in the amount of five percent of the total contract price. A bid bond must be executed with a surety company authorized to do business in Texas. All bidders are also required to furnish a certification or acknowledgment stating that the contractor or vendor is free from suspension or debarment pursuant to federal regulation 45CFR Part 76.

. Together with the signing of a contract or issuance of a purchase order following the acceptance of a bid, and prior to commencement of the actual work, the bidder shall furnish a performance bond to the County for the full amount of the contract, if that contract exceeds $50,000.

. If the contract is for $50,000 or less, no money will be paid to the contractor until completion and acceptance of the work or the fulfillment of the purchase obligation to the County, and, if applicable, the receipt by County of satisfactory evidence that all subcontractors and material men have been paid.

INSTRUCTIONS TO BIDDERS

. If a contract is for the construction, alteration or repair of public buildings or public works, the contractor *shall* provide a payment bond for a contract in excess of Twenty Five Thousand Dollars ($25,000.00), as required by Tex. Govt. Code Ch. 2253.

. For requirements contracts, bond requirements are determined by applying the proposed unit price to the estimated quantities included in the specifications.

19. Ethical Standards:

. It shall be a breach of ethics to offer, give or agree to give any elected official, department head or employee, or former elected official, department head or employee, of the County, or for any elected official, department head or employee or former elected official, department head or employee of the County, to solicit, demand, accept or agree to accept from another person, entity or organization, a gratuity or an offer of employment in connection with any decision, approval, disapproval, recommendation, preparation or any part of a program requirement or purchase request, influencing the content of any specification or procurement standard, rendering of advice, investigation, auditing, or in any other advisory capacity in any proceeding or application, request for ruling, determination, claim or controversy, or other particular matter pertaining to any program requirement or a contract or subcontract, or to any solicitation or proposal therefore pending before any department or agency of the County.

. It shall be a breach of ethics for any payment, gratuity or offer of employment to be made by or on behalf of a subcontractor under a contract to the prime contractor or higher tier subcontractor for any contract for the County, or any person associated therewith, as an inducement for the award of a subcontract or order.

. No public official shall have an interest in a contract awarded hereunder except in accordance with Tex. Loc. Govt. Code Chapter 171.

20. Disclosure of Conflict of Interest

. Effective January 1, 2006, Chapter 176 of the Texas Local Government Code requires that any vendor, person, consultant or contractor considering doing business with Hidalgo County to disclose in the Conflict of Interest Questionnaire (the "CIQ") attached as Exhibit D, the vendor, person, consultant or contractor's affiliation or business relationship that might cause a conflict of interest with the County. By law, the CIQ must be filed with the Hidalgo County Clerk's Office no later than the seventh business day after the date the person becomes aware of facts that require that statement to be filed. The disclosure requirement applies to

INSTRUCTIONS TO BIDDERS

a person or business who contracts or seeks to contract with Hidalgo County for the sale or purchase of property, goods or service. Any purchase order or contract resulting from this process shall be considered null and void if the successful bidder fails to comply with Texas Local Government Code Chapter 176. Vendors, consultants, contractors and others who desire to conduct business with Hidalgo County are encouraged to refer to Texas Local Government Code Chapter 176 for the details of this law. An offense under Texas Local Government Code Chapter 176 is a Class C Misdemeanor.

Please Submit completed CIQ forms to the Hidalgo County Clerk's Office located at 100 N. Closner, Edinburg, Texas 78539-Hidalgo County Courthouse **COMPLETION AND SUBMISSION OF FORM CIQ IS THE SOLE RESPONSIBILITY OF THE PROSPECTIVE BIDDER.**

21. If, during the life of any contract or bid awarded, the successful bidder's net prices generally available to other customers for items awarded herein are reduced below the contracted price, it is understood and agreed that the benefits of such reduction shall be extended to County.

22. Bids, and all goods and services provided thereunder, shall comply with all federal, state and local laws concerning this type(s) of goods and/or services.

23. Minimum Standards For Responsible Prospective Bidders: A prospective bidder must affirmatively demonstrate bidder's responsibility. A prospective bidder, by submitting a bid, represents to County that it meets the following requirements:

- Possess or is able to obtain adequate financial resources as required to perform under the bid;
- Be able to comply with the required or proposed delivery schedule;
- Have a satisfactory record of performance;
- Have a satisfactory record of integrity and ethics;
- Be otherwise qualified and eligible to receive an award.

24. Successful bidder will pay or cause to be paid, without cost or expenses to County, all FICA, FUTA/SUTA and Federal Income Withholding Taxes of all employees, and all wages and benefits as required by Federal or State law. Successful bidder's officers, agents and/or employees will not be entitled to any benefits of an employee or elected official of County, including, but not limited to, benefits associated with County's civil service system.

25. Any contract award to a successful bidder will be in effect until (a) the contract expires, (b) delivery and acceptance of products, and/or performance of services ordered, or (c) terminated by County with thirty day's written notice prior to cancellation.

INSTRUCTIONS TO BIDDERS

26. County reserves the right to enforce performance of any contract awarded hereunder in any manner prescribed by law or deemed to be in the best interest of the County in the event of breach or default by successful bidder; County reserves the right to terminate any contract immediately in the event a successful bidder fails to:

    A. Meet schedules;
    B. Pay any required fees or taxes; or
    C. Otherwise perform in accordance with the specifications.

27. Successful bidder shall defend, indemnify and save harmless County and all its elected officials, officers, agents and employees from all suits, actions, or other claims of any character, name and description brought for or on account of any injuries or damages received or sustained by any person, persons, or property on account of any negligent act or fault of the successful bidder, or of any agent, employee, subcontractor or supplier of successful bidder in the execution of, or performance under, any contract which may result from bid award or which arises from any event or casualty happening on or within County premises themselves or happening upon or in any halls, elevators, entrances, stairways or approaches of or to such County facilities. Successful bidder shall pay any judgment with costs which may be obtained against County growing out of such injury or damages, and shall, upon request, provide a defense to County by counsel reasonably acceptable to County. Successful bidder's indemnity hereunder shall include, but is not limited to, claims relating to patent, copyright or trademark infringement, and the like, arising out of the goods and services provided by successful bidder.

28. Successful bidder shall warrant that all items/services shall conform with the specifications and/or all warranties provided under the Uniform Commercial Code and be free from all defects in material, workmanship and the like. Items supplied under a contract pursuant to this Request for Bids shall be subject to County's approval. Items found to be defective or not meeting specifications shall be replaced by successful bidder within two business days at no expense to County. Items not picked up within one (1) week after notification shall be deemed a donation to County and may be used or disposed of at County's discretion and without waiver of any other rights of County as to the item's nonconformity.

29. This document and any disputes arising hereunder shall be governed and construed according to the laws of the State of Texas, and will be performable exclusively in Hidalgo County, Texas.

30. The successful bidder shall not assign, sell, transfer or convey its rights under any awarded contract, in whole or in part, without the prior written consent of County.

BID PROPOSAL

Hidalgo County Purchasing Department
ATTENTION: Martha Salazar
2802 S. Business Hwy 281
Edinburg, Texas 78539

Dear Ms. Salazar:

The undersigned Bidder, pursuant to the foregoing Notice and Instructions to Bidders for **Bid Number: 2016-260-07-06-YSS – Paving and Drainage Improvements for Colonia Noreste Subdivision** located in Hidalgo County, together with all appurtenances (hereinafter called "Project"), having examined the Drawings and Specifications and related Contract Documents and the site of the proposed work, and being familiar with all the conditions surrounding construction of the proposed Project, including the availability of labor and materials, will construct the Project in accordance with the Contract Documents and addenda thereto, within the time set forth therein, for the prices and Bid stated under Item A on the following pages of this Bid Proposal. The prices and/or amounts shown are to cover all costs, including profit and overhead, incurred in performing the work required under the Contract Documents, of which this Bid is a part. (Note: It is understood that those bid items identified shall be considered as pay items, all other work shall be incidental to the various bid items. It is also noted that estimated quantities are provided for information only.)

The undersigned Bidder further acknowledges that the price includes acknowledgement and understanding of all receipt of all Addenda as identified under Item B on the following pages of this Bid Propsal.

The undersigned Bidder agrees to commence work within ten (10) working days of written notice to commence work and to substantially complete the work on which he has bid **90** calendar days. The Contractor further agrees to pay, as liquidated damages, the sum of **$500.00** for each consecutive calendar day thereafter as hereinafter provided in the Construction Contract.

Enclosed with this Proposal is a Cashier's Check or Certified Check for:
_____ Dollars (_____);

or a Bid Bond in the sum of:
5% of Greatest Amount Bid Dollars (_____); which is agreed either shall be collected and retained by the **Owner** under the conditions hereof within ten (10) days after the date this proposal is accepted; then otherwise the said bond or check shall be returned to the undersigned upon demand.

Respectfully submitted,

BIDDER: 2GS, LLC, d/b/a Earthworks Enterprise

Corporate Seal (if applicable):

Principal Signature: _____ Date: July 5, 2016

Name / Title: Humberto García, Jr., Member

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

Telephone: (956) 424-3414

Signaure: _____ Date: July 5, 2016
Witness to Principal

Printed Name / Title: A. Omar Flores, Jr., Office Manager

A.BID

BASE BID - NORESTE SUBDIVISION					
SPEC NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE (in figures)	UNIT TOTAL (in figures)
0100	PREPARING ROW	48	STA	$ 800.00	$38,400.00
0110	EXCAVATION (ROADWAY)	6327	CY	$ 6.70	$ 42,390.90
0132	EMBANKMENT (FINAL)(DENS CONT)(TY C)	107	CY	$ 10.00	$ 1,070.00
0164	CELL FBR MLCH SEED (PERM)(URBAN)(SANDY)	16101	SY	$ 0.75	$ 12,075.75
0168	VEGETATIVE WATERING	747	MG	$ 10.00	$ 7,470.00
0247	FL BS (RDWY DEL)(TY E GR 4)(FNAL POS)	2338	CY	$ 20.00	$ 46,760.00
0260	LIME TRT (NEW BASE)(8")	10520	SY	$ 3.00	$ 31,560.00
0260	LIME (HYD, COM, OR QK(SLURRY))	79	TON	$ 200.00	$ 15,800.00
0310	PRIME COAT (MC-30)	2104	GAL	$ 4.00	$ 8,416.00
0341	D-GR HMA TY-D SAC-B PG76-22	1200	TON	$ 115.00	$ 138,000.00
0464	15 IN RCP	3703	LF	$ 20.00	$ 74,060.00
0464	18 IN RCP	252	LF	$ 28.00	$ 7,056.00
0464	24 IN RCP	89	LF	$ 33.00	$ 2,937.00
0465	TY C INLET	1	EA	$ 3,500.00	$ 3,500.00
0502	BARRICADES, SIGNS, AND TRAFFIC HANDLING *	3	MO	$ 2,500.00	$ 7,500.00
0530	DRIVEWAYS (CONC)	2364	SY	$ 33.00	$ 78,012.00
0530	DRIVEWAYS (ACP)	1777	SY	$ 10.00	$ 17,770.00
0531	SIDEWALK (CONC)	30	SY	$ 35.00	$ 1,050.00
0560	MAILBOX INSTALL-S (TWG-POST) TY 2	112	EA	$ 75.00	$ 8,400.00
7000	STORM WATER POLLUTION PREVENETION PLAN **	1	LS	$ 2,500.00	$ 2,500.00
				BASE BID TOTAL (in figures)	$ 544,727.65

In words:

Five Hundred Forty-Four Thousand Seven Hundred Twenty-Seven Dollars and Sixty-Five Cents

In case of DISCREPANCIES, Unit Price RULES OVER Unit Total and Total Amounts.

* THE CONTRACTOR SHALL PROVIDE A SIGNED AND SEALED TRAFFIC CONTROL PLAN THAT WILL BE IMPLEMENTED AND MAINTAINED THROUGHOUT CONSTRUCTION. PROVISION OF THE SIGNED/SEALED TCP SHALL BE SUBSIDIARY TO ITEM 502.

** THE CONTRACTOR SHALL PROVIDE AN SW3P FOR APPROVAL BY THE ENGINEER/OWNER, OBTAIN ALL NECESSARY PERMITS AND INSTALL ALL BMPs AS INDICATED ON THE APPROVED SW3P. PLAN, PERMIT, AND BMPs ARE PART OF ITEM 7000. TOTAL DISTURBED AREA IS ESTIMATED TO BE 5.5 AC.

A.BID (cont'd)

ALTERNATE BID *					
SPEC NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE (in figures)	UNIT TOTAL (in figures)
8000	15 IN ADS	3377	LF	$ 15.00	$ 50,655.00
				ALTERNATE BID TOTAL (in figures)	$ 50,655.00

In words: Fifty Thousand Six Hundred Fifty-Five Dollars and Zero Cents

In case of DISCREPANCIES, Unit Price RULES OVER Unit Total and Total Amounts.

* **THIS ALTERNATE BID, IF ACCEPTED, WILL REPLACE AN EQUIVALENT AMOUNT OF PROPOSED RCP IN THE BASE BID.**

B. ADDENDA

Receipt of the following Addenda is acknowledged as follows:

ADDENDUM	ADDENDUM DATE	ACKNOWLEDGEMENT	
No. 1	_____	Signature: _____	Date: _____
No. 2	_____	Signature: _____	Date: _____
No. 3	_____	Signature: _____	Date: _____
No. 4	_____	Signature: _____	Date: _____

Paving and Drainage Improvements for Colonia Noreste Subdivision
Hidalgo County Precinct No. 1
Bid Number: 2016-260-07-06-YSS

9.53
7-6-16

BID PROPOSAL

Hidalgo County Purchasing Department
ATTENTION: Martha Salazar
2802 S. Business Hwy 281
Edinburg, Texas 78539

Dear Ms. Salazar:

The undersigned Bidder, pursuant to the foregoing Notice and Instructions to Bidders for **Bid Number: 2016-260-07-06-YSS – Paving and Drainage Improvements for Colonia Noreste Subdivision** located in Hidalgo County, together with all appurtenances (hereinafter called "Project"), having examined the Drawings and Specifications and related Contract Documents and the site of the proposed work, and being familiar with all the conditions surrounding construction of the proposed Project, including the availability of labor and materials, will construct the Project in accordance with the Contract Documents and addenda thereto, within the time set forth therein, for the prices and Bid stated under Item A on the following pages of this Bid Proposal. The prices and or amounts shown are to cover all costs including profit and overhead incurred in performing the work required under the Contract Documents, of which this Bid is a part. (Note: It is understood that those bid items identified shall be considered as pay items, all other work shall be incidental to the various bid items. It is also noted that estimated quantities are provided for information only.)

The undersigned Bidder further acknowledges that the price includes acknowledgement and understanding of all receipt of all Addenda as identified under Item B on the following pages of this Bid Propsal.

The undersigned Bidder agrees to commence work within ten (10) working days of written notice to commence work and to substantially complete the work on which he has bid 90 calendar days. The Contractor further agrees to pay, as liquidated damages, the sum of **$500.00** for each consecutive calendar day thereafter as hereinafter provided in the Construction Contract.

Enclosed with this Proposal is a Cashier's Check or Certified Check for _____ Dollars (_____),

or a Bid Bond in the sum of 5% of Greatest Amount Bid Dollars (_____), which is agreed either shall be collected and retained by the **Owner** under the conditions hereof within ten (10) days after the date this proposal is accepted; then otherwise the said bond or check shall be returned to the undersigned upon demand.

Respectfully submitted,

BIDDER: 2GS, LLC, d/b/a Earthworks Enterprise

Principal Signature: _____ Date: July 5, 2016

Corporate Seal (if applicable)

Name Title: Humberto García, Jr., Member

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

Telephone: (956) 424-3414

Signature: _____ Date: July 5, 2016
Witness to Principal

Printed Name Title: A. Omar Flores, Jr., Office Manager

Paving and Drainage Improvements for Colonia Noreste Subdivision
Hidalgo County Precinct No. 1
Bid Number: 2016-260-07-06-YSS

9-53 7-6-16

A.BID

BASE BID - NORESTE SUBDIVISION					
SPEC NO	DESCRIPTION	QTY	UNIT	UNIT PRICE (in figures)	UNIT TOTAL (in figures)
0100	PREPARING ROW	48	STA	$ 800.00	$38,400.00
0110	EXCAVATION (ROADWAY)	6327	CY	$ 6.70	$ 42,390.90
0132	EMBANKMENT (FINAL)(DENS CONT)(TY C)	107	CY	$ 10.00	$ 1,070.00
0164	CELL FBR MLCH SEED (PERM)(URBAN)(SANDY)	16101	SY	$ 0.75	$ 12,075.75
0168	VEGETATIVE WATERING	747	MG	$ 10.00	$ 7,470.00
0247	FL BS (RDWY DEL)(TY E GR 4)(FNAL POS)	2338	CY	$ 20.00	$ 46,760.00
0260	LIME TRT (NEW BASE)(8")	10520	SY	$ 3.00	$ 31,560.00
0260	LIME (HYD. COM. OR QK(SLURRY))	79	TON	$ 200.00	$ 15,800.00
0310	PRIME COAT (MC-30)	2104	GAL	$ 4.00	$ 8,416.00
0341	D-GR HMA TY-D SAC-B PG76-22	1200	TON	$ 115.00	$ 138,000.00
0464	15 IN RCP	3703	LF	$ 20.00	$ 74,060.00
0464	18 IN RCP	252	LF	$ 28.00	$ 7,056.00
0464	24 IN RCP	89	LF	$ 33.00	$ 2,937.00
0465	TY C INLET	1	EA	$ 3,500.00	$ 3,500.00
0502	BARRICADES, SIGNS, AND TRAFFIC HANDLING *	3	MO	$ 2,500.00	$ 7,500.00
0530	DRIVEWAYS (CONC)	2364	SY	$ 33.00	$ 78,012.00
0530	DRIVEWAYS (ACP)	1777	SY	$ 10.00	$ 17,770.00
0531	SIDEWALK (CONC)	30	SY	$ 35.00	$ 1,050.00
0560	MAILBOX INSTALL-S (TWG POST) TY 2	112	EA	$ 75.00	$ 8,400.00
7000	STORM WATER POLLUTION PREVENETION PLAN **	1	LS	$ 2,500.00	$ 2,500.00
				BASE BID TOTAL (in figures)	$ 544,727.65

In words:

Five Hundred Forty-Four Thousand Seven Hundred Twenty-Seven Dollars and Sixty-Five Cents

In case of DISCREPANCIES, Unit Price RULES OVER Unit Total and Total Amounts.

* THE CONTRACTOR SHALL PROVIDE A SIGNED AND SEALED TRAFFIC CONTROL PLAN THAT WILL BE IMPLEMENTED AND MAINTAINED THROUGHOUT CONSTRUCTION. PROVISION OF THE SIGNED/SEALED TCP SHALL BE SUBSIDIARY TO ITEM 502.

** THE CONTRACTOR SHALL PROVIDE AN SW3P FOR APPROVAL BY THE ENGINEER/OWNER. OBTAIN ALL NECESSARY PERMITS AND INSTALL ALL BMPs AS INDICATED ON THE APPROVED SW3P. PLAN. PERMIT AND BMPs ARE PART OF ITEM 7000. TOTAL DISTURBED AREA IS ESTIMATED TO BE 5.5 AC.

9:53 7-6-16

A. BID (cont'd)

ALTERNATE BID					
SPEC NO	DESCRIPTION	QTY	UNIT	UNIT PRICE (in figures)	UNIT TOTAL (in figures)
8000	15 IN ADS	3377	LF	$ 15.00	$ 50,655.00
				ALTERNATE BID TOTAL (in figures)	$ 50,655.00

In words: Fifty Thousand Six Hundred Fifty Five Dollars and Zero Cents

In case of DISCREPANCIES, Unit Price RULES OVER Unit Total and Total Amounts.

THIS ALTERNATE BID, IF ACCEPTED, WILL REPLACE AN EQUIVALENT AMOUNT OF PROPOSED RCP IN THE BASE BID.

B. ADDENDA

Receipt of the following Addenda is acknowledged as follows:

ADDENDUM	ADDENDUM DATE	ACKNOWLEDGEMENT	
No. 1		Signature:	Date:
No. 2		Signature:	Date:
No. 3		Signature:	Date:
No. 4		Signature:	Date:

BIDDER'S ACKNOWLEDGEMENT

Hidalgo County Purchasing Department
ATTENTION: Martha Salazar
2802 S. Business Hwy 281
Edinburg, Texas 78539

In accordance with the Specifications, and subject to all laws and regulations of the United States and state and local laws, the undersigned Bidder proposes and commits to furnish all labor, equipment, material, software and services as set forth in the documents hereinbefore mentioned. The undersigned Bidder further agrees, upon acceptance of its bid, to execute a contract and/or Purchase Order issued by Hidalgo County for performing and completing the work described in the Specifications, within the time stated, and for the prices proposed in the documents attached hereto and made a part hereof.

Bidder acknowledges receipt of all of the pages of the documents referenced in the Invitation to Bid Checklist presented in connection with this procurement. Bidder understands that Hidalgo County reserves the right to reject any or all bids and further reserves the right to design the evaluation criteria to be used in selecting the lowest and best bid.

Bidder agrees that this bid shall be good and may not be withdrawn for a period of ninety (90) calendar days after the scheduled closing time for receiving bids, as contained in the Specifications.

Respectfully submitted,

BIDDER: 2GS, LLC dba Earthworks Enterprise

Principal Signature: _____ Date: July 5, 2016

Name / Title: Humberto Garcia, Jr., Member

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

PROJECT REQUIREMENTS ACKNOWLEDGEMENT

This is to certify that I, Humberto García, Jr. , as Principal of 2GS, LLC, dba Earthworks Enterprise possess all of the following applicable and necessary requirements and required documents to perform and provide the Work associated with the Project: **Bid Number: 2016-260-07-06-YSS – Paving and Drainage Improvements for Colonia Noreste Subdivision.**

(1) Licenses:

(2) Bonds:
- ☐ Bid Bond
- ☐ Performance Bond
- ☐ Payment Bond

(3) Certificates:
- ☐ Certificates of Insurance or Insurance Requirements Acknowledgement

(4) Affidavits:
- ☐ Non-Collusion Affidavit Of Prime Bidder
- ☐ Sales Tax and Local Sales Tax Exemption Certificate

(5) Permits:

(6) Conflict of Interest Questionnaire

Furthermore, I am providing copies of the required documentation so that, if my company is awarded this bid, I may be eligible to enter into a Contract with Hidalgo County and proceed to complete the project in a timely manner, and within the Contract Time identified in the Contract. I understand that any licenses, bonds, certificates, permits or other requirements must be presented as part of my Bid package in order to expedite the bid evaluation process, and that failure to provide said documentation will result in the disqualification of my Bid.

BIDDER: 2GS, LLC, dba Earthworks Enteprise

Principal Signature: _____ Date: July 5, 2016

Name / Title: Humberto García, Jr., Member

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

BID BOND

THE STATE OF)
) ss. KNOW ALL MEN BY THESE PRESENTS:
COUNTY OF Hidalgo)

That we, 2GS, LLC, of the City of Penitas, County of Hidalgo, and State of Texas (hereinafter called "Principal") as Principal, and Hartford Fire Insurance Company (hereinafter called the Surety) as Surety, authorized under the laws of the State of Connecticut to act as surety on bonds for principals, are held and firmly bound unto Hidalgo County (hereinafter called the Owner) as obligee, in the sum of 5% Greatest Amount Bid ($ 5%) in lawful money of the United States for the payment of Principal and Surety, and bind ourselves, our heirs, executors, administrators, successors and assigns, jointly and severally and firmly by these presents.

WHEREAS, the Principal has, submitted a Bid Form (Proposal) to enter into a certain written agreement with Owner for Construction of Colonia Noreste Subdivision hereinafter referred to as "Agreement."

NOW, THEREFORE, the condition of this obligation is such that if the Owner shall accept the Bid Form (Proposal) of the the Principal and the Principal shall faithfully enter into agreement with Owner in accordance with the terms of such Bid, and give such Bonds as are specified in the Bidding or Contract Documents; or in the event of the failure of Principal to enter such Agreement and give such Bond or Bonds, if the Principal shall pay to Owner the difference not to exceed the sum hereof between the amount specified in said Bid and such larger amount for which the Owner may in good faith contract with another party to perform the work covered by said Bid, then this obligation shall be null and void, otherwise to remain in full force and effect.

SIGNED AND SEALED THIS 5th day of July A.D. 2016

PRINCIPAL: 2GS, LLC

Witness

By: Humberto Garcia

P.O. Box 595

Penitas TX 78576

Address

Witness

SURETY: Hartford Fire Insurance Company

By: Andy Alvarez

Attorney-in-Fact

P.O. Drawer 3783

McAllen, TX 78502

Address

956-787-8536

(Surety's Telephone Number)

POWER OF ATTORNEY

Direct Inquiries/Claims to:
THE HARTFORD
Bond T-4
One Hartford Plaza
Hartford, Connecticut 06155
call: **888-266-3488** *or fax:* **860-757-5835)**

KNOW ALL PERSONS BY THESE PRESENTS THAT: **Agency Code:** 65-813646

- [X] **Hartford Fire Insurance Company**, a corporation duly organized under the laws of the State of Connecticut
- [X] **Hartford Casualty Insurance Company**, a corporation duly organized under the laws of the State of Indiana
- [ ] **Hartford Accident and Indemnity Company**, a corporation duly organized under the laws of the State of Connecticut
- [ ] **Hartford Underwriters Insurance Company**, a corporation duly organized under the laws of the State of Connecticut
- [ ] **Twin City Fire Insurance Company**, a corporation duly organized under the laws of the State of Indiana
- [ ] **Hartford Insurance Company of Illinois**, a corporation duly organized under the laws of the State of Illinois
- [ ] **Hartford Insurance Company of the Midwest**, a corporation duly organized under the laws of the State of Indiana
- [ ] **Hartford Insurance Company of the Southeast**, a corporation duly organized under the laws of the State of Florida

having their home office in Hartford, Connecticut (hereinafter collectively referred to as the "Companies") do hereby make, constitute and appoint
up to the amount of Unlimited :
Andy Alvarez, Phil Young, Dewey Young of SAN JUAN, Texas

their true and lawful Attorney(s)-in-Fact, each in their separate capacity if more than one is named above, to sign its name as surety(ies) only as delineated above by ☒, and to execute, seal and acknowledge any and all bonds, undertakings, contracts and other written instruments in the nature thereof, on behalf of the Companies in their business of guaranteeing the fidelity of persons, guaranteeing the performance of contracts and executing or guaranteeing bonds and undertakings required or permitted in any actions or proceedings allowed by law.

In Witness Whereof, and as authorized by a Resolution of the Board of Directors of the Companies on August 1, 2009, the Companies have caused these presents to be signed by its Vice President and its corporate seals to be hereto affixed, duly attested by its Assistant Secretary. Further, pursuant to Resolution of the Board of Directors of the Companies, the Companies hereby unambiguously affirm that they are and will be bound by any mechanically applied signatures applied to this Power of Attorney.

Wesley W. Cowling, Assistant Secretary

M. Ross Fisher, Vice President

STATE OF CONNECTICUT
COUNTY OF HARTFORD } ss. Hartford

On this 12th day of July, 2012, before me personally came M. Ross Fisher, to me known, who being by me duly sworn, did depose and say: that he resides in the County of Hartford, State of Connecticut; that he is the Vice President of the Companies, the corporations described in and which executed the above instrument; that he knows the seals of the said corporations; that the seals affixed to the said instrument are such corporate seals; that they were so affixed by authority of the Boards of Directors of said corporations and that he signed his name thereto by like authority.

Kathleen T. Maynard
Notary Public
My Commission Expires July 31, 2016

CERTIFICATE

I, the undersigned, Vice President of the Companies, DO HEREBY CERTIFY that the above and foregoing is a true and correct copy of the Power of Attorney executed by said Companies, which is still in full force effective as of July 5th, 2016
Signed and sealed at the City of Hartford.

Gary W. Stumper, Vice President

INSURANCE REQUIREMENTS ACKNOWLEDGEMENT

I, Humberto García, Jr., authorized representative for 2GS, LLC, dba Earthworks Enterprise, hereby acknowledge Hidalgo County's insurance requirements, and will meet said requirements by checking one of the following:

- ☐ Said insurance requirements will be acquired upon notification of intent to award bid at the next regularly scheduled Hidalgo County Commissioner's Court meeting; (*an insurance certificate for the required insurance limits shall be provided to the Hidalgo County Purchasing Department by no later 9:30 am., the morning of the Commissioner's Court meeting, in order to qualify for award of bid and to execute a contract between our Company and Hidalgo County);

- ☐ We currently carry the following:

  Automobile Liability $_____ General Liability: $_____

  And, to meet Hidalgo County's insurance requirements, will acquire any additional amount needed to meet the Hidalgo County's requirements upon notification of intent to award bid at the next scheduled Hidalgo County Commissioner's Court meeting(*an insurance certificate for the required insurance limits shall be provided to the Hidalgo County Purchasing Department by no later 9:30 am., the morning of the Commissioner's Court meeting, in order to qualify for award of bid and to execute a contract between our Company and Hidalgo County);

- ■ We already meet said insurance requirements, and have attached a copy of the certificate of insurance.

Further, it is understood that failure to provide Certificates of Insurance at the Hidalgo County Commissioner's Court meeting will cause the bid award to be rescinded and then awarded to next lowest bidder. Certificates of insurance will be monitored / verified on **a quarterly basis** to ensure coverage policy is in place.

BIDDER: 2GS, LLC, dba Earthworks Enterprise

Signature: _____ Date: July 5, 2016

Name / Title: Humberto García, Jr., Member

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 7/5/2016

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Higginbotham Insurance Agency, Inc.
1400 McColl Rd. Ste 105
McAllen TX 78501

CONTACT NAME: Leticia Gallegos
PHONE (A/C, No, Ext): 956-668-3516 FAX (A/C, No): 956-687-1286
E-MAIL ADDRESS: leticia.gallegos@higginbotham.net

INSURED 2GSLL
2GS, LLC, dba Earthworks Enterprise
PO Box 595
Penitas TX 78576

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : James River Insurance Company	12203
INSURER B : Ohio Security Insurance Company	24082
INSURER C : Texas Mutual Insurance Company	22945
INSURER D : The Travelers Lloyds Insurance Co	41262
INSURER E :	
INSURER F :	

COVERAGES **CERTIFICATE NUMBER:** 2057494271 **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY	Y	Y	000703560	2/21/2016	2/21/2017	EACH OCCURRENCE	$1,000,000
	CLAIMS-MADE X OCCUR						DAMAGE TO RENTED PREMISES (Ea occurrence)	$50,000
	X 5,000						MED EXP (Any one person)	$1,000
							PERSONAL & ADV INJURY	$1,000,000
	GEN'L AGGREGATE LIMIT APPLIES PER						GENERAL AGGREGATE	$2,000,000
	POLICY PRO-JECT LOC						PRODUCTS - COMP/OP AGG	$2,000,000
	OTHER							$
B	AUTOMOBILE LIABILITY	Y	Y	BAS55991781	2/21/2016	2/21/2017	COMBINED SINGLE LIMIT (Ea accident)	$1,000,000
	X ANY AUTO						BODILY INJURY (Per person)	$
	ALL OWNED AUTOS / SCHEDULED AUTOS						BODILY INJURY (Per accident)	$
	HIRED AUTOS / NON-OWNED AUTOS						PROPERTY DAMAGE (Per accident)	$
								$
	UMBRELLA LIAB OCCUR						EACH OCCURRENCE	$
	EXCESS LIAB CLAIMS-MADE						AGGREGATE	$
	DED RETENTION $							$
C	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY		Y	TSF0001234244	2/21/2016	2/21/2017	X PER STATUTE OTH-ER	
	ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) Y / N / N / A						E.L. EACH ACCIDENT	$1,000,000
	If yes, describe under DESCRIPTION OF OPERATIONS below						E.L. DISEASE - EA EMPLOYEE	$1,000,000
							E.L. DISEASE - POLICY LIMIT	$1,000,000
D	Inland Marine			QT6608G686515TLC16	2/21/2016	2/21/2017	Limit Leased/Rented Deductible	$750,000 $200,000 $2,500

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

Automatic Additional insured Endorsement Construction or Service Contracts when required by written contract applies to General Liability and Auto policies.

Waiver of Transfer of Rights of Recovery Against Others to us applies to General Liability coverage when required by written contract.
Texas Waiver of our Right to Recover from Others applies to Workers Compensation coverage when agreed by written contract and as permitted by law.
Project: Hidalgo County Colonia Noreste Subdivision

CERTIFICATE HOLDER

Hidalgo County
2802 S Business Highway 281
Edinburg TX 78539

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

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Noreste Subdivision
Hidalgo County Precinct No. 1
Bid Number: 2016-260-00-00-YSS

NON-COLLUSION AFFIDAVIT OF PRIME BIDDER

The State of Texas §
§
County of Hidalgo §

Humberto García, Jr. being first duly sworn, deposes and says that

(1) He is Member, of 2GS, LLC, dba Earthworks Enterprise, the Bidder that has submitted the attached bid;

(2) He is fully informed respecting the preparation and contents of the attached Bid and of all pertinent circumstances respecting such bid;

(3) Such bid is genuine and is not a collusive or sham Bid;

(4) Neither the said Bidder nor any of its officers, partners, owners, agents, representatives, employees, or parties in interest, including this affiant, has in any way colluded, conspired, connived or agreed, directly or indirectly with any other Bidder, firm or person to submit a collusive or sham Bid in connection with the Contract for which the attached Bid has been submitted or to refrain from bidding in connection with such Contract, or has in any manner, directly or indirectly, sought by agreement or collusion or communication or conference with any other Bidder, firm or person to fix the price or prices in the attached Bid or of any other Bidder, or to fix any overhead, profit or cost element of the Bid price of any other Bidder, or to secure through any collusion, conspiracy, connivance or unlawful agreement any advantage against the Owner or any person interested in the proposed Contract; and

(5)The price or prices quoted in the attached Bid are fair and proper and are not tainted by any collusion, conspiracy, connivance or unlawful agreement on the part of the Bidder or any of its agents, representatives, owners, employees, or parties in interest, including this affiant.

BIDDER: 2GS, LLC, dba Earthworks Enterprise

Signature: _____ Date: July 5, 2016

Name / Title: Humberto García, Jr., Member

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

ARMANDO OMAR FLORES JR
Notary Public, State of Texas
Comm. Expires 03-23-2020
Notary ID 130592795

Subscribed and sworn to before me this 5th day of July, 2016.

By: Armando Omar Flores, Jr., Notary Public in and for Hidalgo County, Texas.
My commission expires March 23, 2020.

DISCLOSURE OF CONFLICT OF INTEREST

Effective January 1, 2006, Chapter 176 of the Texas Local Government Code requires that any vendor, person, consultant or contractor considering doing business with Hidalgo County ("the County") to disclose in the Conflict of Interest Questionnaire (the "CIQ") attached as Exhibit D, the vendor, person, consultant or contractor's affiliation or business relationship that might cause a conflict of interest with the County. By law, the CIQ must be filed with the Hidalgo County Clerk's Office no later than the seventh business day after the date the person becomes aware of facts that require that statement to be filed. The disclosure requirement applies to a person or business who contracts or seeks to contract with Hidalgo County for the sale or purchase of property, goods or service. Any purchase order or contract resulting from this process shall be considered null and void if the successful bidder fails to comply with Texas Local Government Code Chapter 176. Vendors, consultants, contractors and others who desire to conduct business with Hidalgo County are encouraged to refer to Texas Local Government Code Chapter 176 for the details of this law. An offense under Texas Local Government Code Chapter 176 is a Class C Misdemeanor.

Please Submit completed forms to the Hidalgo County Clerk's Office located at 100 N. Closner, Edinburg, Texas 78539-Hidalgo County Courthouse

COMPLETION AND SUBMISSION OF FORM CIQ IS THE SOLE RESPONSIBILITY OF THE PROSPECTIVE BIDDER.

2677371

CONFLICT OF INTEREST QUESTIONNAIRE

FORM CIQ

For vendor or other person doing business with local governmental entity

This questionnaire reflects changes made to the law by H.B. 1491, 80th Leg., Regular Session.

This questionnaire is being filed in accordance with Chapter 176, Local Government Code by a person who has a business relationship as defined by Section 176.001(1-a) with a local governmental entity and the person meets requirements under Section 176.006(a).

By law this questionnaire must be filed with the records administrator of the local governmental entity not later than the 7th business day after the date the person becomes aware of facts that require the statement to be filed. See Section 176.006, Local Government Code.

A person commits an offense if the person knowingly violates Section 176.006, Local Government Code. An offense under this section is a Class C misdemeanor.

OFFICE USE ONLY
Date Received

1 Name of person who has a business relationship with local governmental entity.

2GS, LLC dba Earthworks Enterprise

2 ☐ Check this box if you are filing an update to a previously filed questionnaire.

(The law requires that you file an updated completed questionnaire with the appropriate filing authority not later than the 7th business day after the date the originally filed questionnaire becomes incomplete or inaccurate.)

3 Name of local government officer with whom filer has employment or business relationship.

Name of Officer

This section (item 3 including subparts A, B, C & D) must be completed for each officer with whom the filer has an employment or other business relationship as defined by Section 176.001(1-a), Local Government Code. Attach additional pages to this Form CIQ as necessary.

A. Is the local government officer named in this section receiving or likely to receive taxable income, other than investment income, from the filer of the questionnaire?

☐ Yes ■ No

B. Is the filer of the questionnaire receiving or likely to receive taxable income, other than investment income, from or at the direction of the local government officer named in this section AND the taxable income is not received from the local governmental entity?

☐ Yes ■ No

C. Is the filer of this questionnaire employed by a corporation or other business entity with respect to which the local government officer serves as an officer or director, or holds an ownership of 10 percent or more?

☐ Yes ■ No

D. Describe each employment or business relationship with the local government officer named in this section.

N/A

4

Signature of person doing business with the governmental entity

January 14, 2016

Date

Humberto Garcia Jr.

Adopted 06/29/2007

Hidalgo County
Arturo Guajardo Jr.
County Clerk
Edinburg,TX 78540

Instrument Number: 2016-2677371
As
Recording

Recorded On: January 14, 2016

Billable Pages: 1

Number of Pages: 2

Parties:

To

Comment: CONFLICT OF INTEREST

** Examined and Charged as Follows: **

Recording	36.00
Total Recording:	36.00

********** THIS PAGE IS PART OF THE INSTRUMENT **********
Any provision herein which restricts the Sale, Rental or use of the described REAL PROPERTY because of color or race is invalid and unenforceable under federal law.

File Information:

Document Number: 2016-2677371
Receipt Number: 1574660
Recorded Date/Time: January 14 2016 04:00P

User / Station: I Leal - Cash Station 02

Record and Return To:

2GS LLC DBA EARTHWORKS ENTERPRISE
ORIGINAL RETURN TO CUSTOMER
PENITAS TX 78576

STATE OF TEXAS
COUNTY OF HIDALGO

I hereby certify that this instrument was FILED in the File Number sequence on the date/time printed heron, and was duly RECORDED in the Official Records of Hidalgo County, Texas

Arturo Guajardo Jr.
County Clerk
Hidalgo County, TX

THE STATE OF TEXAS §
§
COUNTY OF HIDALGO §

CONSTRUCTION CONTRACT
C-16-260-07-19

This Agreement, entered into this **19** day of **July**, 2016 by and between Hidalgo County (hereinafter called the "OWNER," and, **2Gs, LLC, Dba Earthworks Enterprise** (a Texas corporation), of County of Hidalgo, and State of Texas, hereinafter called "CONTRACTOR".

WITNESSETH

That for and in consideration of the payments and agreement hereinafter mentioned, to be made and performed by the OWNER, the CONTRACTOR hereby agrees with the OWNER to commence and complete the construction described as follows:

Paving and Drainage Improvements for Colonia Noreste Subdivision

Hereinafter called the project, for the sum of Five Hundred Forty Four Thousand Seven Hundred Twenty Seven Dollars and Sixty Five Cents ($544,727.65) and all extra work in connection therewith, under the terms and stated in the General and Special Conditions of the Contract; and at his (its or their) own proper cost and expense to furnish all the materials, supplies, machinery, equipment, tools, superintendence, labor, insurance, and other accessories and services necessary to complete the said project in accordance with the conditions and prices stated in the Proposal, the General Conditions and Special Conditions printed or written explanatory matter thereof, the specifications and contract documents therefore as prepared by **TEDSI Infrastructure Group**, entitled the Architect/Engineer, and as enumerated in Paragraph 1.01.A.12 of the General Conditions, all of which are made a part hereof and collectively evidence and constitute the contract.

The CONTRACTOR hereby agrees to commence work under this contract on or after a date to be specified in written "Notice to Proceed" of the OWNER and to fully complete the project within **90** consecutive calendar days thereafter. The CONTRACTOR further agrees to pay, as liquidated damages, the sum of **$500.00** for each consecutive calendar day thereafter.

The OWNER agrees to pay the CONTRACTOR in current funds for the performance of the contract, subject to additions and deductions, as provided in the General Conditions of the contract, and to make payments on account thereof as provided in Paragraphs 14.02.C and 14.07.C of the General Conditions.

H.G

IN WITNESS WHREOF, the parties to these present have executed this contract in five (5) counterparts, each of which shall be deemed an original, in year and day first above mentioned.

APPROVED BY COMMISIONERS COURT ON _____ ,2016

CONTRACTOR: _____
Print Name & Title: Humberto García, Jr.
Name of Firm: 2GS, LLC, Dba Earthworks Enterprise

Address: P. O. Box 595
Peñitas, TX 78576-0595
Fed I.D. #/SS #: 45-4338911

STATE OF TEXAS

COUNTY OF HIDALGO

This instrument was acknowledged before me on this the 25th day of August,

2016 by Member (Title) Of and on behalf of 2GS, LLC, Dba Earthworks Enteprise (A corporation)

ARMANDO OMAR FLORES JR
Notary Public, State of Texas
Comm. Expires 03-23-2020
Notary ID 130592795

_____
Notary Public-Signature

Armando Omar Flores, Jr.
My commission expires
March 23, 2020.

APPROVED AS TO FORM:
Atlas & Hall, L.L.P.
800 Pecan
McAllen, Texas 78504

BY: _____

ATTEST:

_____
Arturo Guajardo, Jr., County Clerk

COMMISSIONERS COURT
HIDALGO COUNTY, TEXAS

COUNTY OF HIDALGO:

_____
Ramon Garcia, County Judge

APPROVED BY
COMMISSIONERS' COURT
ON: 8/30/16

PART I

CONTRACT AWARD FORMS AND CERTIFICATIONS

FORMS TO SIGN BY CONTRACTOR AS PART OF EXECUTED AGREEMENT:

I.1 NON-COLLUSION AFFIDAVIT OF CONTRACTOR

I.2 PERFORMANCE BOND

I.3 PAYMENT BOND

I.4 INSURANCE REQUIREMENTS AND CONTRACTOR'S CERTIFICATE OF INSURANCE

I.5 SALES TAX AND LOCAL SALES TAX CERTIFICATE

FORMS TO SIGN PRIOR TO FINAL PAYMENT / ACCEPTANCE OF WORK:

I.6 AFFIDAVIT AND WAIVER OF LIEN – PRIME CONTRACTOR

I.7 RELEASE AND WAIVER OF CLAIMS BY SUBCONTRACTORS AND PRODUCT VENDORS

I.8 CONTRACTOR'S AFFIDAVIT AS TO STATUS OF LIEN

OTHER:

I.9 WAGE RATES (GENERAL DECISION NUMBER: TX140008 01/03/2014)

FORM I.1

NON-COLLUSION AFFIDAVIT OF CONTRACTOR

The State of Texas §
§
County of Hidalgo §

Humberto García, Jr. being first duly sworn, deposes and says that:

(1) He / She is Member of 2GS, LLC, Dba Earthworks Enterprise, the Contractor that submitted the Bid on the accepted Contract Price;

(2) He / She is fully informed respecting the preparation and contents of the Bid on the accepted Contract Price and of all pertinent circumstances respecting such Bid;

(3) Such Bid on the accepted Contract Price is genuine and is not a collusive or sham Bid;

(4) Neither the said Contractor nor any of its officers, partners, owners, agents, representatives, employees, or parties in interest, including this affiant, has in any way colluded, conspired, connived or agreed, directly or indirectly with any other Bidder, firm or person to submit a collusive or sham Bid in connection with the Bid on the accepted Contract Price or to refrain from bidding in connection with such Contract, or has in any manner, directly or indirectly, sought by agreement or collusion or communication or conference with any other Bidder, firm or person to fix the price or prices in the attached Bid or of any other Bidder, or to fix any overhead, profit or cost element of the Bid price of any other Bidder, or to secure through any collusion, conspiracy, connivance or unlawful agreement any advantage against the Owner or any person interested in the proposed Contract; and

(5)The price or prices quoted in the Bid on the accepted Contract Price are fair and proper and are not tainted by any collusion, conspiracy, connivance or unlawful agreement on the part of the Contractor or any of its agents, representatives, owners, employees, or parties in interest, including this affiant.

CONTRACTOR: 2GS, LLC, Dba Earthworks Enterprise

Signature: _____ Date: August 22, 2016

Name / Title: Humberto García, Jr.

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

ARMANDO OMAR FLORES JR
Notary Public, State of Texas
My Comm. Exp. 3-23-2020
Notary ID 130522795

Subscribed and sworn to before me this 22nd day of August, 20 16.

By: Armando Omar Flores, Jr., Notary Public in and for Hidalgo County, Texas.
My commission expires March 23, 2020.

FORM I.1
NON-COLLUSION AFFIDAVIT OF CONTRACTOR

The State of Texas §
§
County of Hidalgo §

_____ being first duly sworn, deposes and says that:

(1) He / She is _____ of _____, the Contractor that submitted the Bid on the accepted Contract Price;

(2) He / She is fully informed respecting the preparation and contents of the Bid on the accepted Contract Price and of all pertinent circumstances respecting such Bid;

(3) Such Bid on the accepted Contract Price is genuine and is not a collusive or sham Bid;

(4) Neither the said Contractor nor any of its officers, partners, owners, agents, representatives, employees, or parties in interest, including this affiant, has in any way colluded, conspired, connived or agreed, directly or indirectly with any other Bidder, firm or person to submit a collusive or sham Bid in connection with the Bid on the accepted Contract Price or to refrain from bidding in connection with such Contract, or has in any manner, directly or indirectly, sought by agreement or collusion or communication or conference with any other Bidder, firm or person to fix the price or prices in the attached Bid or of any other Bidder, or to fix any overhead, profit or cost element of the Bid price of any other Bidder, or to secure through any collusion, conspiracy, connivance or unlawful agreement any advantage against the Owner or any person interested in the proposed Contract; and

(5) The price or prices quoted in the Bid on the accepted Contract Price are fair and proper and are not tainted by any collusion, conspiracy, connivance or unlawful agreement on the part of the Contractor or any of its agents, representatives, owners, employees, or parties in interest, including this affiant.

CONTRACTOR: _____

Signature:_____ Date: _____

Name / Title: _____

Address: _____
(Street, City, State, Zip)

Subscribed and sworn to before me this _____day of _____, 20___.

By: _____, Notary Public in and for Hidalgo County, Texas.
My commission expires _____.

Statutory Performance Bond Pursuant to Chapter 2253
Of The Texas Government Code
(Public Work)
(Penalty of this Bond must be 100% of Contract Amount) Bond# 65BCSHH4760

KNOW ALL MEN BY THESE PRESENTS, That 2GS, LLC dba Earthworks Enterprise

(hereinafter called the Principal), as Principal, and Hartford Fire Insurance Company

(hereinafter called Surety), as Surety, are held and firmly bound unto

Hidalgo County

(hereinafter called the Obligee), in the amount of Five Hundred Forty Four Thousand Seven Hundred Twenty Seven and 65/100*** **Dollars ($** 544,727.65** **)**

for the payment whereof the said Principal and Surety bind themselves and heir heirs, administrators, executors, successors and assigns, jointly and severally, firmly by these presents.

WHEREAS, the Principal has entered into a certain written contract with the Obligee, dated the 19th day of July, 2016 for

Hidalgo County Precinct No. 1 - Paving and Drainage Improvements for Colonia Noreste

which contract is hereby referred to and made a part hereof as fully and to the same extent as if copied at length herein.

NOW, THEREFORE, THE CONDITION OF THIS OBLIGATION IS SUCH, that if the said Principal shall faithfully perform the work in accordance with the plans, specifications and contract documents, then this obligation shall be void, otherwise to remain in full force and effect.

PROVIDED, HOWEVER, that this bond is executed pursuant to the provisions of Chapter 2253 of the Texas Government Code and all liabilities on this bond shall be determined in accordance with the provisions, conditions and limitations of said Chapter to the same extent as if it were copied at length herein.

SURETY, for value received, stipulates and agrees that no change, extension of time, alteration or addition to the terms of the contract, or to the work performed thereunder, or the plans, specifications or drawings accompanying the same, shall in anywise affect its obligation on this bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the contract, or to the work to be performed thereunder.

IN WITNESS WHEREOF, the said Principal and Surety have signed this instrument this day 19th of July, 2016

Witness Omar Flores

2GS, LLC
By:
Humberto Garcia, Jr.

Witness Phil Young

Hartford Fire Insurance Company
By:
Andy Alvarez , Attorney-In-Fact

Statutory Payment Bond Pursuant to Chapter 2253 Of The Texas Government Code (Public Work) (Penalty of this Bond must be 100% of Contract Amount)

Bond# 65BCSHH4760

KNOW ALL MEN BY THESE PRESENTS, That 2GS, LLC dba Earthworks Enterprise

hereinafter called the Principal), as Principal, and Hartford Fire Insurance Company

(hereinafter called the Surety), as Surety, are held and firmly bound unto

Hidalgo County

(hereinafter called the Obligee), in the amount of Five Hundred Forty Four Thousand Seven Hundred Twenty Seven and 65/100**** **Dollars ($** 544,727.65 **)**

for the payment of whereof the said Principal and Surety bind themselves and their heirs, administrators, executors, successors and assigns, jointly and severally, firmly by these presents.

WHEREAS, the Principal has entered into a certain written contract with the Obligee, dated the 19th day of July, 2016 for

Hidalgo County Precinct No. 1 - Paving and Drainage Improvements for Colonia Noreste

which contract is hereby referred to and made a part hereof as fully and to the same extent as if copied at length herein.

NOW, THEREFORE, THE CONDITION OF THIS OBLIGATION IS SUCH, that if the said Principal shall pay all claimants supplying labor and material to him or a subcontractor in the prosecution of the work provided for in said contract, then this obligation shall be void; otherwise to remain in full force and effect.

PROVIDED, HOWEVER, that this bond is executed pursuant to the provisions of Chapter 2253 of the Texas Government Code and all liabilities on this bond shall be determined in accordance with the provisions, conditions and limitation of said Chapter to the same extent as if it were copied at length herein.

SURETY, for value received, stipulates and agrees that no change, extension of time, alteration or addition to the terms of the contract, or to the work performed thereunder, or the plans, specifications or drawings accompanying the same, shall in anywise affect its obligation on this bond, and it does hereby waive notice of any such change, extension of time, alteration or addition to the terms of the contract, or to the work to be performed thereunder,

IN WITNESS WHEREOF, the said Principal and Surety have signed this instrument this day 19th of July, 2016

Witness Omar Flores

2GS, LLC

By: _____

Humberto Garcia, Jr

Witness Phil Young

Hartford Fire Insurance Company

By: _____

Andy Alvarez Attorney-In-Fact

IMPORTANT NOTICE

To obtain information or make a complaint:

You may contact your agent.

You may call Hartford Insurance Group at the toll free telephone number for information or to make a complaint at:

1-800-392-7805

You may also write to The Hartford:

The Hartford
Hartford Financial Products
2 Park Avenue, 5th Floor
New York, New York 10016
1-212-277-0400

You may contact the Texas Department of Insurance to obtain information on companies, coverages, rights or complaints at:

1-800-252-3439

You may write the Texas Department of Insurance

P.O. Box 149104
Austin, TX 78714-9104
Fax Number (512) 475-1771
Web: http://www.tdi.state.tx.us
E-mail: ConsumerProtection@tdi.state.tx.us

PREMIUM OR CLAIMS DISPUTES: Should you have a dispute concerning your premium or about a claim you should contact the agent first. If the dispute is not resolved, you may contact the Texas Department of Insurance.

ATTACH THIS NOTICE TO YOUR POLICY: This notice is for your information only and does not become a part or condition of the attached document.

AVISO IMPORTANTE

Para obtener informacion o para someter una queja.

Puede comunicarse con su agente.

Usted puede llamar al numero de telefono gratis de The Hartford Insurance Group para informacion o para someter una queja al

1-800-392-7805

Usted tambien puede escribir a The Hartford.

The Hartford
Hartford Financial Products
2 Park Avenue, 5th Floor
New York, New York 10016
1-212-277-0400

Puede comunicarse con el Departamento de Seguros de Texas para obtener informacion acerca de compañías, coberturas, derechos o quejas al:

1-800-252-3439

Puede escribir al Departamento de Seguros de Texas

P.O. Box 149104
Austin, TX 78714-9104
Fax Number (512) 475-1771
Web: http://www.tdi.state.tx.us
E-mail: ConsumerProtection@tdi.state.tx.us

DISPUTAS SOBRE PRIMAS O RECLAMOS: Si tiene una disputa concerniente a su prima o a un reclamo, debe comunicarse con su agente primero. Si no se resuelve la disputa, puede entonces comunicarse con el departamento (TDI).

UNA ESTE AVISO A SU POLIZA: Este aviso es solo para proposito de informacion y no se convierte en parte o condicion del documento adjunto.

POWER OF ATTORNEY

Direct Inquiries/Claims to:
THE HARTFORD
Bond T-4
One Hartford Plaza
Hartford, Connecticut 06155
call: **888-266-3488** *or fax:* **860-757-5835)**

KNOW ALL PERSONS BY THESE PRESENTS THAT: **Agency Code:** 65-813646

- [x] **Hartford Fire Insurance Company**, a corporation duly organized under the laws of the State of Connecticut
- [x] **Hartford Casualty Insurance Company**, a corporation duly organized under the laws of the State of Indiana
- [ ] **Hartford Accident and Indemnity Company**, a corporation duly organized under the laws of the State of Connecticut
- [ ] **Hartford Underwriters Insurance Company**, a corporation duly organized under the laws of the State of Connecticut
- [ ] **Twin City Fire Insurance Company**, a corporation duly organized under the laws of the State of Indiana
- [ ] **Hartford Insurance Company of Illinois**, a corporation duly organized under the laws of the State of Illinois
- [ ] **Hartford Insurance Company of the Midwest**, a corporation duly organized under the laws of the State of Indiana
- [ ] **Hartford Insurance Company of the Southeast,** a corporation duly organized under the laws of the State of Florida

having their home office in Hartford, Connecticut (hereinafter collectively referred to as the "Companies") do hereby make, constitute and appoint, ***up to the amount of*** Unlimited :

Andy Alvarez, Phil Young, Dewey Young of SAN JUAN, Texas

their true and lawful Attorney(s)-in-Fact, each in their separate capacity if more than one is named above, to sign its name as surety(ies) only as delineated above by ☒, and to execute, seal and acknowledge any and all bonds, undertakings, contracts and other written instruments in the nature thereof, on behalf of the Companies in their business of guaranteeing the fidelity of persons, guaranteeing the performance of contracts and executing or guaranteeing bonds and undertakings required or permitted in any actions or proceedings allowed by law.

In Witness Whereof, and as authorized by a Resolution of the Board of Directors of the Companies on August 1, 2009, the Companies have caused these presents to be signed by its Vice President and its corporate seals to be hereto affixed, duly attested by its Assistant Secretary. Further, pursuant to Resolution of the Board of Directors of the Companies, the Companies hereby unambiguously affirm that they are and will be bound by any mechanically applied signatures applied to this Power of Attorney.

Wesley W. Cowling, Assistant Secretary

M. Ross Fisher, Vice President

STATE OF CONNECTICUT }
COUNTY OF HARTFORD } ss. Hartford

On this 12th day of July, 2012, before me personally came M. Ross Fisher, to me known, who being by me duly sworn, did depose and say: that he resides in the County of Hartford, State of Connecticut; that he is the Vice President of the Companies, the corporations described in and which executed the above instrument; that he knows the seals of the said corporations; that the seals affixed to the said instrument are such corporate seals; that they were so affixed by authority of the Boards of Directors of said corporations and that he signed his name thereto by like authority.

Kathleen T. Maynard
Notary Public
My Commission Expires July 31, 2016

CERTIFICATE

I, the undersigned, Vice President of the Companies, DO HEREBY CERTIFY that the above and foregoing is a true and correct copy of the Power of Attorney executed by said Companies, which is still in full force effective as of July 19th, 2016

Signed and sealed at the City of Hartford.

Gary W. Stumper, Vice President

FORM I.4

CONTRACTOR'S CERTIFICATE OF INSURANCE

The Contractor shall furnish proof of insurance, which will also include any subcontractor that is subcontracted by the Contractor in at least the following limits, to be in place prior to providing any services under this Contract and to continue at all times in force in effect during the term of this Contract:

(1) Automobile liability insurance policy with limits of at least three hundred thousand dollars ($300,000.00) per person and five hundred thousand dollars $500,000.00 per occurrence, consistent with potential exposure to Hidalgo County under the Texas Tort Claims Act. Coverage should injury to or death of persons and property damage claims (with limits up to five hundred thousand dollars ($500,000.00)) arising out of the services provided to Hidalgo County hereunder;

(2) Uninsured/Underinsured motorist coverage in an amount equal to the bodily injury limits set forth immediately above;

(3) A five hundred thousand dollar ($500,000.00) Comprehensive General Liability insurance policy providing additional coverage to all underlying liabilities of Hidalgo County consistent with potential exposure of Hidalgo County under the Texas Tort Claims Act;

(4) Workers compensation insurance in amounts established by Texas law, unless the Bidder is specifically exempted from the Texas Workers' Compensation Act, Texas Labor Code Chapter 401, et. seq.

Certificates of insurance naming Hidalgo County as an additional insured shall be submitted to Hidalgo County for approval prior to any services being performed by Contractor. Each policy of insurance required hereunder shall extend for a period equivalent to, or longer than the term of the Contract, and any insurer hereunder shall be required to give at least thirty (30) days written notice to Hidalgo County prior to the cancellation of any such coverage on the termination date, or otherwise. This Contract shall be automatically suspended upon the cancellation, or other termination, of any required policy of insurance hereunder, and such suspension shall continue until evidence adequate replacement coverage is provided to Hidalgo County. If replacement coverage is not provided within thirty (30) days following suspension of the Contract, this Contract shall automatically terminate.

CERTIFICATE OF LIABILITY INSURANCE

DATE (MM/DD/YYYY): 7/5/2016

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

IMPORTANT: If the certificate holder is an ADDITIONAL INSURED, the policy(ies) must be endorsed. If SUBROGATION IS WAIVED, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer rights to the certificate holder in lieu of such endorsement(s).

PRODUCER
Higginbotham Insurance Agency, Inc.
1400 McColl Rd. Ste 105
McAllen TX 78501

CONTACT NAME: Leticia Gallegos
PHONE (A/C, No, Ext): 956-668-3516 FAX (A/C, No): 956-687-1286
E-MAIL ADDRESS: leticia.gallegos@higginbotham.net

INSURER(S) AFFORDING COVERAGE	NAIC #
INSURER A : James River Insurance Company	12203
INSURER B : Ohio Security Insurance Company	24082
INSURER C : Texas Mutual Insurance Company	22945
INSURER D : The Travelers Lloyds Insurance Co	41262
INSURER E :	
INSURER F :	

INSURED
2GSLL
2GS, LLC. dba Earthworks Enterprise
PO Box 595
Penitas TX 78576

COVERAGES **CERTIFICATE NUMBER:** 2057494271 **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSD	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS	
A	X COMMERCIAL GENERAL LIABILITY CLAIMS-MADE X OCCUR X 5,000 GEN'L AGGREGATE LIMIT APPLIES PER: POLICY PRO-JECT LOC OTHER:	Y	Y	000703560	2/21/2016	2/21/2017	EACH OCCURRENCE DAMAGE TO RENTED PREMISES (Ea occurrence) MED EXP (Any one person) PERSONAL & ADV INJURY GENERAL AGGREGATE PRODUCTS - COMP/OP AGG $	$1,000,000 $50,000 $1,000 $1,000,000 $2,000,000 $2,000,000
B	AUTOMOBILE LIABILITY X ANY AUTO ALL OWNED AUTOS SCHEDULED AUTOS HIRED AUTOS NON-OWNED AUTOS	Y	Y	BAS55991781	2/21/2016	2/21/2017	COMBINED SINGLE LIMIT (Ea accident) BODILY INJURY (Per person) BODILY INJURY (Per accident) PROPERTY DAMAGE (Per accident) $	$1,000,000 $ $ $
	UMBRELLA LIAB OCCUR EXCESS LIAB CLAIMS-MADE DED RETENTION $						EACH OCCURRENCE AGGREGATE $	$ $
C	WORKERS COMPENSATION AND EMPLOYERS' LIABILITY ANY PROPRIETOR/PARTNER/EXECUTIVE OFFICER/MEMBER EXCLUDED? (Mandatory in NH) Y / N N/A If yes, describe under DESCRIPTION OF OPERATIONS below		Y	TSF0001234244	2/21/2016	2/21/2017	X PER STATUTE OTH-ER E.L. EACH ACCIDENT E.L. DISEASE - EA EMPLOYEE E.L. DISEASE - POLICY LIMIT	 $1,000,000 $1,000,000 $1,000,000
D	Inland Marine			QT6608G686515TLC16	2/21/2016	2/21/2017	Limit Leased/Rented Deductible	$750,000 $200,000 $2,500

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

Automatic Additional insured Endorsement Construction or Service Contracts when required by written contract applies to General Liability and Auto policies.

Waiver of Transfer of Rights of Recovery Against Others to us applies to General Liability coverage when required by written contract.
Texas Waiver of our Right to Recover from Others applies to Workers Compensation coverage when agreed by written contract and as permitted by law.
Project: Hidalgo County Colonia Noreste Subdivision

CERTIFICATE HOLDER

Hidalgo County
2802 S Business Highway 281
Edinburg TX 78539

CANCELLATION

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE

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FORM I.5

SALES TAX AND LOCAL SALES TAX EXEMPTION CERTIFICATE FOR CONTRACTORS

This Contract is to be performed for an exempt organization as defined by Article 20.04 (H)(4) of the Texas Limited Sales, Excise, and Use Tax Act and the undersigned hereby claims an exemption from payment of taxes under Chapter 20, Title 122A, revised civil statutes of Texas, and Article 1066 (C), entitle Local Sales and Use Tax, revised civil statutes of Texas.

The Contractor performing this Contract may purchase, rent, or lease materials, supplies, equipment used or consumed in the performance of this Contract by issuing to his retailer an exemption certificate in lieu of the tax, said exemption certificate complying with State Comptroller's Ruling No. 95.9.07. Any such exemption certificate issued by the Contractor in lieu of the tax shall be subject to the provisions of the State Comptroller's Ruling No. 905.0.09 as amended to be effective October 2, 1968.

EXECUTED this the 5th day of July 2016.

CONTRACTOR: Earthworks Enterprise

Principal Signature: _____ Date: July 5, 2016

Name / Title: Humberto García, Jr., Member

Address: P. O. Box 595, Peñitas, TX 78576-0595
(Street, City, State, Zip)

FORM I.6

AFFIDAVIT AND WAIVER OF LIEN
CONTRACTOR

The State of Texas §
§
County of Hidalgo §

THIS AFFIDAVIT TO BE COMPLETED AND SUBMITTED UPON ACCEPTANCE OF COMPLETED PROJECT BY OWNER AND PRIOR TO FINAL PAYMENT.

_____, the undersigned Principal of _____, Contractor, personally appeared before me, the undersigned Notary Public in and for Hidalgo County, Texas, who being duly sworn by me states on oath that all product suppliers, subcontractors, payrolls, sales tax, privilege tax or license, old age benefits tax, state and federal unemployment insurance, and other liabilities in the performance of **Contract No.** _____ **Paving and Drainage Improvements for Colonia Noreste Subdivision**, Project, have been paid in full, and that the above named Contractor waives any claims and releases to Hidalgo County, Owner, from any rights or claims (including lien rights) for debts due and owing by virtue of the furnishing of any labor, products, and supplies furnished for the Project.

The above named Contractor agrees to indemnify the Owner and save him harmless on account of any loss Contractor may sustain in reliance upon this Affidavit and Waiver of Lien including the amount of any lien Contractor may be compelled to pay all costs relating thereto and a reasonable attorney's fee.

CONTRACTOR: _____

Signature:_____ Date: _____

Name / Title: _____

Address: _____
(Street, City, State, Zip)

Subscribed and sworn to before me this _____day of _____, 20__.

By: _____, Notary Public in and for Hidalgo County, Texas.
My commission expires _____.

FORM I.7

RELEASE AND WAIVER OF CLAIMS BY SUBCONTRACTORS AND PRODUCT VENDORS

The State of Texas §
§
County of Hidalgo §

THIS AFFIDAVIT TO BE COMPLETED BY EACH SUBCONTRACTOR AND VENDOR AND SUBMITTED PRIOR TO FINAL PAYMENT.

_____, the undersigned Principal of _____, Sub-Contractor / Vendor, personally appeared before me, the undersigned Notary Public in and for Hidalgo County, Texas, who being duly sworn by me states on oath that all bills for labor and products, subcontractors, payrolls, sales tax, privilege tax or license, old age benefits tax, state and federal unemployment insurance, and other liabilities in the performance of subcontract for furnishing labor or products in the construction of **Contract No. _____ Paving and Drainage Improvements for Colonia Noreste Subdivision**, Project, have been paid in full or that funds are in hand to discharge such liabilities when due, and that the above named Sub-Contractor / Vendor waives any claims and releases to Hidalgo County, Owner, and _____, Contractor, from any rights or claims (including lien rights) for debts due and owing by virtue of the furnishing of any labor, products, and supplies furnished for the Project.

SUB-CONTRACTOR OR VENDOR: _____

Signature:_____ Date: _____

Name / Title: _____

Address: _____
(Street, City, State, Zip)

Subscribed and sworn to before me this _____day of _____, 20__.

By: _____, Notary Public in and for Hidalgo County, Texas.

My commission expires _____.

FORM I.8

CONTRACTOR'S AFFIDAVIT AS TO STATUS OF LIEN

The State of Texas §
§
County of Hidalgo §

THIS AFFIDAVIT TO BE COMPLETED AND SUBMITTED UPON ACCEPTANCE OF COMPLETED PROJECT BY OWNER AND PRIOR TO FINAL PAYMENT.

_____, the undersigned Principal of _____, Contractor, personally appeared before me, the undersigned Notary Public in and for Hidalgo County, Texas, who being duly sworn by me states on oath that to the best of his knowledge and belief, except as listed below, the Releases and Waivers of Claim attached hereto include all subcontractors and vendor of labor, products, and equipment provided by all persons who may have liens against the property of Hidalgo County, Owner, arising out of the construction of **Contract No.** _____ **Paving and Drainage Improvements for Colonia Noreste Subdivision** Project.

Exceptions: (If none, write "None".) Any exception listed shall be bonded by the Contractor to indemnify the Owner, and a copy of each bond shall be attached hereto.

1.
2.
3.
4.

CONTRACTOR: _____

Signature:_____ Date: _____

Name / Title: _____

Address: _____
(Street, City, State, Zip)

Subscribed and sworn to before me this _____day of _____, 20__

By: _____, Notary Public in and for Hidalgo County, Texas.
My commission expires _____.

FORM I.9
WAGE RATES
(GENERAL DECISION NO: TX160008 01/08/2016)

General Decision Number: TX160008 01/08/2016 TX8

Superseded General Decision Number: TX20150008

State: Texas

Construction Types: Heavy and Highway

Counties: Cameron, Hidalgo and Webb Counties in Texas.

HEAVY & HIGHWAY CONSTRUCTION PROJECTS

Note: Under Executive Order (EO) 13658, an hourly minimum wage of $10.15 for calendar year 2016 applies to all contracts subject to the Davis-Bacon Act for which the solicitation was issued on or after January 1, 2015. If this contract is covered by the EO, the contractor must pay all workers in any classification listed on this wage determination at least $10.15 (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on the contract in calendar year 2016. The EO minimum wage rate will be adjusted annually. Additional information on contractor requirements and worker protections under the EO is available at www.dol.gov/whd/govcontracts.

Modification Number	Publication Date
0	01/08/2016

* SUTX2011-003 08/02/2011

	Rates	Fringes
CEMENT MASON/CONCRETE FINISHER (Paving & Structures)	$ 12.46	
FORM BUILDER/FORM SETTER (Structures)	$ 12.30	
FORM SETTER (Paving & Curb)	$ 12.16	
LABORER		
Asphalt Raker	$ 10.61	
Flagger	$ 9.10	
Laborer, Common	$ 9.86	
Laborer, Utility	$ 11.53	
Pipelayer	$ 11.87	
Work Zone Barricade Servicer	$ 12.88	
POWER EQUIPMENT OPERATOR:		
Asphalt Distributor	$ 13.48	
Asphalt Paving Machine	$ 12.25	
Broom or Sweeper	$ 10.33	
Crane, Lattice Boom 80 Tons or Less	$ 14.39	
Crawler Tractor	$ 16.63	
Excavator, 50,000 lbs or less	$ 12.56	
Excavator, over 50,000 lbs	$ 15.23	
Foundation Drill, Truck Mounted	$ 16.86	
Front End Loader Operator, Over 3 CY	$ 13.69	

Front End Loader, 3 CY or less.....$ 13.49
Loader/Backhoe.....$ 12.77
Mechanic.....$ 15.47
Milling Machine.....$ 14.64
Motor Grader Operator, Rough.....$ 14.62
Motor Grader, Fine Grade....$ 16.52
Scraper.....$ 11.07

Servicer.....$ 12.34

Steel Worker (Reinforcing).....$ 14.07

TRUCK DRIVER
Lowboy-Float.....$ 13.63
Single Axle.....$ 10.82
Single or Tandem Axle Dump..$ 14.53
Tandem Axle Tractor with Semi Trailer.....$ 12.12

WELDER.....$ 14.02

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

==========

Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of "identifiers" that indicate whether the particular rate is a union rate (current union negotiated rate for local), a survey rate (weighted average rate) or a union average rate (weighted union average rate).

Union Rate Identifiers

A four letter classification abbreviation identifier enclosed in dotted lines beginning with characters other than "SU" or "UAVG" denotes that the union classification and rate were prevailing for that classification in the survey. Example: PLUM0198-005 07/01/2014. PLUM is an abbreviation identifier of the union which prevailed in the survey for this classification, which in this example would be Plumbers. 0198 indicates the local union number or district council number where applicable, i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. 07/01/2014 is the effective date of the most current negotiated rate, which in this example is July 1, 2014.

Union prevailing wage rates are updated to reflect all rate

changes in the collective bargaining agreement (CBA) governing this classification and rate.

Survey Rate Identifiers

Classifications listed under the "SU" identifier indicate that no one rate prevailed for this classification in the survey and the published rate is derived by computing a weighted average rate based on all the rates reported in the survey for that classification. As this weighted average rate includes all rates reported in the survey, it may include both union and non-union rates. Example: SULA2012-007 5/13/2014. SU indicates the rates are survey rates based on a weighted average calculation of rates and are not majority rates. LA indicates the State of Louisiana. 2012 is the year of survey on which these classifications and rates are based. The next number, 007 in the example, is an internal number used in producing the wage determination. 5/13/2014 indicates the survey completion date for the classifications and rates under that identifier.

Survey wage rates are not updated and remain in effect until a new survey is conducted.

Union Average Rate Identifiers

Classification(s) listed under the UAVG identifier indicate that no single majority rate prevailed for those classifications; however, 100% of the data reported for the classifications was union data. EXAMPLE: UAVG-OH-0010 08/29/2014. UAVG indicates that the rate is a weighted union average rate. OH indicates the state. The next number, 0010 in the example, is an internal number used in producing the wage determination. 08/29/2014 indicates the survey completion date for the classifications and rates under that identifier.

A UAVG rate will be updated once a year, usually in January of each year, to reflect a weighted average of the current negotiated/CBA rate of the union locals from which the rate is based.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

* an existing published wage determination
* a survey underlying a wage determination
* a Wage and Hour Division letter setting forth a position on a wage determination matter
* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour Regional Office for the area in which the survey was conducted because those Regional Offices have responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the

Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations
Wage and Hour Division
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

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END OF GENERAL DECISION

PART II

GENERAL CONDITIONS

II.1 STANDARD GENERAL CONDITIONS

II.2 SUPPLEMENTARY GENERAL CONDITIONS

II.3 GOVERNING SPECIFICATIONS

II.4 GENERAL NOTES

STANDARD GENERAL CONDITIONS OF THE CONSTRUCTION CONTRACT

Prepared by

ENGINEERS JOINT CONTRACT DOCUMENTS COMMITTEE

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TABLE OF CONTENTS

Page

ARTICLE 1 - DEFINITIONS AND TERMINOLOGY 6
1.01 *Defined Terms* 6
1.02 *Terminology* 8

ARTICLE 2 - PRELIMINARY MATTERS 9
2.01 *Delivery of Bonds* 9
2.02 *Copies of Documents* 9
2.03 *Commencement of Contract Times; Notice to Proceed* 9
2.04 *Starting the Work* 9
2.05 *Before Starting Construction* 9
2.06 *Preconstruction Conference* 10
2.07 *Initial Acceptance of Schedules* 10

ARTICLE 3 - CONTRACT DOCUMENTS: INTENT, AMENDING, REUSE 10
3.01 *Intent* 10
3.02 *Reference Standards* 10
3.03 *Reporting and Resolving Discrepancies* 10
3.04 *Amending and Supplementing Contract Documents* 11
3.05 *Reuse of Documents* 11

ARTICLE 4 - AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; REFERENCE POINTS 11
4.01 *Availability of Lands* 11
4.02 *Subsurface and Physical Conditions* 12
4.03 *Differing Subsurface or Physical Conditions* 12
4.04 *Underground Facilities* 13
4.05 *Reference Points* 13
4.06 *Hazardous Environmental Condition at Site* 14

ARTICLE 5 - BONDS AND INSURANCE 15
5.01 *Performance, Payment, and Other Bonds* 15
5.02 *Licensed Sureties and Insurers* 15
5.03 *Certificates of Insurance* 15
5.04 *CONTRACTOR's Liability Insurance* 15
5.05 *OWNER's Liability Insurance* 16
5.06 *Property Insurance* 16
5.07 *Waiver of Rights* 17
5.08 *Receipt and Application of Insurance Proceeds* 18
5.09 *Acceptance of Bonds and Insurance; Option to Replace* 18
5.10 *Partial Utilization, Acknowledgment of Property Insurer* 18

ARTICLE 6 - CONTRACTOR'S RESPONSIBILITIES 18
6.01 *Supervision and Superintendence* 18
6.02 *Labor; Working Hours* 19
6.03 *Services, Materials, and Equipment* 19
6.04 *Progress Schedule* 19
6.05 *Substitutes and "Or-Equals"* 19
6.06 Concerning Subcontractors, Suppliers, and Others *21*

6.07 *Patent Fees and Royalties* 21
6.08 *Permits* 22
6.09 *Laws and Regulations* 22
6.10 *Taxes* 22
6.11 *Use of Site and Other Areas* 22
6.12 *Record Documents* 22
6.13 *Safety and Protection* 23
6.14 *Safety Representative* 23
6.15 *Hazard Communication Programs* 23
6.16 *Emergencies* 23
6.17 *Shop Drawings and Samples* 24
6.18 *Continuing the Work* 25
6.19 *CONTRACTOR's General Warranty and Guarantee* 25
6.20 *Indemnification* 25

ARTICLE 7 - OTHER WORK 26
7.01 *Related Work at Site* 26
7.02 *Coordination* 26

ARTICLE 8 - OWNER'S RESPONSIBILITIES 27
8.01 *Communications to Contractor* 27
8.02 *Replacement of ENGINEER* 27
8.03 *Furnish Data* 27
8.04 *Pay Promptly When Due* 27
8.05 *Lands and Easements; Reports and Tests* 27
8.06 *Insurance* 27
8.07 *Change Orders* 27
8.08 *Inspections, Tests, and Approvals* 27
8.09 *Limitations on OWNER's Responsibilities* 27
8.10 *Undisclosed Hazardous Environmental Condition* 27
8.11 *Evidence of Financial Arrangements* 27

ARTICLE 9 - ENGINEER'S STATUS DURING CONSTRUCTION 27
9.01 *OWNER'S Representative* 27
9.02 *Visits to Site* 28
9.03 *Project Representative* 28
9.04 *Clarifications and Interpretations* 28
9.05 *Authorized Variations in Work* 28
9.06 *Rejecting Defective Work* 29
9.07 *Shop Drawings, Change Orders and Payments* 29
9.08 Determinations for Unit Price Work *28*
9.09 *Decisions on Requirements of Contract Documents and Acceptability of Work* 28
9.10 *Limitations on ENGINEER's Authority and Responsibilities* 28

ARTICLE 10 - CHANGES IN THE WORK; CLAIMS 29
10.01 *Authorized Changes in the Work* 29
10.02 *Unauthorized Changes in the Work* 29
10.03 *Execution of Change Orders* 30
10.04 *Notification to Surety* 30
10.05 *Claims and Disputes* 30

ARTICLE 11 - COST OF THE WORK; CASH ALLOWANCES; UNIT PRICE WORK 30
11.01 *Cost of the Work* 30

11.02 *Cash Allowances* 32
11.03 *Unit Price Work* 33

ARTICLE 12 - CHANGE OF CONTRACT PRICE; CHANGE OF CONTRACT TIMES 33
12.01 *Change of Contract Price* 33
12.02 *Change of Contract Times* 34
12.03 *Delays Beyond CONTRACTOR's Control* 34
12.04 *Delays Within CONTRACTOR's Control* 34
1205 Delays Beyond OWNER's and CONTRACTOR'S Control *34*
12.06 *Delay Damages* 34

ARTICLE 13 - TESTS AND INSPECTIONS; CORRECTION, REMOVAL OR ACCEPTANCE OF DEFECTIVE WORK 34
13.01 *Notice of Defects* 34
13.02 *Access to Work* 34
13.03 *Tests and Inspections* 35
13.04 *Uncovering Work* 35
13.05 *OWNER May Stop the Work* 35
13.06 *Correction or Removal of Defective Work* 36
13.07 *Correction Period* 36
13.08 *Acceptance of Defective Work* 36
13.09 *OWNER May Correct Defective Work* 36

ARTICLE 14 - PAYMENTS TO CONTRACTOR AND COMPLETION 37
14.01 *Schedule of Values* 37
14.02 *Progress Payments* 37
14.03 *CONTRACTOR's Warranty of Title* 38
14.04 *Substantial Completion* 39
14.05 *Partial Utilization* 39
14.06 *Final Inspection* 39
14.07 *Final Payment* 40
14.08 *Final Completion Delayed* 40
14.09 *Waiver of Claims* 41

ARTICLE 15 - SUSPENSION OF WORK AND TERMINATION 41
15.01 OWNER May Suspend Work 41
15.02 *OWNER May Terminate for Cause* 41
15.03 *OWNER May Terminate For Convenience* 41
15.04 *CONTRACTOR May Stop Work or Terminate* 42

ARTICLE 16 - DISPUTE RESOLUTION 42
16.01 *Methods and Procedures* 42

ARTICLE 17 - MISCELLANEOUS 43
17.01 *Giving Notice* 43
17.02 *Computation of Times* 43
17.03 *Cumulative Remedies* 43
17.04 *Survival of Obligations* 43
17.05 *Controlling Law* 43

GENERAL CONDITIONS

ARTICLE 1 - DEFINITIONS AND TERMINOLOGY

1.01 *Defined Terms*

A. Wherever used in the Contract Documents and printed with initial or all capital letters, the terms listed below will have the meanings indicated which are applicable to both the singular and plural thereof.

1. *Addenda*--Written or graphic instruments issued prior to the opening of Bids which clarify, correct, or change the Bidding Requirements or the Contract Documents.

2. *Agreement*--The written instrument which is evidence of the agreement between OWNER and CONTRACTOR covering the Work.

3. *Application for Payment*--The form acceptable to ENGINEER which is to be used by CONTRACTOR during the course of the Work in requesting progress or final payments and which is to be accompanied by such supporting documentation as is required by the Contract Documents.

4. *Asbestos*--Any material that contains more than one percent asbestos and is friable or is releasing asbestos fibers into the air above current action levels established by the United States Occupational Safety and Health Administration.

5. *Bid*--The offer or proposal of a bidder submitted on the prescribed form setting forth the prices for the Work to be performed.

6. *Bidding Documents*--The Bidding Requirements and the proposed Contract Documents (including all Addenda issued prior to receipt of Bids).

7. *Bidding Requirements*--The Advertisement or Invitation to Bid, Instructions to Bidders, Bid security form, if any, and the Bid form with any supplements.

8. *Bonds*--Performance and payment bonds and other instruments of security.

9. *Change Order*--A document recommended by ENGINEER which is signed by CONTRACTOR and OWNER and authorizes an addition, deletion, or revision in the Work or an adjustment in the Contract Price or the Contract Times, issued on or after the Effective Date of the Agreement.

10. *Claim*--A demand or assertion by OWNER or CONTRACTOR seeking an adjustment of Contract Price or Contract Times, or both, or other relief with respect to the terms of the Contract. A demand for money or services by a third party is not a Claim.

11. *Contract*--The entire and integrated written agreement between the OWNER and CONTRACTOR concerning the Work. The Contract supersedes prior negotiations, representations, or agreements, whether written or oral.

12. *Contract Documents*--The Contract Documents establish the rights and obligations of the parties and include the Agreement, Addenda (which pertain to the Contract Documents), CONTRACTOR's Bid (including documentation accompanying the Bid and any post Bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Agreement, the Notice to Proceed, the Bonds, these General Conditions, the Supplementary Conditions, the Specifications and the Drawings as the same are more specifically identified in the Agreement, together with all Written Amendments, Change Orders, Work Change Directives, Field Orders, and ENGINEER's written interpretations and clarifications issued on or after the Effective Date of the Agreement. Approved Shop Drawings and the reports and drawings of subsurface and physical conditions are not Contract Documents. Only printed or hard copies of the items listed in this paragraph are Contract Documents. Files in electronic media format of text, data, graphics, and the like that may be furnished by OWNER to CONTRACTOR are not Contract Documents.

13. *Contract Price*--The moneys payable by OWNER to CONTRACTOR for completion of the Work in accordance with the Contract Documents as stated in the Agreement (subject to the provisions of paragraph 11.03 in the case of Unit Price Work).

14. *Contract Times*--The number of days or the dates stated in the Agreement to: (i) achieve Substantial Completion; and (ii) complete the Work so that it is ready for final payment as evidenced by ENGINEER's written recommendation of final payment.

15. *CONTRACTOR*--The individual or entity with whom OWNER has entered into the Agreement.

16. *Cost of the Work*--See paragraph 11.01.A for definition.

17. *Drawings*--That part of the Contract Documents prepared or approved by ENGINEER which graphically shows the scope, extent, and character of the Work to be performed by CONTRACTOR. Shop Drawings and other CONTRACTOR submittals are not Drawings as so defined.

18. *Effective Date of the Agreement*--The date indicated in the Agreement on which it becomes effective, but if no such date is indicated, it means the date on which the Agreement is signed and delivered by the last of the two parties to sign and deliver.

19. *ENGINEER*--The individual or entity named as such in the Agreement.

20. *ENGINEER's Consultant*--An individual or entity having a contract with ENGINEER to furnish services as ENGINEER's independent professional associate or consultant with respect to the Project and who is identified as such in the Supplementary Conditions.

21. *Field Order*--A written order issued by ENGINEER which requires minor changes in the Work but which does not involve a change in the Contract Price or the Contract Times.

22. *General Requirements*--Sections of Division 1 of the Specifications. The General Requirements pertain to all sections of the Specifications.

23. *Hazardous Environmental Condition*--The presence at the Site of Asbestos, PCBs, Petroleum, Hazardous Waste, or Radioactive Material in such quantities or circumstances that may present a substantial danger to persons or property exposed thereto in connection with the Work.

24. *Hazardous Waste*--The term Hazardous Waste shall have the meaning provided in Section 1004 of the Solid Waste Disposal Act (42 USC Section 6903) as amended from time to time.

25. *Laws and Regulations; Laws or Regulations*--Any and all applicable laws, rules, regulations, ordinances, codes, and orders of any and all governmental bodies, agencies, authorities, and courts having jurisdiction.

26. *Liens*--Charges, security interests, or encumbrances upon Project funds, real property, or personal property.

27. *Milestone*--A principal event specified in the Contract Documents relating to an intermediate completion date or time prior to Substantial Completion of all the Work.

28. *Notice of Award*--The written notice by OWNER to the apparent successful bidder stating that upon timely compliance by the apparent successful bidder with the conditions precedent listed therein, OWNER will sign and deliver the Agreement.

29. *Notice to Proceed*--A written notice given by OWNER to CONTRACTOR fixing the date on which the Contract Times will commence to run and on which CONTRACTOR shall start to perform the Work under the Contract Documents.

30. *OWNER*--The individual, entity, public body, or authority with whom CONTRACTOR has entered into the Agreement and for whom the Work is to be performed.

31. *Partial Utilization*--Use by OWNER of a substantially completed part of the Work for the purpose for which it is intended (or a related purpose) prior to Substantial Completion of all the Work.

32. *PCBs*--Polychlorinated biphenyls.

33. *Petroleum*--Petroleum, including crude oil or any fraction thereof which is liquid at standard conditions of temperature and pressure (60 degrees Fahrenheit and 14.7 pounds per square inch absolute), such as oil, petroleum, fuel oil, oil sludge, oil refuse, gasoline, kerosene, and oil mixed with other non-Hazardous Waste and crude oils.

34. *Project*--The total construction of which the Work to be performed under the Contract Documents may be the whole, or a part as may be indicated elsewhere in the Contract Documents.

35. *Project Manual*--The bound documentary information prepared for bidding and constructing the Work. A listing of the contents of the Project Manual, which may be bound in one or more volumes, is contained in the table(s) of contents.

36. *Radioactive Material*--Source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954 (42 USC Section 2011 et seq.) as amended from time to time.

37. *Resident Project Representative*--The authorized representative of ENGINEER who may be assigned to the Site or any part thereof.

38. *Samples*--Physical examples of materials, equipment, or workmanship that are representative of some portion of the Work and which establish the standards by which such portion of the Work will be judged.

39. *Shop Drawings*--All drawings, diagrams, illustrations, schedules, and other data or information which are specifically prepared or assembled by or for CONTRACTOR and submitted by CONTRACTOR to illustrate some portion of the Work.

40. *Site*--Lands or areas indicated in the Contract Documents as being furnished by OWNER upon which the Work is to be performed, including rights-of-way and easements for access thereto, and such other lands furnished by OWNER which are designated for the use of CONTRACTOR.

41. *Specifications*--That part of the Contract Documents consisting of written technical descriptions of materials, equipment, systems, standards, and workmanship as applied to the Work and certain administrative details applicable thereto.

42. *Subcontractor*--An individual or entity having a direct contract with CONTRACTOR or with any other Subcontractor for the performance of a part of the Work at the Site.

43. *Substantial Completion*--The time at which the Work (or a specified part thereof) has progressed to the point where, in the opinion of ENGINEER, the Work (or a specified part thereof) is sufficiently complete, in accordance with the Contract Documents, so that the Work (or a specified part thereof) can be utilized for the purposes for which it is intended. The terms "substantially complete" and "substantially completed" as applied to all or part of the Work refer to Substantial Completion thereof.

44. *Supplementary Conditions*--That part of the Contract Documents which amends or supplements these General Conditions.

45. *Supplier*--A manufacturer, fabricator, supplier, distributor, materialman, or vendor having a direct contract with CONTRACTOR or with any Subcontractor to furnish materials or equipment to be incorporated in the Work by CONTRACTOR or any Subcontractor.

46. *Underground Facilities*--All underground pipelines, conduits, ducts, cables, wires, manholes, vaults, tanks, tunnels, or other such facilities or attachments, and any encasements containing such facilities, including those that convey electricity, gases, steam, liquid petroleum products, telephone or other communications, cable television, water, wastewater, storm water, other liquids or chemicals, or traffic or other control systems.

47. *Unit Price Work*--Work to be paid for on the basis of unit prices.

48. *Work*--The entire completed construction or the various separately identifiable parts thereof required to be provided under the Contract Documents. Work includes and is the result of performing or providing all labor, services, and documentation necessary to produce such construction, and furnishing, installing, and incorporating all materials and equipment into such construction, all as required by the Contract Documents.

49. *Work Change Directive*--A written statement to CONTRACTOR issued on or after the Effective Date of the Agreement and signed by OWNER and recommended by ENGINEER ordering an addition, deletion, or revision in the Work, or responding to differing or unforeseen subsurface or physical conditions under which the Work is to be performed or to emergencies. A Work Change Directive will not change the Contract Price or the Contract Times but is evidence that the parties expect that the change ordered or documented by a Work Change Directive will be incorporated in a subsequently issued Change Order following negotiations by the parties as to its effect, if any, on the Contract Price or Contract Times.

50. *Written Amendment*--A written statement modifying the Contract Documents, signed by OWNER and CONTRACTOR on or after the Effective Date of the Agreement and normally dealing with the nonengineering or nontechnical rather than strictly construction-related aspects of the Contract Documents.

1.02 *Terminology*

A. *Intent of Certain Terms or Adjectives*

1. Whenever in the Contract Documents the terms "as allowed," "as approved," or terms of like effect or import are used, or the adjectives "reasonable," "suitable," "acceptable," "proper," "satisfactory," or adjectives of like effect or import are used to describe an action or determination of ENGINEER as to the Work, it is intended that such action or determination will be solely to evaluate, in general, the completed Work for compliance with the requirements of and information in the Contract Documents and conformance with the design concept of the completed Project as a functioning whole as shown or indicated in the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective shall not be effective to assign to ENGINEER any duty or authority to supervise or direct the performance of the Work or any duty or authority to undertake responsibility contrary to the provisions of paragraph 9.10 or any other provision of the Contract Documents.

B. *Day*

1. The word "day" shall constitute a calendar day of 24 hours measured from midnight to the next midnight.

C. *Defective*

1. The word "defective," when modifying the word "Work," refers to Work that is unsatisfactory, faulty, or deficient in that it does not conform to the Contract Documents or does not meet the requirements of any inspection, reference standard, test, or approval referred to in the Contract Documents, or has been damaged prior to ENGINEER's recommendation of final payment (unless responsibility for the protection thereof has been assumed by OWNER at Substantial Completion in accordance with paragraph 14.04 or 14.05).

D. *Furnish, Install, Perform, Provide*

1. The word "furnish," when used in connection with services, materials, or equipment, shall mean to supply and deliver said services, materials, or equipment to the Site (or some other specified location) ready for use or installation and in usable or operable condition.

2. The word "install," when used in connection with services, materials, or equipment, shall mean to put into use or place in final position said services, materials, or equipment complete and ready for intended use.

3. The words "perform" or "provide," when used in connection with services, materials, or equipment, shall mean to furnish and install said services, materials, or equipment complete and ready for intended use.

4. When "furnish," "install," "perform," or "provide" is not used in connection with services, materials, or equipment in a context clearly requiring an obligation of CONTRACTOR, "provide" is implied.

E. Unless stated otherwise in the Contract Documents, words or phrases which have a well-known technical or construction industry or trade meaning are used in the Contract Documents in accordance with such recognized meaning.

ARTICLE 2 - PRELIMINARY MATTERS

2.01 *Delivery of Bonds*

A. When CONTRACTOR delivers the executed Agreements to OWNER, CONTRACTOR shall also deliver to OWNER such Bonds as CONTRACTOR may be required to furnish.

2.02 *Copies of Documents*

A. OWNER shall furnish to CONTRACTOR up to ten copies of the Contract Documents. Additional copies will be furnished upon request at the cost of reproduction.

2.03 *Commencement of Contract Times; Notice to Proceed*

A. The Contract Times will commence to run on the thirtieth day after the Effective Date of the Agreement or, if a Notice to Proceed is given, on the day indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within 30 days after the Effective Date of the Agreement. In no event will the Contract Times com-

mence to run later than the sixtieth day after the day of Bid opening or the thirtieth day after the Effective Date of the Agreement, whichever date is earlier.

2.04 *Starting the Work*

A. CONTRACTOR shall start to perform the Work on the date when the Contract Times commence to run. No Work shall be done at the Site prior to the date on which the Contract Times commence to run.

2.05 *Before Starting Construction*

A. *CONTRACTOR's Review of Contract Documents:* Before undertaking each part of the Work, CONTRACTOR shall carefully study and compare the Contract Documents and check and verify pertinent figures therein and all applicable field measurements. CONTRACTOR shall promptly report in writing to ENGINEER any conflict, error, ambiguity, or discrepancy which CONTRACTOR may discover and shall obtain a written interpretation or clarification from ENGINEER before proceeding with any Work affected thereby; however, CONTRACTOR shall not be liable to OWNER or ENGINEER for failure to report any conflict, error, ambiguity, or discrepancy in the Contract Documents unless CONTRACTOR knew or reasonably should have known thereof.

B. *Preliminary Schedules:* Within ten days after the Effective Date of the Agreement (unless otherwise specified in the General Requirements), CONTRACTOR shall submit to ENGINEER for its timely review:

1. a preliminary progress schedule indicating the times (numbers of days or dates) for starting and completing the various stages of the Work, including any Milestones specified in the Contract Documents;

2. a preliminary schedule of Shop Drawing and Sample submittals which will list each required submittal and the times for submitting, reviewing, and processing such submittal; and

3. a preliminary schedule of values for all of the Work which includes quantities and prices of items which when added together equal the Contract Price and subdivides the Work into component parts in sufficient detail to serve as the basis for progress payments during performance of the Work. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work.

C. *Evidence of Insurance:* Before any Work at the Site is started, CONTRACTOR and OWNER shall each deliver to the other, with copies to each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance which either of them or any additional insured may reasonably request) which CONTRACTOR and OWNER respectively are required to purchase and maintain in accordance with Article 5.

2.06 *Preconstruction Conference*

A. Within 20 days after the Contract Times start to run, but before any Work at the Site is started, a conference attended by CONTRACTOR, ENGINEER, and others as appropriate will be held to establish a working understanding among the parties as to the Work and to discuss the schedules referred to in paragraph 2.05.B, procedures for handling Shop Drawings and other submittals, processing Applications for Payment, and maintaining required records.

2.07 *Initial Acceptance of Schedules*

A. Unless otherwise provided in the Contract Documents, at least ten days before submission of the first Application for Payment a conference attended by CONTRACTOR, ENGINEER, and others as appropriate will be held to review for acceptability to ENGINEER as provided below the schedules submitted in accordance with paragraph 2.05.B. CONTRACTOR shall have an additional ten days to make corrections and adjustments and to complete and resubmit the schedules. No progress payment shall be made to CONTRACTOR until acceptable schedules are submitted to ENGINEER.

1. The progress schedule will be acceptable to ENGINEER if it provides an orderly progression of the Work to completion within any specified Milestones and the Contract Times. Such acceptance will not impose on ENGINEER responsibility for the progress schedule, for sequencing, scheduling, or progress of the Work nor interfere with or relieve CONTRACTOR from CONTRACTOR's full responsibility therefor.

2. CONTRACTOR's schedule of Shop Drawing and Sample submittals will be acceptable to ENGINEER if it provides a workable arrangement for reviewing and processing the required submittals.

3. CONTRACTOR's schedule of values will be acceptable to ENGINEER as to form and substance if it provides a reasonable allocation of the Contract Price to component parts of the Work.

ARTICLE 3 - CONTRACT DOCUMENTS: INTENT, AMENDING, REUSE

3.01 *Intent*

A. The Contract Documents are complementary; what is called for by one is as binding as if called for by all.

B. It is the intent of the Contract Documents to describe a functionally complete Project (or part thereof) to be constructed in accordance with the Contract Documents. Any labor, documentation, services, materials, or equipment that may reasonably be inferred from the Contract Documents or from prevailing custom or trade usage as being required to produce the intended result will be provided whether or not specifically called for at no additional cost to OWNER.

C. Clarifications and interpretations of the Contract Documents shall be issued by ENGINEER as provided in Article 9.

3.02 *Reference Standards*

A. *Standards, Specifications, Codes, Laws, and Regulations*

1. Reference to standards, specifications, manuals, or codes of any technical society, organization, or association, or to Laws or Regulations, whether such reference be specific or by implication, shall mean the standard, specification, manual, code, or Laws or Regulations in effect at the time of opening of Bids (or on the Effective Date of the Agreement if there were no Bids), except as may be otherwise specifically stated in the Contract Documents.

2. No provision of any such standard, specification, manual or code, or any instruction of a Supplier shall be effective to change the duties or responsibilities of OWNER, CONTRACTOR, or ENGINEER, or any of their subcontractors, consultants, agents, or employees from those set forth in the Contract Documents, nor shall any such provision or instruction be effective to assign to OWNER, ENGINEER, or any of ENGINEER's Consultants, agents, or employees any duty or authority to supervise or direct the performance of the Work or any duty or authority to undertake responsibility inconsistent with the provisions of the Contract Documents.

3.03 *Reporting and Resolving Discrepancies*

A. *Reporting Discrepancies*

1. If, during the performance of the Work, CONTRACTOR discovers any conflict, error, ambiguity, or discrepancy within the Contract Documents or between the Contract Documents and any provision of any Law or Regulation applicable to the performance of the Work or of any standard, specification, manual or code, or of any instruction of any Supplier, CONTRACTOR shall report it to ENGINEER in writing at once. CONTRACTOR shall not proceed with the Work affected thereby (except in an emergency as required by paragraph 6.16.A) until an amendment or supplement to the Contract Documents has been issued by one of the methods indicated in paragraph 3.04; provided, however, that CONTRACTOR shall not be liable to OWNER or ENGINEER for failure to report any such conflict, error, ambiguity, or discrepancy unless CONTRACTOR knew or reasonably should have known thereof.

B. *Resolving Discrepancies*

1. Except as may be otherwise specifically stated in the Contract Documents, the provisions of the Contract Documents shall take precedence in resolving any conflict, error, ambiguity, or discrepancy between the provisions of the Contract Documents and:

a. the provisions of any standard, specification, manual, code, or instruction (whether or not specifically incorporated by reference in the Contract Documents); or

b. the provisions of any Laws or Regulations applicable to the performance of the Work (unless such an interpretation of the provisions of the Contract Documents would result in violation of such Law or Regulation).

3.04 *Amending and Supplementing Contract Documents*

A. The Contract Documents may be amended to provide for additions, deletions, and revisions in the Work or to modify the terms and conditions thereof in one or

B. The requirements of the Contract Documents may be supplemented, and minor variations and deviations in the Work may be authorized, by one or more of the following ways: (i) a Field Order; (ii) ENGINEER's approval of a Shop Drawing or Sample; or (iii) ENGINEER's written interpretation or clarification.

3.05 *Reuse of Documents*

A. CONTRACTOR and any Subcontractor or Supplier or other individual or entity performing or furnishing any of the Work under a direct or indirect contract with OWNER: (i) shall not have or acquire any title to or ownership rights in any of the Drawings, Specifications, or other documents (or copies of any thereof) prepared by or bearing the seal of ENGINEER or ENGINEER's Consultant, including electronic media editions; and (ii) shall not reuse any of such Drawings, Specifications, other documents, or copies thereof on extensions of the Project or any other project without written consent of OWNER and ENGINEER and specific written verification or adaption by ENGINEER. This prohibition will survive final payment, completion, and acceptance of the Work, or termination or completion of the Contract. Nothing herein shall preclude CONTRACTOR from retaining copies of the Contract Documents for record purposes.

ARTICLE 4 - AVAILABILITY OF LANDS; SUBSURFACE AND PHYSICAL CONDITIONS; REFERENCE POINTS

4.01 *Availability of Lands*

A. OWNER shall furnish the Site. OWNER shall notify CONTRACTOR of any encumbrances or restrictions not of general application but specifically related to use of the Site with which CONTRACTOR must comply in performing the Work. OWNER will obtain in a timely manner and pay for easements for permanent structures or permanent changes in existing facilities. If CONTRACTOR and OWNER are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, as a result of any delay in OWNER's furnishing the Site, CONTRACTOR may make a Claim therefor as provided in paragraph 10.05.

B. Upon reasonable written request, OWNER shall furnish CONTRACTOR with a current statement of record legal title and legal description of the lands upon which the Work is to be performed and OWNER's interest therein as necessary for giving notice of or filing a mechanic's or construction lien against such lands in accordance with applicable Laws and Regulations.

C. CONTRACTOR shall provide for all additional lands and access thereto that may be required for temporary construction facilities or storage of materials and equipment.

4.02 *Subsurface and Physical Conditions*

A. *Reports and Drawings:* The Supplementary Conditions identify:

1. those reports of explorations and tests of subsurface conditions at or contiguous to the Site that ENGINEER has used in preparing the Contract Documents; and

2. those drawings of physical conditions in or relating to existing surface or subsurface structures at or contiguous to the Site (except Underground Facilities) that ENGINEER has used in preparing the Contract Documents.

B. *Limited Reliance by CONTRACTOR on Technical Data Authorized:* CONTRACTOR may rely upon the general accuracy of the "technical data" contained in such reports and drawings, but such reports and drawings are not Contract Documents. Such "technical data" is identified in the Supplementary Conditions. Except for such reliance on such "technical data," CONTRACTOR may not rely upon or make any Claim against OWNER, ENGINEER, or any of ENGINEER's Consultants with respect to:

1. the completeness of such reports and drawings for CONTRACTOR's purposes, includ-

ing, but not limited to, any aspects of the means, methods, techniques, sequences, and procedures of construction to be employed by CONTRACTOR, and safety precautions and programs incident thereto; or

2. other data, interpretations, opinions, and information contained in such reports or shown or indicated in such drawings; or

3. any CONTRACTOR interpretation of or conclusion drawn from any "technical data" or any such other data, interpretations, opinions, or information.

4.03 *Differing Subsurface or Physical Conditions*

A. *Notice:* If CONTRACTOR believes that any subsurface or physical condition at or contiguous to the Site that is uncovered or revealed either:

1. is of such a nature as to establish that any "technical data" on which CONTRACTOR is entitled to rely as provided in paragraph 4.02 is materially inaccurate; or

2. is of such a nature as to require a change in the Contract Documents; or

3. differs materially from that shown or indicated in the Contract Documents; or

4. is of an unusual nature, and differs materially from conditions ordinarily encountered and generally recognized as inherent in work of the character provided for in the Contract Documents; then CONTRACTOR shall, promptly after becoming aware thereof and before further disturbing the subsurface or physical conditions or performing any Work in connection therewith (except in an emergency as required by paragraph 6.16.A), notify OWNER and ENGINEER in writing about such condition. CONTRACTOR shall not further disturb such condition or perform any Work in connection therewith (except as aforesaid) until receipt of written order to do so.

B. *ENGINEER's Review:* After receipt of written notice as required by paragraph 4.03.A, ENGINEER will promptly review the pertinent condition, determine the necessity of OWNER's obtaining additional exploration or tests with respect thereto, and advise OWNER in writing (with a copy to CONTRACTOR) of ENGINEER's findings and conclusions.

C. *Possible Price and Times Adjustments*

1. The Contract Price or the Contract Times, or both, will be equitably adjusted to the extent that the existence of such differing subsurface or physical condition causes an increase or decrease in CONTRACTOR's cost of, or time required for, performance of the Work; subject, however, to the following:

a. such condition must meet any one or more of the categories described in paragraph 4.03.A; and

b. with respect to Work that is paid for on a Unit Price Basis, any adjustment in Contract Price will be subject to the provisions of paragraphs 9.08 and 11.03.

2. CONTRACTOR shall not be entitled to any adjustment in the Contract Price or Contract Times if:

a. CONTRACTOR knew of the existence of such conditions at the time CONTRACTOR made a final commitment to OWNER in respect of Contract Price and Contract Times by the submission of a Bid or becoming bound under a negotiated contract; or

b. the existence of such condition could reasonably have been discovered or revealed as a result of any examination, investigation, exploration, test, or study of the Site and contiguous areas required by the Bidding Requirements or Contract Documents to be conducted by or for CONTRACTOR prior to CONTRACTOR's making such final commitment; or

c. CONTRACTOR failed to give the written notice within the time and as required by paragraph 4.03.A.

3. If OWNER and CONTRACTOR are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, a Claim may be

made therefor as provided in paragraph 10.05. However, OWNER, ENGINEER, and ENGINEER's Consultants shall not be liable to CONTRACTOR for any claims, costs, losses, or damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by CONTRACTOR on or in connection with any other project or anticipated project.

4.04 *Underground Facilities*

A. *Shown or Indicated:* The information and data shown or indicated in the Contract Documents with respect to existing Underground Facilities at or contiguous to the Site is based on information and data furnished to OWNER or ENGINEER by the owners of such Underground Facilities, including OWNER, or by others. Unless it is otherwise expressly provided in the Supplementary Conditions:

1. OWNER and ENGINEER shall not be responsible for the accuracy or completeness of any such information or data; and

2. the cost of all of the following will be included in the Contract Price, and CONTRACTOR shall have full responsibility for:

a. reviewing and checking all such information and data,

b. locating all Underground Facilities shown or indicated in the Contract Documents,

c. coordination of the Work with the owners of such Underground Facilities, including OWNER, during construction, and

d. the safety and protection of all such Underground Facilities and repairing any damage thereto resulting from the Work.

B. *Not Shown or Indicated*

1. If an Underground Facility is uncovered or revealed at or contiguous to the Site which was not shown or indicated, or not shown or indicated with reasonable accuracy in the Contract Documents, CONTRACTOR shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith (except in an emergency as required by paragraph 6.16.A), identify the owner of such Underground Facility and give written notice to that owner and to OWNER and ENGINEER. ENGINEER will promptly review the Underground Facility and determine the extent, if any, to which a change is required in the Contract Documents to reflect and document the consequences of the existence or location of the Underground Facility. During such time, CONTRACTOR shall be responsible for the safety and protection of such Underground Facility.

2. If ENGINEER concludes that a change in the Contract Documents is required, a Work Change Directive or a Change Order will be issued to reflect and document such consequences. An equitable adjustment shall be made in the Contract Price of Contract Times, or both, to the extent that they are attributable to the existence or location of any Underground Facility that was not shown or indicated or not shown or indicated with reasonable accuracy in the Contract Documents and that CONTRACTOR did not know of and could not reasonably have been expected to be aware of or to have anticipated. If OWNER and CONTRACTOR are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment in Contract Price or Contract Times, OWNER or CONTRACTOR may make a Claim therefor as provided in paragraph 10.05.

4.05 *Reference Points*

A. OWNER shall provide engineering surveys to establish reference points for construction which in ENGINEER's judgment are necessary to enable CONTRACTOR to proceed with the Work. CONTRACTOR shall be responsible for laying out the Work, shall protect and preserve the established reference points and property monuments, and shall make no changes or relocations without the prior written approval of OWNER. CONTRACTOR shall report to ENGINEER whenever any reference point or property monument is lost or destroyed or requires relocation because of necessary changes in grades or locations, and shall be responsible for the accurate replacement or relocation of such reference points or property monuments by professionally qualified personnel.

4.06 *Hazardous Environmental Condition at Site*

A. *Reports and Drawings:* Reference is made to the Supplementary Conditions for the identification of those reports and drawings relating to a Hazardous Environmental Condition identified at the Site, if any, that have been utilized by the ENGINEER in the preparation of the Contract Documents.

B. *Limited Reliance by CONTRACTOR on Technical Data Authorized:* CONTRACTOR may rely upon the general accuracy of the "technical data" contained in such reports and drawings, but such reports and drawings are not Contract Documents. Such "technical data" is identified in the Supplementary Conditions. Except for such reliance on such "technical data," CONTRACTOR may not rely upon or make any Claim against OWNER, ENGINEER or any of ENGINEER's Consultants with respect to:

1. the completeness of such reports and drawings for CONTRACTOR's purposes, including, but not limited to, any aspects of the means, methods, techniques, sequences and procedures of construction to be employed by CONTRACTOR and safety precautions and programs incident thereto; or

2. other data, interpretations, opinions and information contained in such reports or shown or indicated in such drawings; or

3. any CONTRACTOR interpretation of or conclusion drawn from any "technical data" or any such other data, interpretations, opinions or information.

C. CONTRACTOR shall not be responsible for any Hazardous Environmental Condition uncovered or revealed at the Site which was not shown or indicated in Drawings or Specifications or identified in the Contract Documents to be within the scope of the Work. CONTRACTOR shall be responsible for a Hazardous Environmental Condition created with any materials brought to the Site by CONTRACTOR, Subcontractors, Suppliers, or anyone else for whom CONTRACTOR is responsible.

D. If CONTRACTOR encounters a Hazardous Environmental Condition or if CONTRACTOR or anyone for whom CONTRACTOR is responsible creates a Hazardous Environmental Condition, CONTRACTOR shall immediately: (i) secure or otherwise isolate such condition; (ii) stop all Work in connection with such condition and in any area affected thereby (except in an emergency as required by paragraph 6.16); and (iii) notify OWNER and ENGINEER (and promptly thereafter confirm such notice in writing). OWNER shall promptly consult with ENGINEER concerning the necessity for OWNER to retain a qualified expert to evaluate such condition or take corrective action, if any.

E. CONTRACTOR shall not be required to resume Work in connection with such condition or in any affected area until after OWNER has obtained any required permits related thereto and delivered to CONTRACTOR written notice: (i) specifying that such condition and any affected area is or has been rendered safe for the resumption of Work; or (ii) specifying any special conditions under which such Work may be resumed safely. If OWNER and CONTRACTOR cannot agree as to entitlement to or on the amount or extent, if any, of any adjustment in Contract Price or Contract Times, or both, as a result of such Work stoppage or such special conditions under which Work is agreed to be resumed by CONTRACTOR, either party may make a Claim therefor as provided in paragraph 10.05.

F. If after receipt of such written notice CONTRACTOR does not agree to resume such Work based on a reasonable belief it is unsafe, or does not agree to resume such Work under such special conditions, then OWNER may order the portion of the Work that is in the area affected by such condition to be deleted from the Work. If OWNER and CONTRACTOR cannot agree as to entitlement to or on the amount or extent, if any, of an adjustment in Contract Price or Contract Times as a result of deleting such portion of the Work, then either party may make a Claim therefor as provided in paragraph 10.05. OWNER may have such deleted portion of the Work performed by OWNER's own forces or others in accordance with Article 7.

G. To the fullest extent permitted by Laws and Regulations, OWNER shall indemnify and hold harmless CONTRACTOR, Subcontractors, ENGINEER, ENGINEER's Consultants and the officers, directors, partners, employees, agents, other consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition, provided that such Hazardous Environmental Condition: (i) was not shown or indicated in the Drawings or

Specifications or identified in the Contract Documents to be included within the scope of the Work, and (ii) was not created by CONTRACTOR or by anyone for whom CONTRACTOR is responsible. Nothing in this paragraph 4.06.E shall obligate OWNER to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

H. To the fullest extent permitted by Laws and Regulations, CONTRACTOR shall indemnify and hold harmless OWNER, ENGINEER, ENGINEER's Consultants, and the officers, directors, partners, employees, agents, other consultants, and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to a Hazardous Environmental Condition created by CONTRACTOR or by anyone for whom CONTRACTOR is responsible. Nothing in this paragraph 4.06.F shall obligate CONTRACTOR to indemnify any individual or entity from and against the consequences of that individual's or entity's own negligence.

I. The provisions of paragraphs 4.02, 4.03, and 4.04 are not intended to apply to a Hazardous Environmental Condition uncovered or revealed at the Site.

ARTICLE 5 - BONDS AND INSURANCE

5.01 *Performance, Payment, and Other Bonds*

A. CONTRACTOR shall furnish performance and payment Bonds, each in an amount at least equal to the Contract Price as security for the faithful performance and payment of all CONTRACTOR's obligations under the Contract Documents. These Bonds shall remain in effect at least until one year after the date when final payment becomes due, except as provided otherwise by Laws or Regulations or by the Contract Documents. CONTRACTOR shall also furnish such other Bonds as are required by the Contract Documents.

B. All Bonds shall be in the form prescribed by the Contract Documents except as provided otherwise by Laws or Regulations, and shall be executed by such sureties as are named in the current list of "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Circular 570 (amended) by the Financial Management Service, Surety Bond Branch, U.S. Department of the Treasury. All Bonds signed by an agent must be accompanied by a certified copy of such agent's authority to act.

C. If the surety on any Bond furnished by CONTRACTOR is declared bankrupt or becomes insolvent or its right to do business is terminated in any state where any part of the Project is located or it ceases to meet the requirements of paragraph 5.01.B, CONTRACTOR shall within 20 days thereafter substitute another Bond and surety, both of which shall comply with the requirements of paragraphs 5.01.B and 5.02.

5.02 *Licensed Sureties and Insurers*

A. All Bonds and insurance required by the Contract Documents to be purchased and maintained by OWNER or CONTRACTOR shall be obtained from surety or insurance companies that are duly licensed or authorized in the jurisdiction in which the Project is located to issue Bonds or insurance policies for the limits and coverages so required. Such surety and insurance companies shall also meet such additional requirements and qualifications as may be provided in the Supplementary Conditions.

5.03 *Certificates of Insurance*

A. CONTRACTOR shall deliver to OWNER, with copies to each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance requested by OWNER or any other additional insured) which CONTRACTOR is required to purchase and maintain. OWNER shall deliver to CONTRACTOR, with copies to each additional insured identified in the Supplementary Conditions, certificates of insurance (and other evidence of insurance requested by CONTRACTOR or any other additional insured) which OWNER is required to purchase and maintain.

5.04 *CONTRACTOR's Liability Insurance*

A. CONTRACTOR shall purchase and maintain such liability and other insurance as is appropriate for the Work being performed and as will provide protection from claims set forth below which may arise out of or result from CONTRACTOR's performance of the Work and CONTRACTOR's other obligations under the Contract Documents, whether it is to be performed by CONTRACTOR, any Subcontractor or Supplier, or by anyone directly or indirectly employed by any of them to

perform any of the Work, or by anyone for whose acts any of them may be liable:

1. claims under workers' compensation, disability benefits, and other similar employee benefit acts;

2. claims for damages because of bodily injury, occupational sickness or disease, or death of CONTRACTOR's employees;

3. claims for damages because of bodily injury, sickness or disease, or death of any person other than CONTRACTOR's employees;

4. claims for damages insured by reasonably available personal injury liability coverage which are sustained: (i) by any person as a result of an offense directly or indirectly related to the employment of such person by CONTRACTOR, or (ii) by any other person for any other reason;

5. claims for damages, other than to the Work itself, because of injury to or destruction of tangible property wherever located, including loss of use resulting therefrom; and

6. claims for damages because of bodily injury or death of any person or property damage arising out of the ownership, maintenance or use of any motor vehicle.

B. The policies of insurance so required by this paragraph 5.04 to be purchased and maintained shall:

1. with respect to insurance required by paragraphs 5.04.A.3 through 5.04.A.6 inclusive, include as additional insureds (subject to any customary exclusion in respect of professional liability) OWNER, ENGINEER, ENGINEER's Consultants, and any other individuals or entities identified in the Supplementary Conditions, all of whom shall be listed as additional insureds, and include coverage for the respective officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of all such additional insureds, and the insurance afforded to these additional insureds shall provide primary coverage for all claims covered thereby;

2. include at least the specific coverages and be written for not less than the limits of liability provided in the Supplementary Conditions or required by Laws or Regulations, whichever is greater;

3. include completed operations insurance;

4. include contractual liability insurance covering CONTRACTOR's indemnity obligations under paragraphs 6.07, 6.11, and 6.20;

5. contain a provision or endorsement that the coverage afforded will not be canceled, materially changed or renewal refused until at least thirty days prior written notice has been given to OWNER and CONTRACTOR and to each other additional insured identified in the Supplementary Conditions to whom a certificate of insurance has been issued (and the certificates of insurance furnished by the CONTRACTOR pursuant to paragraph 5.03 will so provide);

6. remain in effect at least until final payment and at all times thereafter when CONTRACTOR may be correcting, removing, or replacing defective Work in accordance with paragraph 13.07; and

7. with respect to completed operations insurance, and any insurance coverage written on a claims-made basis, remain in effect for at least two years after final payment (and CONTRACTOR shall furnish OWNER and each other additional insured identified in the Supplementary Conditions, to whom a certificate of insurance has been issued, evidence satisfactory to OWNER and any such additional insured of continuation of such insurance at final payment and one year thereafter).

5.05 *OWNER's Liability Insurance*

A. In addition to the insurance required to be provided by CONTRACTOR under paragraph 5.04, OWNER, at OWNER's option, may purchase and maintain at OWNER's expense OWNER's own liability insurance as will protect OWNER against claims which may arise from operations under the Contract Documents.

5.06 *Property Insurance*

A. Unless otherwise provided in the Supplementary Conditions, OWNER shall purchase and maintain property

insurance upon the Work at the Site in the amount of the full replacement cost thereof (subject to such deductible amounts as may be provided in the Supplementary Conditions or required by Laws and Regulations). This insurance shall:

1. include the interests of OWNER, CONTRACTOR, Subcontractors, ENGINEER, ENGINEER's Consultants, and any other individuals or entities identified in the Supplementary Conditions, and the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them, each of whom is deemed to have an insurable interest and shall be listed as an additional insured;

2. be written on a Builder's Risk "all-risk" or open peril or special causes of loss policy form that shall at least include insurance for physical loss or damage to the Work, temporary buildings, false work, and materials and equipment in transit, and shall insure against at least the following perils or causes of loss: fire, lightning, extended coverage, theft, vandalism and malicious mischief, earthquake, collapse, debris removal, demolition occasioned by enforcement of Laws and Regulations, water damage, and such other perils or causes of loss as may be specifically required by the Supplementary Conditions;

3. include expenses incurred in the repair or replacement of any insured property (including but not limited to fees and charges of engineers and architects);

4. cover materials and equipment stored at the Site or at another location that was agreed to in writing by OWNER prior to being incorporated in the Work, provided that such materials and equipment have been included in an Application for Payment recommended by ENGINEER;

5. allow for partial utilization of the Work by OWNER;

6. include testing and startup; and

7. be maintained in effect until final payment is made unless otherwise agreed to in writing by OWNER, CONTRACTOR, and ENGINEER with 30 days written notice to each other additional insured to whom a certificate of insurance has been issued.

B. OWNER shall purchase and maintain such boiler and machinery insurance or additional property insurance as may be required by the Supplementary Conditions or Laws and Regulations which will include the interests of OWNER, CONTRACTOR, Subcontractors, ENGINEER, ENGINEER's Consultants, and any other individuals or entities identified in the Supplementary Conditions, each of whom is deemed to have an insurable interest and shall be listed as an insured or additional insured.

C. All the policies of insurance (and the certificates or other evidence thereof) required to be purchased and maintained in accordance with paragraph 5.06 will contain a provision or endorsement that the coverage afforded will not be canceled or materially changed or renewal refused until at least 30 days prior written notice has been given to OWNER and CONTRACTOR and to each other additional insured to whom a certificate of insurance has been issued and will contain waiver provisions in accordance with paragraph 5.07.

D. OWNER shall not be responsible for purchasing and maintaining any property insurance specified in this paragraph 5.06 to protect the interests of CONTRACTOR, Subcontractors, or others in the Work to the extent of any deductible amounts that are identified in the Supplementary Conditions. The risk of loss within such identified deductible amount will be borne by CONTRACTOR, Subcontractors, or others suffering any such loss, and if any of them wishes property insurance coverage within the limits of such amounts, each may purchase and maintain it at the purchaser's own expense.

E. If CONTRACTOR requests in writing that other special insurance be included in the property insurance policies provided under paragraph 5.06, OWNER shall, if possible, include such insurance, and the cost thereof will be charged to CONTRACTOR by appropriate Change Order or Written Amendment. Prior to commencement of the Work at the Site, OWNER shall in writing advise CONTRACTOR whether or not such other insurance has been procured by OWNER.

5.07 *Waiver of Rights*

A. OWNER and CONTRACTOR intend that all policies purchased in accordance with paragraph 5.06 will protect OWNER, CONTRACTOR, Subcontractors, ENGINEER, ENGINEER's Consultants, and all other

individuals or entities identified in the Supplementary Conditions to be listed as insureds or additional insureds (and the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them) in such policies and will provide primary coverage for all losses and damages caused by the perils or causes of loss covered thereby. All such policies shall contain provisions to the effect that in the event of payment of any loss or damage the insurers will have no rights of recovery against any of the insureds or additional insureds thereunder. OWNER and CONTRACTOR waive all rights against each other and their respective officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them for all losses and damages caused by, arising out of or resulting from any of the perils or causes of loss covered by such policies and any other property insurance applicable to the Work; and, in addition, waive all such rights against Subcontractors, ENGINEER, ENGINEER's Consultants, and all other individuals or entities identified in the Supplementary Conditions to be listed as insureds or additional insureds (and the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them) under such policies for losses and damages so caused.

None of the above waivers shall extend to the rights that any party making such waiver may have to the proceeds of insurance held by OWNER as trustee or otherwise payable under any policy so issued.

B. OWNER waives all rights against CONTRACTOR, Subcontractors, ENGINEER, ENGINEER's Consultants, and the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them for:

1. loss due to business interruption, loss of use, or other consequential loss extending beyond direct physical loss or damage to OWNER's property or the Work caused by, arising out of, or resulting from fire or other peril whether or not insured by OWNER; and

2. loss or damage to the completed Project or part thereof caused by, arising out of, or resulting from fire or other insured peril or cause of loss covered by any property insurance maintained on the completed Project or part thereof by OWNER during partial utilization pursuant to paragraph 14.05, after Substantial Completion pursuant to paragraph 14.04, or after final payment pursuant to paragraph 14.07.

C. Any insurance policy maintained by OWNER covering any loss, damage or consequential loss referred to in paragraph 5.07.B shall contain provisions to the effect that in the event of payment of any such loss, damage, or consequential loss, the insurers will have no rights of recovery against CONTRACTOR, Subcontractors, ENGINEER, or ENGINEER's Consultants and the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them.

5.08 *Receipt and Application of Insurance Proceeds*

A.* Any insured loss under the policies of insurance required by paragraph 5.06 will be adjusted with OWNER and made payable to OWNER as fiduciary for the insureds, as their interests may appear, subject to the requirements of any applicable mortgage clause and of paragraph 5.08.B. OWNER shall deposit in a separate account any money so received and shall distribute it in accordance with such agreement as the parties in interest may reach. If no other special agreement is reached, the damaged Work shall be repaired or replaced, the moneys so received applied on account thereof, and the Work and the cost thereof covered by an appropriate Change Order or Written Amendment.

B. OWNER as fiduciary shall have power to adjust and settle any loss with the insurers unless one of the parties in interest shall object in writing within 15 days after the occurrence of loss to OWNER's exercise of this power. If such objection be made, OWNER as fiduciary shall make settlement with the insurers in accordance with such agreement as the parties in interest may reach. If no such agreement among the parties in interest is reached, OWNER as fiduciary shall adjust and settle the loss with the insurers and, if required in writing by any party in interest, OWNER as fiduciary shall give bond for the proper performance of such duties.

5.09 *Acceptance of Bonds and Insurance; Option to Replace*

A.* If either OWNER or CONTRACTOR has any objection to the coverage afforded by or other provisions of the Bonds or insurance required to be purchased and maintained by the other party in accordance with Article 5 on the basis of non-conformance with the Contract Documents, the objecting party shall so notify the other party in writing within 10 days after receipt of the

certificates (or other evidence requested) required by paragraph 2.05.C. OWNER and CONTRACTOR shall each provide to the other such additional information in respect of insurance provided as the other may reasonably request. If either party does not purchase or maintain all of the Bonds and insurance required of such party by the Contract Documents, such party shall notify the other party in writing of such failure to purchase prior to the start of the Work, or of such failure to maintain prior to any change in the required coverage. Without prejudice to any other right or remedy, the other party may elect to obtain equivalent Bonds or insurance to protect such other party's interests at the expense of the party who was required to provide such coverage, and a Change Order shall be issued to adjust the Contract Price accordingly.

5.10 *Partial Utilization, Acknowledgment of Property Insurer*

A. If OWNER finds it necessary to occupy or use a portion or portions of the Work prior to Substantial Completion of all the Work as provided in paragraph 14.05, no such use or occupancy shall commence before the insurers providing the property insurance pursuant to paragraph 5.06 have acknowledged notice thereof and in writing effected any changes in coverage necessitated thereby. The insurers providing the property insurance shall consent by endorsement on the policy or policies, but the property insurance shall not be canceled or permitted to lapse on account of any such partial use or occupancy.

ARTICLE 6 - CONTRACTOR'S RESPONSIBILITIES

6.01 *Supervision and Superintendence*

A. CONTRACTOR shall supervise, inspect, and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with

the Contract Documents. CONTRACTOR shall be solely responsible for the means, methods, techniques, sequences,
and procedures of construction, but CONTRACTOR shall not be responsible for the negligence of OWNER or ENGINEER in the design or specification of a specific means, method, technique, sequence, or procedure of construction which is shown or indicated in and expressly required by the Contract Documents. CONTRACTOR shall be responsible to see that the completed Work complies accurately with the Contract Documents.

B. At all times during the progress of the Work, CONTRACTOR shall assign a competent resident superintendent thereto who shall not be replaced without written notice to OWNER and ENGINEER except under extraordinary circumstances. The superintendent will be CONTRACTOR's representative at the Site and shall have authority to act on behalf of CONTRACTOR. All communications given to or received from the superintendent shall be binding on CONTRACTOR.

6.02 *Labor; Working Hours*

A. CONTRACTOR shall provide competent, suitably qualified personnel to survey, lay out, and construct the

Work as required by the Contract Documents. CONTRACTOR shall at all times maintain good discipline and order at the Site.

B. Except as otherwise required for the safety or protection of persons or the Work or property at the Site or adjacent thereto, and except as otherwise stated in the Contract Documents, all Work at the Site shall be performed during regular working hours, and CONTRACTOR will not permit overtime work or the performance of Work on Saturday, Sunday, or any legal holiday without OWNER's written consent (which will not be unreasonably withheld) given after prior written notice to ENGINEER.

6.03 *Services, Materials, and Equipment*

A. Unless otherwise specified in the General Requirements, CONTRACTOR shall provide and assume full responsibility for all services, materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, telephone, water, sanitary facilities, temporary facilities, and all other facilities and incidentals necessary for the performance, testing, start-up, and completion of the Work.

B. All materials and equipment incorporated into the Work shall be as specified or, if not specified, shall be of good quality and new, except as otherwise provided in the Contract Documents. All warranties and guarantees specifically called for by the Specifications shall expressly

run to the benefit of OWNER. If required by ENGINEER, CONTRACTOR shall furnish satisfactory evidence (including reports of required tests) as to the source, kind, and quality of materials and equipment. All materials and equipment shall be stored, applied, installed, connected, erected, protected, used, cleaned, and conditioned in accordance with instructions of the applicable Supplier, except as otherwise may be provided in the Contract Documents.

6.04 *Progress Schedule*

A. CONTRACTOR shall adhere to the progress schedule established in accordance with paragraph 2.07 as it may be adjusted from time to time as provided below.

1. CONTRACTOR shall submit to ENGINEER for acceptance (to the extent indicated in paragraph 2.07) proposed adjustments in the progress schedule that will not result in changing the Contract Times (or Milestones). Such adjustments will conform generally to the progress schedule then in effect and additionally will comply with any provisions of the General Requirements applicable thereto.

2. Proposed adjustments in the progress schedule that will change the Contract Times (or Milestones) shall be submitted in accordance with the requirements of Article 12. Such adjustments may only be made by a Change Order or Written Amendment in accordance with Article 12.

6.05 *Substitutes and "Or-Equals"*

A. Whenever an item of material or equipment is specified or described in the Contract Documents by using the name of a proprietary item or the name of a particular Supplier, the specification or description is intended to establish the type, function, appearance, and quality required. Unless the specification or description contains or is followed by words reading that no like, equivalent, or "or-equal" item or no substitution is permitted, other items of material or equipment or material or equipment of other Suppliers may be submitted to ENGINEER for review under the circumstances described below.

1. *"Or-Equal" Items:* If in ENGINEER's sole discretion an item of material or equipment proposed by CONTRACTOR is functionally equal to that named and sufficiently similar so that no change in related Work will be required, it may be considered by ENGINEER as an "or-equal" item, in which case review and approval of the proposed item may, in ENGINEER's sole discretion, be accomplished without compliance with some or all of the requirements for approval of proposed substitute items. For the purposes of this paragraph 6.05.A.1, a proposed item of material or equipment will be considered functionally equal to an item so named if:

a. in the exercise of reasonable judgment ENGINEER determines that: (i) it is at least equal in quality, durability, appearance, strength, and design characteristics; (ii) it will reliably perform at least equally well the function imposed by the design concept of the completed Project as a functioning whole, and;

b. CONTRACTOR certifies that: (i) there is no increase in cost to the OWNER; and (ii) it will conform substantially, even with deviations, to the detailed requirements of the item named in the Contract Documents.

2. Substitute Items

a. If in ENGINEER's sole discretion an item of material or equipment proposed by CONTRACTOR does not qualify as an "or-equal" item under paragraph 6.05.A.1, it will be considered a proposed substitute item.

b. CONTRACTOR shall submit sufficient information as provided below to allow ENGINEER to determine that the item of material or equipment proposed is essentially equivalent to that named and an acceptable substitute therefor. Requests for review of proposed substitute items of material or equipment will not be accepted by ENGINEER from anyone other than CONTRACTOR.

c. The procedure for review by ENGINEER will be as set forth in paragraph 6.05.A.2.d, as supplemented in the General Requirements and as ENGINEER may decide is appropriate under the circumstances.

d. CONTRACTOR shall first make written application to ENGINEER for review of a proposed substitute item of material or equipment that CONTRACTOR seeks to furnish or use. The application shall certify

that the proposed substitute item will perform adequately the functions and achieve the results called for by the general design, be similar in substance to that specified, and be suited to the same use as that specified. The application will state the extent, if any, to which the use of the proposed substitute item will prejudice CONTRACTOR's achievement of Substantial Completion on time, whether or not use of the proposed substitute item in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with OWNER for work on the Project) to adapt the design to the proposed substitute item and whether or not incorporation or use of the proposed substitute item in connection with the Work is subject to payment of any license fee or royalty. All variations of the proposed substitute item from that specified will be identified in the application, and available engineering, sales, maintenance, repair, and replacement services will be indicated. The application will also contain an itemized estimate of all costs or credits that will result directly or indirectly from use of such substitute item, including costs of redesign and claims of other contractors affected by any resulting change, all of which will be considered by ENGINEER in evaluating the proposed substitute item. ENGINEER may require CONTRACTOR to furnish additional data about the proposed substitute item.

B. *Substitute Construction Methods or Procedures:* If a specific means, method, technique, sequence, or procedure of construction is shown or indicated in and expressly required by the Contract Documents, CONTRACTOR may furnish or utilize a substitute means, method, technique, sequence, or procedure of construction approved by ENGINEER. CONTRACTOR shall submit sufficient information to allow ENGINEER, in ENGINEER's sole discretion, to determine that the substitute proposed is equivalent to that expressly called for by the Contract Documents. The procedure for review by ENGINEER will be similar to that provided in subparagraph 6.05.A.2.

C. *Engineer's Evaluation:* ENGINEER will be allowed a reasonable time within which to evaluate each proposal or submittal made pursuant to paragraphs 6.05.A and 6.05.B. ENGINEER will be the sole judge of acceptability. No "or-equal" or substitute will be ordered, installed or utilized until ENGINEER's review is complete, which will be evidenced by either a Change Order for a substitute or an approved Shop Drawing for an "or equal." ENGINEER will advise CONTRACTOR in writing of any negative determination.

D. *Special Guarantee:* OWNER may require CONTRACTOR to furnish at CONTRACTOR's expense a special performance guarantee or other surety with respect to any substitute.

E. *ENGINEER's Cost Reimbursement:* ENGINEER will record time required by ENGINEER and ENGINEER's Consultants in evaluating substitute proposed or submitted by CONTRACTOR pursuant to paragraphs 6.05.A.2 and 6.05.B and in making changes in the Contract Documents (or in the provisions of any other direct contract with OWNER for work on the Project) occasioned thereby. Whether or not ENGINEER approves a substitute item so proposed or submitted by CONTRACTOR, CONTRACTOR shall reimburse OWNER for the charges of ENGINEER and ENGINEER's Consultants for evaluating each such proposed substitute.

F. *CONTRACTOR's Expense:* CONTRACTOR shall provide all data in support of any proposed substitute or "or-equal" at CONTRACTOR's expense.

6.06 *Concerning Subcontractors, Suppliers, and Others*

A. CONTRACTOR shall not employ any Subcontractor, Supplier, or other individual or entity (including those acceptable to OWNER as indicated in paragraph 6.06.B), whether initially or as a replacement, against whom OWNER may have reasonable objection. CONTRACTOR shall not be required to employ any Subcontractor, Supplier, or other individual or entity to furnish or perform any of the Work against whom CONTRACTOR has reasonable objection.

B. If the Supplementary Conditions require the identity of certain Subcontractors, Suppliers, or other individuals or entities to be submitted to OWNER in advance for acceptance by OWNER by a specified date prior to the Effective Date of the Agreement, and if CONTRACTOR has submitted a list thereof in accordance with the Supplementary Conditions, OWNER's acceptance (either in writing or by failing to make written objection thereto by the date indicated for acceptance or objection in the Bidding Documents or the Contract Documents) of any such Subcontractor, Supplier, or other individual or entity so identified may be revoked on the basis of reasonable objection after due investigation. CONTRACTOR shall submit an acceptable replacement

for the rejected Subcontractor, Supplier, or other individual or entity, and the Contract Price will be adjusted by the difference in the cost occasioned by such replacement, and an appropriate Change Order will be issued or Written Amendment signed. No acceptance by OWNER of any such Subcontractor, Supplier, or other individual or entity, whether initially or as a replacement, shall constitute a waiver of any right of OWNER or ENGINEER to reject defective Work.

C. CONTRACTOR shall be fully responsible to OWNER and ENGINEER for all acts and omissions of the Subcontractors, Suppliers, and other individuals or entities performing or furnishing any of the Work just as CONTRACTOR is responsible for CONTRACTOR's own acts and omissions. Nothing in the Contract Documents shall create for the benefit of any such Subcontractor, Supplier, or other individual or entity any contractual relationship between OWNER or ENGINEER and any such Subcontractor, Supplier or other individual or entity, nor shall it create any obligation on the part of OWNER or ENGINEER to pay or to see to the payment of any moneys due any such Subcontractor, Supplier, or other individual or entity except as may otherwise be required by Laws and Regulations.

D. CONTRACTOR shall be solely responsible for scheduling and coordinating the Work of Subcontractors, Suppliers, and other individuals or entities performing or furnishing any of the Work under a direct or indirect contract with CONTRACTOR.

E. CONTRACTOR shall require all Subcontractors, Suppliers, and such other individuals or entities performing or furnishing any of the Work to communicate with ENGINEER through CONTRACTOR.

F. The divisions and sections of the Specifications and the identifications of any Drawings shall not control CONTRACTOR in dividing the Work among Subcontractors or Suppliers or delineating the Work to be performed by any specific trade.

G. All Work performed for CONTRACTOR by a Subcontractor or Supplier will be pursuant to an appropriate agreement between CONTRACTOR and the Subcontractor or Supplier which specifically binds the Subcontractor or Supplier to the applicable terms and conditions of the Contract Documents for the benefit of OWNER and ENGINEER. Whenever any such agreement is with a Subcontractor or Supplier who is listed as an additional insured on the property insurance provided in paragraph 5.06, the agreement between the CONTRACTOR and the Subcontractor or Supplier will contain provisions whereby the Subcontractor or Supplier waives all rights against OWNER, CONTRACTOR, ENGINEER, ENGINEER's Consultants, and all other individuals or entities identified in the Supplementary Conditions to be listed as insureds or additional insureds (and the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them) for all losses and damages caused by, arising out of, relating to, or resulting from any of the perils or causes of loss covered by such policies and any other property insurance applicable to the Work. If the insurers on any such policies require separate waiver forms to be signed by any Subcontractor or Supplier, CONTRACTOR will obtain the same.

6.07 *Patent Fees and Royalties*

A. CONTRACTOR shall pay all license fees and royalties and assume all costs incident to the use in the performance of the Work or the incorporation in the Work of any invention, design, process, product, or device which is the subject of patent rights or copyrights held by others. If a particular invention, design, process, product, or device is specified in the Contract Documents for use in the performance of the Work and if to the actual knowledge of OWNER or ENGINEER its use is subject to patent rights or copyrights calling for the payment of any license fee or royalty to others, the existence of such rights shall be disclosed by OWNER in the Contract Documents. To the fullest extent permitted by Laws and Regulations, CONTRACTOR shall indemnify and hold harmless OWNER, ENGINEER, ENGINEER's Consultants, and the officers, directors, partners, employees or agents, and other consultants of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product, or device not specified in the Contract Documents.

6.08 *Permits*

A. Unless otherwise provided in the Supplementary Conditions, CONTRACTOR shall obtain and pay for all construction permits and licenses. OWNER shall assist CONTRACTOR, when necessary, in obtaining such permits and licenses. CONTRACTOR shall pay all governmental charges and inspection fees necessary for

the prosecution of the Work which are applicable at the time of opening of Bids, or, if there are no Bids, on the Effective Date of the Agreement. CONTRACTOR shall pay all charges of utility owners for connections to the Work, and OWNER shall pay all charges of such utility owners for capital costs related thereto, such as plant investment fees.

6.09 *Laws and Regulations*

A. CONTRACTOR shall give all notices and comply with all Laws and Regulations applicable to the performance of the Work. Except where otherwise expressly required by applicable Laws and Regulations, neither OWNER nor ENGINEER shall be responsible for monitoring CONTRACTOR's compliance with any Laws or Regulations.

B. If CONTRACTOR performs any Work knowing or having reason to know that it is contrary to Laws or Regulations, CONTRACTOR shall bear all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such Work; however, it shall not be CONTRACTOR's primary responsibility to make certain that the Specifications and Drawings are in accordance with Laws and Regulations, but this shall not relieve CONTRACTOR of CONTRACTOR's obligations under paragraph 3.03.

C. Changes in Laws or Regulations not known at the time of opening of Bids (or, on the Effective Date of the Agreement if there were no Bids) having an effect on the cost or time of performance of the Work may be the subject of an adjustment in Contract Price or Contract Times. If OWNER and CONTRACTOR are unable to agree on entitlement to or on the amount or extent, if any, of any such adjustment, a Claim may be made therefor as provided in paragraph 10.05.

6.10 *Taxes*

A. CONTRACTOR shall pay all sales, consumer, use, and other similar taxes required to be paid by CONTRACTOR in accordance with the Laws and Regulations of the place of the Project which are applicable during the performance of the Work.

6.11 *Use of Site and Other Areas*

A. *Limitation on Use of Site and Other Areas*

1. CONTRACTOR shall confine construction equipment, the storage of materials and equipment, and the operations of workers to the Site and other areas permitted by Laws and Regulations,

and shall not unreasonably encumber the Site and other areas with construction equipment or other materials or equipment. CONTRACTOR shall assume full responsibility for any damage to any such land or area, or to the owner or occupant thereof, or of any adjacent land or areas resulting from the performance of the Work.

2. Should any claim be made by any such owner or occupant because of the performance of the Work, CONTRACTOR shall promptly settle with such other party by negotiation or otherwise resolve the claim by arbitration or other dispute resolution proceeding or at law.

3. To the fullest extent permitted by Laws and Regulations, CONTRACTOR shall indemnify and hold harmless OWNER, ENGINEER, ENGINEER's Consultant, and the officers, directors, partners, employees, agents, and other consultants of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to any claim or action, legal or equitable, brought by any such owner or occupant against OWNER, ENGINEER, or any other party indemnified hereunder to the extent caused by or based upon CONTRACTOR's performance of the Work.

B. *Removal of Debris During Performance of the Work:* During the progress of the Work CONTRACTOR shall keep the Site and other areas free from accumulations of waste materials, rubbish, and other debris. Removal and disposal of such waste materials, rubbish, and other debris shall conform to applicable Laws and Regulations.

C. *Cleaning:* Prior to Substantial Completion of the Work CONTRACTOR shall clean the Site and make it ready for utilization by OWNER. At the completion of the Work CONTRACTOR shall remove from the Site all tools, appliances, construction equipment and machinery, and surplus materials and shall restore to original condition all property not designated for alteration by the Contract Documents.

D. *Loading Structures:* CONTRACTOR shall not load nor permit any part of any structure to be loaded in any manner that will endanger the structure, nor shall CONTRACTOR subject any part of the Work or adjacent property to stresses or pressures that will endanger it.

6.12 *Record Documents*

A. CONTRACTOR shall maintain in a safe place at the Site one record copy of all Drawings, Specifications, Addenda, Written Amendments, Change Orders, Work Change Directives, Field Orders, and written interpretations and clarifications in good order and annotated to show changes made during construction. These record documents together with all approved Samples and a counterpart of all approved Shop Drawings will be available to ENGINEER for reference. Upon completion of the Work, these record documents, Samples, and Shop Drawings will be delivered to ENGINEER for OWNER.

6.13 *Safety and Protection*

A. CONTRACTOR shall be solely responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work. CONTRACTOR shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury or loss to:

1. all persons on the Site or who may be affected by the Work;

2. all the Work and materials and equipment to be incorporated therein, whether in storage on or off the Site; and

3. other property at the Site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, utilities, and Underground Facilities not designated for removal, relocation, or replacement in the course of construction.

B. CONTRACTOR shall comply with all applicable Laws and Regulations relating to the safety of persons or property, or to the protection of persons or property from damage, injury, or loss; and shall erect and maintain all necessary safeguards for such safety and protection. CONTRACTOR shall notify owners of adjacent property and of Underground Facilities and other utility owners when prosecution of the Work may affect them, and shall cooperate with them in the protection, removal, relocation, and replacement of their property. All damage, injury, or loss to any property referred to in paragraph 6.13.A.2 or 6.13.A.3 caused, directly or indirectly, in whole or in part, by CONTRACTOR, any Subcontractor, Supplier, or any other individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, shall be remedied by CONTRACTOR (except damage or loss attributable to the fault of Drawings or Specifications or to the acts or omissions of OWNER or ENGINEER or ENGINEER's Consultant, or anyone employed by any of them, or anyone for whose acts any of them may be liable, and not attributable, directly or indirectly, in whole or in part, to the fault or negligence of CONTRACTOR or any Subcontractor, Supplier, or other individual or entity directly or indirectly employed by any of them). CONTRACTOR's duties and responsibilities for safety and for protection of the Work shall continue until such time as all the Work is completed and ENGINEER has issued a notice to OWNER and CONTRACTOR in accordance with paragraph 14.07.B that the Work is acceptable (except as otherwise expressly provided in connection with Substantial Completion).

6.14 *Safety Representative*

A. CONTRACTOR shall designate a qualified and experienced safety representative at the Site whose duties and responsibilities shall be the prevention of accidents and the maintaining and supervising of safety precautions and programs.

6.15 *Hazard Communication Programs*

A. CONTRACTOR shall be responsible for coordinating any exchange of material safety data sheets or other hazard communication information required to be made available to or exchanged between or among employers at the Site in accordance with Laws or Regulations.

6.16 *Emergencies*

A. In emergencies affecting the safety or protection of persons or the Work or property at the Site or adjacent thereto, CONTRACTOR is obligated to act to prevent threatened damage, injury, or loss. CONTRACTOR shall give ENGINEER prompt written notice if CONTRACTOR believes that any significant changes in the Work or variations from the Contract Documents have been caused thereby or are required as a result thereof. If ENGINEER determines that a change in the Contract Documents is required because of the action taken by CONTRACTOR in response to such an emergency, a Work Change Directive or Change Order will be issued.

6.17 *Shop Drawings and Samples*

A. CONTRACTOR shall submit Shop Drawings to ENGINEER for review and approval in accordance with the acceptable schedule of Shop Drawings and Sample submittals. All submittals will be identified as ENGINEER may require and in the number of copies specified in the General Requirements. The data shown on the Shop Drawings will be complete with respect to quantities, dimensions, specified performance and design criteria, materials, and similar data to show ENGINEER the services, materials, and equipment CONTRACTOR proposes to provide and to enable ENGINEER to review the information for the limited purposes required by paragraph 6.17.E.

B. CONTRACTOR shall also submit six (6) Samples to ENGINEER for review and approval in accordance with the acceptable schedule of Shop Drawings and Sample submittals. Each Sample will be identified clearly as to material, Supplier, pertinent data such as catalog numbers, and the use for which intended and otherwise as ENGINEER may require to enable ENGINEER to review the submittal for the limited purposes required by paragraph 6.17.E. The numbers of each Sample to be submitted will be as specified in the Specifications.

C. Where a Shop Drawing or Sample is required by the Contract Documents or the schedule of Shop Drawings and Sample submittals acceptable to ENGINEER as required by paragraph 2.07, any related Work performed prior to ENGINEER's review and approval of the pertinent submittal will be at the sole expense and responsibility of CONTRACTOR.

D. *Submittal Procedures*

1. Before submitting each Shop Drawing or Sample, CONTRACTOR shall have determined and verified:

a. all field measurements, quantities, dimensions, specified performance criteria, installation requirements, materials, catalog numbers, and similar information with respect thereto;

b. all materials with respect to intended use, fabrication, shipping, handling, storage, assembly, and installation pertaining to the performance of the Work;

c. all information relative to means, methods, techniques, sequences, and procedures of construction and safety precautions and programs incident thereto; and

d. CONTRACTOR shall also have reviewed and coordinated each Shop Drawing or

Sample with other Shop Drawings and Samples and with the requirements of the Work and the Contract Documents.

2. Each submittal shall bear a stamp or specific written indication that CONTRACTOR has satisfied CONTRACTOR's obligations under the Contract Documents with respect to CONTRACTOR's review and approval of that submittal.

3. At the time of each submittal, CONTRACTOR shall give ENGINEER specific written notice of such variations, if any, that the Shop Drawing or Sample submitted may have from the requirements of the Contract Documents, such notice to be in a written communication separate from the submittal; and, in addition, shall cause a specific notation to be made on each Shop Drawing and Sample submitted to ENGINEER for review and approval of each such variation.

E. *ENGINEER's Review*

1. ENGINEER will timely review and approve Shop Drawings and Samples in accordance with the schedule of Shop Drawings and Sample submittals acceptable to ENGINEER. ENGINEER's review and approval will be only to determine if the items covered by the submittals

will, after installation or incorporation in the Work, conform to the information given in the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.

2. ENGINEER's review and approval will not extend to means, methods, techniques, sequences, or procedures of construction (except where a particular means, method, technique, sequence, or procedure of construction is specifically and expressly called for by the Contract Documents) or to safety precautions or programs incident thereto. The review and approval of a separate item as such will not indicate approval of the assembly in which the item functions.

3. ENGINEER's review and approval of Shop Drawings or Samples shall not relieve CONTRACTOR from responsibility for any variation from the requirements of the Contract Documents unless CONTRACTOR has in writing called ENGINEER's attention to each such variation at the time of each submittal as required by paragraph 6.17.D.3 and ENGINEER has given written approval of each such variation by specific written notation thereof incorporated in or accompanying the Shop Drawing or Sample approval; nor will any approval by ENGINEER relieve CONTRACTOR from responsibility for complying with the requirements of paragraph 6.17.D.1.

F. *Resubmittal Procedures*

1. CONTRACTOR shall make corrections required by ENGINEER and shall return the required number of corrected copies of Shop Drawings and submit as required new Samples for review and approval. CONTRACTOR shall direct specific attention in writing to revisions other than the corrections called for by ENGINEER on previous submittals.

6.18 *Continuing the Work*

A. CONTRACTOR shall carry on the Work and adhere to the progress schedule during all disputes or disagreements with OWNER. No Work shall be delayed or postponed pending resolution of any disputes or disagreements, except as permitted by paragraph 15.04 or as OWNER and CONTRACTOR may otherwise agree in writing.

6.19 *CONTRACTOR's General Warranty and Guarantee*

A. CONTRACTOR warrants and guarantees to OWNER, ENGINEER, and ENGINEER's Consultants that all Work will be in accordance with the Contract Documents and will not be defective. CONTRACTOR's warranty and guarantee hereunder excludes defects or damage caused by:

1. abuse, modification, or improper maintenance or operation by persons other than CONTRACTOR, Subcontractors, Suppliers, or any other individual or entity for whom CONTRACTOR is responsible; or

2. normal wear and tear under normal usage.

B. CONTRACTOR's obligation to perform and complete the Work in accordance with the Contract Documents shall be absolute. None of the following will constitute an acceptance of Work that is not in accordance with the Contract Documents or a release of CONTRACTOR's obligation to perform the Work in accordance with the Contract Documents:

1. observations by ENGINEER;

2. recommendation by ENGINEER or payment by OWNER of any progress or final payment;

3. the issuance of a certificate of Substantial Completion by ENGINEER or any payment related thereto by OWNER;

4. use or occupancy of the Work or any part thereof by OWNER;

5. any acceptance by OWNER or any failure to do so;

6. any review and approval of a Shop Drawing or Sample submittal or the issuance of a notice of acceptability by ENGINEER;

7. any inspection, test, or approval by others; or

8. any correction of defective Work by OWNER.

6.20 *Indemnification*

A. To the fullest extent permitted by Laws and Regulations, CONTRACTOR shall indemnify and hold harmless OWNER, ENGINEER, ENGINEER's Consultants, and the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them from and against all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to the performance of the Work, provided that any such claim, cost, loss, or damage:

1. is attributable to bodily injury, sickness, disease, or death, or to injury to or destruction of tangible property (other than the Work itself), including the loss of use resulting therefrom; and

2. is caused in whole or in part by any negligent act or omission of CONTRACTOR, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work or anyone for whose acts any of them may be liable, regardless of whether or not caused in part by any negligence or omission of an individual or entity indemnified hereunder or whether liability is imposed upon such indemnified party by Laws and Regulations regardless of the negligence of any such individual or entity.

B. In any and all claims against OWNER or ENGINEER or any of their respective consultants, agents, officers, directors, partners, or employees by any employee (or the survivor or personal representative of such employee) of CONTRACTOR, any Subcontractor, any Supplier, or any individual or entity directly or indirectly employed by any of them to perform any of the Work, or anyone for whose acts any of them may be liable, the indemnification obligation under paragraph 6.20.A shall not be limited in any way by any limitation on the amount or type of damages, compensation, or benefits payable by or for CONTRACTOR or any such Subcontractor, Supplier, or other individual or entity under workers' compensation acts, disability benefit acts, or other employee benefit acts.

C. The indemnification obligations of CONTRACTOR under paragraph 6.20.A shall not extend to the liability of ENGINEER and ENGINEER's Consultants or to the officers, directors, partners, employees, agents, and other consultants and subcontractors of each and any of them arising out of:

1. the preparation or approval of, or the failure to prepare or approve, maps, Drawings, opinions, reports, surveys, Change Orders, designs, or Specifications; or

2. giving directions or instructions, or failing to give them, if that is the primary cause of the injury or damage.

ARTICLE 7 - OTHER WORK

7.01 *Related Work at Site*

A. OWNER may perform other work related to the Project at the Site by OWNER's employees, or let other direct contracts therefor, or have other work performed by utility owners. If such other work is not noted in the Contract Documents, then:

1. written notice thereof will be given to CONTRACTOR prior to starting any such other work; and

2. if OWNER and CONTRACTOR are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times that should be allowed as a result of such other work, a Claim may be made therefor as provided in paragraph 10.05.

B. CONTRACTOR shall afford each other contractor who is a party to such a direct contract and each utility owner (and OWNER, if OWNER is performing the other work with OWNER's employees) proper and safe access to the Site and a reasonable opportunity for the introduction and storage of materials and equipment and the execution of such other work and shall properly coordinate the Work with theirs. Unless otherwise provided in the Contract Documents, CONTRACTOR shall do all cutting, fitting, and patching of the Work that may be required to properly connect or otherwise make its several parts come together and properly integrate with such other work. CONTRACTOR shall not endanger any work of others by cutting, excavating, or otherwise altering their work and will only cut or alter their work with the written consent of ENGINEER and the others whose work will be affected. The duties and responsibilities of CONTRACTOR under this paragraph are for the benefit of

such utility owners and other contractors to the extent that there are comparable provisions for the benefit of CONTRACTOR in said direct contracts between OWNER and such utility owners and other contractors.

C. If the proper execution or results of any part of CONTRACTOR's Work depends upon work performed by others under this Article 7, CONTRACTOR shall inspect such other work and promptly report to ENGINEER in writing any delays, defects, or deficiencies in such other work that render it unavailable or unsuitable for the proper execution and results of CONTRACTOR's Work. CONTRACTOR's failure to so report will constitute an acceptance of such other work as fit and proper for integration with CONTRACTOR's Work except for latent defects and deficiencies in such other work.

7.02 *Coordination*

A. If OWNER intends to contract with others for the performance of other work on the Project at the Site, the following will be set forth in Supplementary Conditions:

1. the individual or entity who will have authority and responsibility for coordination of the activities among the various contractors will be identified;

2. the specific matters to be covered by such authority and responsibility will be itemized; and

3. the extent of such authority and responsibilities will be provided.

B. Unless otherwise provided in the Supplementary Conditions, OWNER shall have sole authority and responsibility for such coordination.

ARTICLE 8 - OWNER'S RESPONSIBILITIES

8.01 *Communications to Contractor*

A. Except as otherwise provided in these General Conditions, OWNER shall issue all communications to CONTRACTOR through ENGINEER.

8.02 *Replacement of ENGINEER*

A. In case of termination of the employment of ENGINEER, OWNER shall appoint an engineer to whom CONTRACTOR makes no reasonable objection, whose status under the Contract Documents shall be that of the former ENGINEER.

8.03 *Furnish Data*

A. OWNER shall promptly furnish the data required of OWNER under the Contract Documents.

8.04 *Pay Promptly When Due*

A. OWNER shall make payments to CONTRACTOR promptly when they are due as provided in paragraphs 14.02.C and 14.07.C.

8.05 *Lands and Easements; Reports and Tests*

A. OWNER's duties in respect of providing lands and easements and providing engineering surveys to establish reference points are set forth in paragraphs 4.01 and 4.05. Paragraph 4.02 refers to OWNER's identifying and making available to CONTRACTOR copies of reports of explorations and tests of subsurface conditions and drawings of physical conditions in or relating to existing surface or subsurface structures at or contiguous to the Site that have been utilized by ENGINEER in preparing the Contract Documents.

8.06 *Insurance*

A. OWNER's responsibilities, if any, in respect to purchasing and maintaining liability and property insurance are set forth in Article 5.

8.07 *Change Orders*

A. OWNER is obligated to execute Change Orders as indicated in paragraph 10.03.

8.08 *Inspections, Tests, and Approvals*

A. OWNER's responsibility in respect to certain inspections, tests, and approvals is set forth in paragraph 13.03.B.

8.09 *Limitations on OWNER's Responsibilities*

A. The OWNER shall not supervise, direct, or have control or authority over, nor be responsible for, CONTRACTOR's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of CONTRACTOR to comply with Laws and Regulations applicable to the perfomance of the Work. OWNER will not be responsible for CONTRACTOR's failure to perform the Work in accordance with the Contract Documents.

8.10 *Undisclosed Hazardous Environmental Condition*

A. OWNER's responsibility in respect to an undisclosed Hazardous Environmental Condition is set forth in paragraph 4.06.

8.11 *Evidence of Financial Arrangements*

A. If and to the extent OWNER has agreed to furnish CONTRACTOR reasonable evidence that financial arrangements have been made to satisfy OWNER's obligations under the Contract Documents, OWNER's responsibility in respect thereof will be as set forth in the Supplementary Conditions.

ARTICLE 9 - ENGINEER'S STATUS DURING CONSTRUCTION

9.01 *OWNER'S Representative*

A. ENGINEER will be OWNER's representative during the construction period. The duties and responsibilities and the limitations of authority of ENGINEER as OWNER's representative during construction are set forth in the Contract Documents and will not be changed without written consent of OWNER and ENGINEER.

9.02 *Visits to Site*

A. ENGINEER will make visits to the Site at intervals appropriate to the various stages of construction as ENGINEER deems necessary in order to observe as an experienced and qualified design professional the progress that has been made and the quality of the various aspects of CONTRACTOR's executed Work. Based on information obtained during such visits and observations, ENGINEER, for the benefit of OWNER, will determine, in general, if the Work is proceeding in accordance with the Contract Documents. ENGINEER will not be required to make exhaustive or continuous inspections on the Site to check the quality or quantity of the Work. ENGINEER's efforts will be directed toward providing for OWNER a greater degree of confidence that the completed Work will conform generally to the Contract Documents. On the basis of such visits and observations, ENGINEER will keep OWNER informed of the progress of the Work and will endeavor to guard OWNER against defective Work.

B. ENGINEER's visits and observations are subject to all the limitations on ENGINEER's authority and responsibility set forth in paragraph 9.10, and particularly, but without limitation, during or as a result of ENGINEER's visits or observations of CONTRACTOR's Work ENGINEER will not supervise, direct, control, or have authority over or be responsible for CONTRACTOR's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of CONTRACTOR to comply with Laws and Regulations applicable to the performance of the Work.

9.03 *Project Representative*

A. If OWNER and ENGINEER agree, ENGINEER will furnish a Resident Project Representative to assist ENGINEER in providing more extensive observation of the Work. The responsibilities and authority and limitations thereon of any such Resident Project Representative and assistants will be as provided in paragraph 9.10 and in the Supplementary Conditions. If OWNER designates another representative or agent to represent OWNER at the Site who is not ENGINEER's Consultant, agent or employee, the responsibilities and authority and limitations thereon of such other individual or entity will be as provided in the Supplementary Conditions.

9.04 *Clarifications and Interpretations*

A. ENGINEER will issue with reasonable promptness such written clarifications or interpretations of the requirements of the Contract Documents as ENGINEER may determine necessary, which shall be consistent with the intent of and reasonably inferable from the Contract Docu-

ments. Such written clarifications and interpretations will be binding on OWNER and CONTRACTOR. If OWNER and CONTRACTOR are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, that should be allowed as a result of a written clarification or interpretation, a Claim may be made therefor as provided in paragraph 10.05.

9.05 *Authorized Variations in Work*

A. ENGINEER may authorize minor variations in the Work from the requirements of the Contract Documents which do not involve an adjustment in the Contract Price or the Contract Times and are compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. These may be accomplished by a Field Order and will be binding on OWNER and also on CONTRACTOR, who shall perform the Work involved promptly. If OWNER and CONTRACTOR are unable to agree on entitlement to or on the amount or extent, if any, of any adjustment in the Contract Price or Contract Times, or both, as a result of a Field Order, a Claim may be made therefor as provided in paragraph 10.05.

9.06 *Rejecting Defective Work*

A. ENGINEER will have authority to disapprove or reject Work which ENGINEER believes to be defective, or that ENGINEER believes will not produce a completed Project that conforms to the Contract Documents or that will prejudice the integrity of the design concept of the completed Project as a functioning whole as indicated by the Contract Documents. ENGINEER will also have authority to require special inspection or testing of the Work as provided in paragraph 13.04, whether or not the Work is fabricated, installed, or completed.

9.07 *Shop Drawings, Change Orders and Payments*

A. In connection with ENGINEER's authority as to Shop Drawings and Samples, see paragraph 6.17.

B. In connection with ENGINEER's authority as to Change Orders, see Articles 10, 11, and 12.

C. In connection with ENGINEER's authority as to Applications for Payment, see Article 14.

9.08 *Determinations for Unit Price Work*

A. ENGINEER will determine the actual quantities and classifications of Unit Price Work performed by CONTRACTOR. ENGINEER will review with CONTRACTOR the ENGINEER's preliminary determinations on such matters before rendering a written decision thereon (by recommendation of an Application for Payment or otherwise). ENGINEER's written decision thereon will be final and binding (except as modified by ENGINEER to reflect changed factual conditions or more accurate data) upon OWNER and CONTRACTOR, subject to the provisions of paragraph 10.05.

9.09 *Decisions on Requirements of Contract Documents and Acceptability of Work*

A. ENGINEER will be the initial interpreter of the requirements of the Contract Documents and judge of the acceptability of the Work thereunder. Claims, disputes and other matters relating to the acceptability of the Work, the quantities and classifications of Unit Price Work, the interpretation of the requirements of the Contract Documents pertaining to the performance of the Work, and Claims seeking changes in the Contract Price or Contract Times will be referred initially to ENGINEER in writing, in accordance with the provisions of paragraph 10.05, with a request for a formal decision.

B. When functioning as interpreter and judge under this paragraph 9.09, ENGINEER will not show partiality to OWNER or CONTRACTOR and will not be liable in connection with any interpretation or decision rendered in good faith in such capacity. The rendering of a decision by ENGINEER pursuant to this paragraph 9.09 with respect to any such Claim, dispute, or other matter (except any which have been waived by the making or acceptance of final payment as provided in paragraph 14.07) will be a condition precedent to any exercise by OWNER or CONTRACTOR of such rights or remedies as either may otherwise have under the Contract Documents or by Laws or Regulations in respect of any such Claim, dispute, or other matter.

9.10 *Limitations on ENGINEER's Authority and Responsibilities*

A. Neither ENGINEER's authority or responsibility under this Article 9 or under any other provision of the Contract Documents nor any decision made by ENGINEER in good faith either to exercise or not exercise such

authority or responsibility or the undertaking, exercise, or performance of any authority or responsibility by ENGINEER shall create, impose, or give rise to any duty in contract, tort, or otherwise owed by ENGINEER to CONTRACTOR, any Subcontractor, any Supplier, any other individual or entity, or to any surety for or employee or agent of any of them.

B. ENGINEER will not supervise, direct, control, or have authority over or be responsible for CONTRACTOR's means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for any failure of CONTRACTOR to comply with Laws and Regulations applicable to the performance of the Work. ENGINEER will not be responsible for CONTRACTOR's failure to perform the Work in accordance with the Contract Documents.

C. ENGINEER will not be responsible for the acts or omissions of CONTRACTOR or of any Subcontractor, any Supplier, or of any other individual or entity performing any of the Work.

D. ENGINEER's review of the final Application for Payment and accompanying documentation and all maintenance and operating instructions, schedules, guarantees, Bonds, certificates of inspection, tests and approvals, and other documentation required to be delivered by paragraph 14.07.A will only be to determine generally that their content complies with the requirements of, and in the case of certificates of inspections, tests, and approvals that the results certified indicate compliance with, the Contract Documents.

E. The limitations upon authority and responsibility set forth in this paragraph 9.10 shall also apply to ENGINEER's Consultants, Resident Project Representative, and assistants. See Article 18.

ARTICLE 10 - CHANGES IN THE WORK; CLAIMS

10.01 *Authorized Changes in the Work*

A. Without invalidating the Agreement and without notice to any surety, OWNER may, at any time or from time to time, order additions, deletions, or revisions in the Work by a Written Amendment, a Change Order, or a Work Change Directive. Upon receipt of any such document, CONTRACTOR shall promptly proceed with the Work involved which will be performed under the applicable conditions of the Contract Documents (except as otherwise specifically provided).

B. If OWNER and CONTRACTOR are unable to agree on entitlement to, or on the amount or extent, if any, of an adjustment in the Contract Price or Contract Times, or both, that should be allowed as a result of a Work Change Directive, a Claim may be made therefor as provided in paragraph 10.05.

10.02 *Unauthorized Changes in the Work*

A. CONTRACTOR shall not be entitled to an increase in the Contract Price or an extension of the Contract Times with respect to any work performed that is not required by the Contract Documents as amended, modified, or supplemented as provided in paragraph 3.04, except in the case of an emergency as provided in paragraph 6.16 or in the case of uncovering Work as provided in paragraph 13.04.B.

10.03 *Execution of Change Orders*

A. OWNER and CONTRACTOR shall execute appropriate Change Orders recommended by ENGINEER (or Written Amendments) covering:

1. changes in the Work which are: (i) ordered by OWNER pursuant to paragraph 10.01.A, (ii) required because of acceptance of defective Work under paragraph 13.08.A or OWNER's correction of defective Work under paragraph 13.09, or (iii) agreed to by the parties;

2. changes in the Contract Price or Contract Times which are agreed to by the parties, including any undisputed sum or amount of time for Work actually performed in accordance with a Work Change Directive; and

3. changes in the Contract Price or Contract Times which embody the substance of any written decision rendered by ENGINEER pursuant to paragraph 10.05; provided that, in lieu of executing any such Change Order, an appeal may be taken from any such decision in accordance with the provisions of the Contract Documents and applicable Laws and Regulations, but during any such appeal, CONTRACTOR shall carry on the Work and adhere to the progress schedule as provided in paragraph 6.18.A.

10.04 *Notification to Surety*

A. If notice of any change affecting the general scope of the Work or the provisions of the Contract Documents (including, but not limited to, Contract Price or Contract Times) is required by the provisions of any Bond to be given to a surety, the giving of any such notice will be CONTRACTOR's responsibility. The amount of each applicable Bond will be adjusted to reflect the effect of any such change.

10.05 *Claims and Disputes*

A. *Notice:* Written notice stating the general nature of each Claim, dispute, or other matter shall be delivered by the claimant to ENGINEER and the other party to the Contract promptly (but in no event later than 30 days) after the start of the event giving rise thereto. Notice of the amount or extent of the Claim, dispute, or other matter with supporting data shall be delivered to the ENGINEER and the other party to the Contract within 60 days after the start of such event (unless ENGINEER allows additional time for claimant to submit additional or more accurate data in support of such Claim, dispute, or other matter). A Claim for an adjustment in Contract Price shall be prepared in accordance with the provisions of paragraph 12.01.B. A Claim for an adjustment in Contract Time shall be prepared in accordance with the provisions of paragraph 12.02.B. Each Claim shall be accompanied by claimant's written statement that the adjustment claimed is the entire adjustment to which the claimant believes it is entitled as a result of said event. The opposing party shall submit any response to ENGINEER and the claimant within 30 days after receipt of the claimant's last submittal (unless ENGINEER allows additional time).

B. *ENGINEER's Decision:* ENGINEER will render a formal decision in writing within 30 days after receipt of the last submittal of the claimant or the last submittal of the opposing party, if any. ENGINEER's written decision on such Claim, dispute, or other matter will be final and binding upon OWNER and CONTRACTOR unless:

1. an appeal from ENGINEER's decision is taken within the time limits and in accordance with the dispute resolution procedures set forth in Article 16; or

2. if no such dispute resolution procedures have been set forth in Article 16, a written notice of intention to appeal from ENGINEER's written decision is delivered by OWNER or CONTRACTOR to the other and to ENGINEER within 30 days after the date of such decision, and a formal proceeding is instituted by the appealing party in a forum of competent jurisdiction within 60 days after the date of such decision or within 60 days after Substantial Completion, whichever is later (unless otherwise agreed in writing by OWNER and CONTRACTOR), to exercise such rights or remedies as the appealing party may have with respect to such Claim, dispute, or other matter in accordance with applicable Laws and Regulations.

C. If ENGINEER does not render a formal decision in writing within the time stated in paragraph 10.05.B, a decision denying the Claim in its entirety shall be deemed to have been issued 31 days after receipt of the last submittal of the claimant or the last submittal of the opposing party, if any.

D. No Claim for an adjustment in Contract Price or Contract Times (or Milestones) will be valid if not submitted in accordance with this paragraph 10.05.

ARTICLE 11 - COST OF THE WORK; CASH ALLOWANCES; UNIT PRICE WORK

11.01 *Cost of the Work*

A. *Costs Included:* The term Cost of the Work means the sum of all costs necessarily incurred and paid by CONTRACTOR in the proper performance of the Work. When the value of any Work covered by a Change Order or when a Claim for an adjustment in Contract Price is determined on the basis of Cost of the Work, the costs to be reimbursed to CONTRACTOR will be only those additional or incremental costs required because of the change in the Work or because of the event giving rise to the Claim. Except as otherwise may be agreed to in writing by OWNER, such costs shall be in amounts no higher than those prevailing in the locality of the Project, shall include only the following items, and shall not include any of the costs itemized in paragraph 11.01.B.

1. Payroll costs for employees in the direct employ of CONTRACTOR in the perfomance of the Work under schedules of job classifications agreed upon by OWNER and CONTRACTOR. Such employees shall include without limitation superintendents, foremen, and other personnel employed full time at the Site. Payroll costs for employees not employed full time on the Work

shall be apportioned on the basis of their time spent on the Work. Payroll costs shall include, but not be limited to, salaries and wages plus the cost of fringe benefits, which shall include social security contributions, unemployment, excise, and payroll taxes, workers' compensation, health and retirement benefits, bonuses, sick leave, vacation and holiday pay applicable thereto. The expenses of performing Work outside of regular working hours, on Saturday, Sunday, or legal holidays, shall be included in the above to the extent authorized by OWNER.

2. Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof, and Suppliers' field services required in connection therewith. All cash discounts shall accrue to CONTRACTOR unless OWNER deposits funds with CONTRACTOR with which to make payments, in which case the cash discounts shall accrue to OWNER. All trade discounts, rebates and refunds and returns from sale of surplus materials and equipment shall accrue to OWNER, and CONTRACTOR shall make provisions so that they may be obtained.

3. Payments made by CONTRACTOR to Subcontractors for Work performed by Subcontractors. If required by OWNER, CONTRACTOR shall obtain competitive bids from subcontractors acceptable to OWNER and CONTRACTOR and shall deliver such bids to OWNER, who will then determine, with the advice of ENGINEER, which bids, if any, will be acceptable. If any subcontract provides that the Subcontractor is to be paid on the basis of Cost of the Work plus a fee, the Subcontractor's Cost of the Work and fee shall be determined in the same manner as CONTRACTOR's Cost of the Work and fee as provided in this paragraph 11.01.

4. Costs of special consultants (including but not limited to engineers, architects, testing laboratories, surveyors, attorneys, and accountants) employed for services specifically related to the Work.

5. Supplemental costs including the following:

a. The proportion of necessary transportation, travel, and subsistence expenses of CONTRACTOR's employees incurred in discharge of duties connected with the Work.

b. Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office, and temporary facilities at the Site, and hand tools not owned by the workers, which are consumed in the performance of the Work, and cost, less market value, of such items used but not consumed which remain the property of CONTRACTOR.

c. Rentals of all construction equipment and machinery, and the parts thereof whether rented from CONTRACTOR or others in accordance with rental agreements approved by OWNER with the advice of ENGINEER, and the costs of transportation, loading, unloading, assembly, dismantling, and removal thereof. All such costs shall be in accordance with the terms of said rental agreements. The rental of any such equipment, machinery, or parts shall cease when the use thereof is no longer necessary for the Work.

d. Sales, consumer, use, and other similar taxes related to the Work, and for which CONTRACTOR is liable, imposed by Laws and Regulations.

e. Deposits lost for causes other than negligence of CONTRACTOR, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, and royalty payments and fees for permits and licenses.

f. Losses and damages (and related expenses) caused by damage to the Work, not compensated by insurance or otherwise, sustained by CONTRACTOR in connection with the performance of the Work (except losses and damages within the deductible amounts of property insurance established in accordance with paragraph 5.06.D), provided such losses and damages have resulted from causes other than the negligence of CONTRACTOR, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable. Such losses shall include settlements made with the written consent and approval of OWNER. No such losses, damages, and expenses shall be included in the Cost of the Work for the purpose of determining CONTRACTOR's fee.

g. The cost of utilities, fuel, and sanitary facilities at the Site.

h. Minor expenses such as telegrams, long distance telephone calls, telephone service at the Site, expressage, and similar petty cash items in connection with the Work.

i. When the Cost of the Work is used to determine the value of a Change Order or of a Claim, the cost of premiums for additional Bonds and insurance required because of the changes in the Work or caused by the event giving rise to the Claim.

j. When all the Work is performed on the basis of cost-plus, the costs of premiums for all Bonds and insurance CONTRACTOR is required by the Contract Documents to purchase and maintain.

B. *Costs Excluded:* The term Cost of the Work shall not include any of the following items:

1. Payroll costs and other compensation of CONTRACTOR's officers, executives, principals (of partnerships and sole proprietorships), general managers, engineers, architects, estimators, attorneys, auditors, accountants, purchasing and contracting agents, expediters, timekeepers, clerks, and other personnel employed by CONTRACTOR, whether at the Site or in CONTRACTOR's principal or branch office for general administration of the Work and not specifically included in the agreed upon schedule of job classifications referred to in paragraph 11.01.A.1 or specifically covered by paragraph 11.01.A.4, all of which are to be considered administrative costs covered by the CONTRACTOR's fee.

2. Expenses of CONTRACTOR's principal and branch offices other than CONTRACTOR's office at the Site.

3. Any part of CONTRACTOR's capital expenses, including interest on CONTRACTOR's capital employed for the Work and charges against CONTRACTOR for delinquent payments.

4. Costs due to the negligence of CONTRACTOR, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, including but not limited to, the correction of defective Work, disposal of materials or equipment wrongly supplied, and making good any damage to property.

5. Other overhead or general expense costs of any kind and the costs of any item not specifically and expressly included in paragraphs 11.01.A and 11.01.B.

C. *CONTRACTOR's Fee:* When all the Work is performed on the basis of cost-plus, CONTRACTOR's fee shall be determined as set forth in the Agreement. When the value of any Work covered by a Change Order or when a Claim for an adjustment in Contract Price is determined on the basis of Cost of the Work, CONTRACTOR's fee shall be determined as set forth in paragraph 12.01.C.

D. *Documentation:* Whenever the Cost of the Work for any purpose is to be determined pursuant to paragraphs 11.01.A and 11.01.B, CONTRACTOR will establish and maintain records thereof in accordance with generally accepted accounting practices and submit in a form acceptable to ENGINEER an itemized cost breakdown together with supporting data.

11.02 *Cash Allowances*

A. It is understood that CONTRACTOR has included in the Contract Price all allowances so named in the Contract Documents and shall cause the Work so covered to be performed for such sums as may be acceptable to OWNER and ENGINEER. CONTRACTOR agrees that:

1. the allowances include the cost to CONTRACTOR (less any applicable trade discounts) of materials and equipment required by the allowances to be delivered at the Site, and all applicable taxes; and

2. CONTRACTOR's costs for unloading and handling on the Site, labor, installation costs, overhead, profit, and other expenses contemplated for the allowances have been included in the Contract Price and not in the allowances, and no demand for additional payment on account of any of the foregoing will be valid.

B. Prior to final payment, an appropriate Change Order will be issued as recommended by ENGINEER to reflect actual amounts due CONTRACTOR on account of

Work covered by allowances, and the Contract Price shall be correspondingly adjusted.

11.03 *Unit Price Work*

A. Where the Contract Documents provide that all or part of the Work is to be Unit Price Work, initially the Contract Price will be deemed to include for all Unit Price Work an amount equal to the sum of the unit price for each separately identified item of Unit Price Work times the estimated quantity of each item as indicated in the Agreement. The estimated quantities of items of Unit Price Work are not guaranteed and are solely for the purpose of comparison of Bids and determining an initial Contract Price. Determinations of the actual quantities and classifications of Unit Price Work performed by CONTRACTOR will be made by ENGINEER subject to the provisions of paragraph 9.08.

B. Each unit price will be deemed to include an amount considered by CONTRACTOR to be adequate to cover CONTRACTOR's overhead and profit for each separately identified item.

C. OWNER or CONTRACTOR may make a Claim for an adjustment in the Contract Price in accordance with paragraph 10.05 if:

1. the quantity of any item of Unit Price Work performed by CONTRACTOR differs materially and significantly from the estimated quantity of such item indicated in the Agreement; and

2. there is no corresponding adjustment with respect any other item of Work; and

3. if CONTRACTOR believes that CONTRACTOR is entitled to an increase in Contract Price as a result of having incurred additional expense or OWNER believes that OWNER is entitled to a decrease in Contract Price and the parties are unable to agree as to the amount of any such increase or decrease.

ARTICLE 12 - CHANGE OF CONTRACT PRICE; CHANGE OF CONTRACT TIMES

12.01 *Change of Contract Price*

A. The Contract Price may only be changed by a Change Order or by a Written Amendment. Any Claim for an adjustment in the Contract Price shall be based on written notice submitted by the party making the Claim to the ENGINEER and the other party to the Contract in accordance with the provisions of paragraph 10.05.

B. The value of any Work covered by a Change Order or of any Claim for an adjustment in the Contract Price will be determined as follows:

1. where the Work involved is covered by unit prices contained in the Contract Documents, by application of such unit prices to the quantities of the items involved (subject to the provisions of paragraph 11.03); or

2. where the Work involved is not covered by unit prices contained in the Contract Documents, by a mutually agreed lump sum (which may include an allowance for overhead and profit not necessarily in accordance with paragraph 12.01.C.2); or

3. where the Work involved is not covered by unit prices contained in the Contract Documents and agreement to a lump sum is not reached under paragraph 12.01.B.2, on the basis of the Cost of the Work (determined as provided in paragraph 11.01) plus a CONTRACTOR's fee for overhead and profit (determined as provided in paragraph 12.01.C).

C. *CONTRACTOR's Fee:* The CONTRACTOR's fee for overhead and profit shall be determined as follows:

1. a mutually acceptable fixed fee; or

2. if a fixed fee is not agreed upon, then a fee based on the following percentages of the various portions of the Cost of the Work:

a. for costs incurred under paragraphs 11.01.A.1 and 11.01.A.2, the CONTRACTOR's fee shall be 15 percent;

b. for costs incurred under paragraph 11.01.A.3, the CONTRACTOR's fee shall be five percent;

c. where one or more tiers of subcontracts are on the basis of Cost of the Work plus a fee and no fixed fee is agreed upon, the intent of paragraph 12.01.C.2.a is that the Subcontractor who actually performs the Work, at whatever tier, will be paid a fee of 15 percent of the costs incurred by such Subcontractor under paragraphs 11.01.A.1 and 11.01.A.2 and that any higher tier Subcontractor and CONTRACTOR will each be paid a fee of five percent of the amount paid to the next lower tier Subcontractor;

d. no fee shall be payable on the basis of costs itemized under paragraphs 11.01.A.4, 11.01.A.5, and 11.01.B;

e. the amount of credit to be allowed by CONTRACTOR to OWNER for any change which results in a net decrease in cost will be the amount of the actual net decrease in cost plus a deduction in CONTRACTOR's fee by an amount equal to five percent of such net decrease; and

f. when both additions and credits are involved in any one change, the adjustment in CONTRACTOR's fee shall be computed on the basis of the net change in accordance with paragraphs 12.01.C.2.a through 12.01.C.2.e, inclusive.

12.02 *Change of Contract Times*

A. The Contract Times (or Milestones) may only be changed by a Change Order or by a Written Amendment. Any Claim for an adjustment in the Contract Times (or Milestones) shall be based on written notice submitted by the party making the claim to the ENGINEER and the other party to the Contract in accordance with the provisions of paragraph 10.05.

B. Any adjustment of the Contract Times (or Milestones) covered by a Change Order or of any Claim for an adjustment in the Contract Times (or Milestones) will be determined in accordance with the provisions of this Article 12.

12.03 *Delays Beyond CONTRACTOR's Control*

A. Where CONTRACTOR is prevented from completing any part of the Work within the Contract Times (or Milestones) due to delay beyond the control of CONTRACTOR, the Contract Times (or Milestones) will be extended in an amount equal to the time lost due to such delay if a Claim is made therefor as provided in paragraph 12.02.A. Delays beyond the control of CONTRACTOR shall include, but not be limited to, acts or neglect by OWNER, acts or neglect of utility owners or other contractors performing other work as contemplated by Article 7, fires, floods, epidemics, abnormal weather conditions, or acts of God.

12.04 *Delays Within CONTRACTOR's Control*

A. The Contract Times (or Milestones) will not be extended due to delays within the control of CONTRACTOR. Delays attributable to and within the control of a Subcontractor or Supplier shall be deemed to be delays within the control of CONTRACTOR.

12.05 *Delays Beyond OWNER's and CONTRACTOR's Control*

A. Where CONTRACTOR is prevented from completing any part of the Work within the Contract Times (or Milestones) due to delay beyond the control of both OWNER and CONTRACTOR, an extension of the Contract Times (or Milestones) in an amount equal to the time lost due to such delay shall be CONTRACTOR's sole and exclusive remedy for such delay.

12.06 *Delay Damages*

A. In no event shall OWNER or ENGINEER be liable to CONTRACTOR, any Subcontractor, any Supplier, or any other person or organization, or to any surety for or employee or agent of any of them, for damages arising out of or resulting from:

1. delays caused by or within the control of CONTRACTOR; or

2. delays beyond the control of both OWNER and CONTRACTOR including but not limited to fires, floods, epidemics, abnormal weather conditions, acts of God, or acts or neglect by utility

owners or other contractors performing other work as contemplated by Article 7.

B. Nothing in this paragraph 12.06 bars a change in Contract Price pursuant to this Article 12 to compensate CONTRACTOR due to delay, interference, or disruption directly attributable to actions or inactions of OWNER or anyone for whom OWNER is responsible.

ARTICLE 13 - TESTS AND INSPECTIONS; CORRECTION, REMOVAL OR ACCEPTANCE OF DEFECTIVE WORK

13.01 *Notice of Defects*

A. Prompt notice of all defective Work of which OWNER or ENGINEER has actual knowledge will be given to CONTRACTOR. All defective Work may be rejected, corrected, or accepted as provided in this Article 13.

13.02 *Access to Work*

A. OWNER, ENGINEER, ENGINEER's Consultants, other representatives and personnel of OWNER, independent testing laboratories, and governmental agencies with jurisdictional interests will have access to the Site and the Work at reasonable times for their observation, inspecting, and testing. CONTRACTOR shall provide them proper and safe conditions for such access and advise them of CONTRACTOR's Site safety procedures and programs so that they may comply therewith as applicable.

13.03 *Tests and Inspections*

A. CONTRACTOR shall give ENGINEER timely notice of readiness of the Work for all required inspections, tests, or approvals and shall cooperate with inspection and testing personnel to facilitate required inspections or tests.

B. OWNER shall employ and pay for the services of an independent testing laboratory to perform all inspections, tests, or approvals required by the Contract Documents except:

1. for inspections, tests, or approvals covered by paragraphs 13.03.C and 13.03.D below;

2. that costs incurred in connection with tests or inspections conducted pursuant to paragraph 13.04.B shall be paid as provided in said paragraph 13.04.B; and

3. as otherwise specifically provided in the Contract Documents.

C. If Laws or Regulations of any public body having jurisdiction require any Work (or part thereof) specifically to be inspected, tested, or approved by an employee or other representative of such public body, CONTRACTOR shall assume full responsibility for arranging and obtaining such inspections, tests, or approvals, pay all costs in connection therewith, and furnish ENGINEER the required certificates of inspection or approval.

D. CONTRACTOR shall be responsible for arranging and obtaining and shall pay all costs in connection with any inspections, tests, or approvals required for OWNER's and ENGINEER's acceptance of materials or equipment to be incorporated in the Work; or acceptance of materials, mix designs, or equipment submitted for approval prior to CONTRACTOR's purchase thereof for incorporation in the Work. Such inspections, tests, or approvals shall be performed by organizations acceptable to OWNER and ENGINEER.

E. If any Work (or the work of others) that is to be inspected, tested, or approved is covered by CONTRACTOR without written concurrence of ENGINEER, it must, if requested by ENGINEER, be uncovered for observation.

F. Uncovering Work as provided in paragraph 13.03.E shall be at CONTRACTOR's expense unless CONTRACTOR has given ENGINEER timely notice of CONTRACTOR's intention to cover the same and ENGINEER has not acted with reasonable promptness in response to such notice.

13.04 *Uncovering Work*

A. If any Work is covered contrary to the written request of ENGINEER, it must, if requested by ENGINEER, be uncovered for ENGINEER's observation and replaced at CONTRACTOR's expense.

B. If ENGINEER considers it necessary or advisable that covered Work be observed by ENGINEER or inspected or tested by others, CONTRACTOR, at ENGINEER's request, shall uncover, expose, or otherwise make available for observation, inspection, or testing as ENGINEER may require, that portion of the Work in

question, furnishing all necessary labor, material, and equipment. If it is found that such Work is defective, CONTRACTOR shall pay all Claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such uncovering, exposure, observation, inspection, and testing, and of satisfactory replacement or reconstruction (including but not limited to all costs of repair or replacement of work of others); and OWNER shall be entitled to an appropriate decrease in the Contract Price. If the parties are unable to agree as to the amount thereof, OWNER may make a Claim therefor as provided in paragraph 10.05. If, however, such Work is not found to be defective, CONTRACTOR shall be allowed an increase in the Contract Price or an extension of the Contract Times (or Milestones), or both, directly attributable to such uncovering, exposure, observation, inspection, testing, replacement, and reconstruction. If the parties are unable to agree as to the amount or extent thereof, CONTRACTOR may make a Claim therefor as provided in paragraph 10.05.

13.05 *OWNER May Stop the Work*

A. If the Work is defective, or CONTRACTOR fails to supply sufficient skilled workers or suitable materials or equipment, or fails to perform the Work in such a way that the completed Work will conform to the Contract Documents, OWNER may order CONTRACTOR to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, this right of OWNER to stop the Work shall not give rise to any duty on the part of OWNER to exercise this right for the benefit of CONTRACTOR, any Subcontractor, any Supplier, any other individual or entity, or any surety for, or employee or agent of any of them.

13.06 *Correction or Removal of Defective Work*

A. CONTRACTOR shall correct all defective Work, whether or not fabricated, installed, or completed, or, if the Work has been rejected by ENGINEER, remove it from the Project and replace it with Work that is not defective. CONTRACTOR shall pay all Claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or removal (including but not limited to all costs of repair or replacement of work of others).

13.07 *Correction Period*

A. If within one year after the date of Substantial Completion or such longer period of time as may be prescribed by Laws or Regulations or by the terms of any applicable special guarantee required by the Contract Documents or by any specific provision of the Contract Documents, any Work is found to be defective, or if the repair of any damages to the land or areas made available for CONTRACTOR's use by OWNER or permitted by Laws and Regulations as contemplated in paragraph 6.11.A is found to be defective, CONTRACTOR shall promptly, without cost to OWNER and in accordance with OWNER's written instructions: (i) repair such defective land or areas, or (ii) correct such defective Work or, if the defective Work has been rejected by OWNER, remove it from the Project and replace it with Work that is not defective, and (iii) satisfactorily correct or repair or remove and replace any damage to other Work, to the work of others or other land or areas resulting therefrom. If CONTRACTOR does not promptly comply with the terms of such instructions, or in an emergency where delay would cause serious risk of loss or damage, OWNER may have the defective Work corrected or repaired or may have the rejected Work removed and replaced, and all Claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) arising out of or relating to such correction or repair or such removal and replacement (including but not limited to all costs of repair or replacement of work of others) will be paid by CONTRACTOR.

B. In special circumstances where a particular item of equipment is placed in continuous service before Substantial Completion of all the Work, the correction period for that item may start to run from an earlier date if so provided in the Specifications or by Written Amendment.

C. Where defective Work (and damage to other Work resulting therefrom) has been corrected or removed and replaced under this paragraph 13.07, the correction period hereunder with respect to such Work will be extended for an additional period of one year after such correction or removal and replacement has been satisfactorily completed.

D. CONTRACTOR's obligations under this paragraph 13.07 are in addition to any other obligation or warranty. The provisions of this paragraph 13.07 shall not be construed as a substitute for or a waiver of the provisions of any applicable statute of limitation or repose.

13.08 *Acceptance of Defective Work*

A. If, instead of requiring correction or removal and replacement of defective Work, OWNER (and, prior to ENGINEER's recommendation of final payment, ENGINEER) prefers to accept it, OWNER may do so. CONTRACTOR shall pay all Claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) attributable to OWNER's evaluation of and determination to accept such defective Work (such costs to be approved by ENGINEER as to reasonableness) and the diminished value of the Work to the extent not otherwise paid by CONTRACTOR pursuant to this sentence. If any such acceptance occurs prior to ENGINEER's recommendation of final payment, a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work, and OWNER shall be entitled to an appropriate decrease in the Contract Price, reflecting the diminished value of Work so accepted. If the parties are unable to agree as to the amount thereof, OWNER may make a Claim therefor as provided in paragraph 10.05. If the acceptance occurs after such recommendation, an appropriate amount will be paid by CONTRACTOR to OWNER.

13.09 *OWNER May Correct Defective Work*

A. If CONTRACTOR fails within a reasonable time after written notice from ENGINEER to correct defective Work or to remove and replace rejected Work as required by ENGINEER in accordance with paragraph 13.06.A, or if CONTRACTOR fails to perform the Work in accordance with the Contract Documents, or if CONTRACTOR fails to comply with any other provision of the Contract Documents, OWNER may, after seven days written notice to CONTRACTOR, correct and remedy any such deficiency.

B. In exercising the rights and remedies under this paragraph, OWNER shall proceed expeditiously. In connection with such corrective and remedial action, OWNER may exclude CONTRACTOR from all or part of the Site, take possession of all or part of the Work and suspend CONTRACTOR's services related thereto, take possession of CONTRACTOR's tools, appliances, construction equipment and machinery at the Site, and incorporate in the Work all materials and equipment stored at the Site or for which OWNER has paid CONTRACTOR but which are stored elsewhere. CONTRACTOR shall allow OWNER, OWNER's representatives, agents and employees, OWNER's other contractors, and ENGINEER and ENGINEER's Consultants access to the Site to enable OWNER to exercise the rights and remedies under this paragraph.

C. All Claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) incurred or sustained by OWNER in exercising the rights and remedies under this paragraph 13.09 will be charged against CONTRACTOR, and a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work; and OWNER shall be entitled to an appropriate decrease in the Contract Price. If the parties are unable to agree as to the amount of the adjustment, OWNER may make a Claim therefor as provided in paragraph 10.05. Such claims, costs, losses and damages will include but not be limited to all costs of repair, or replacement of work of others destroyed or damaged by correction, removal, or replacement of CONTRACTOR's defective Work.

D. CONTRACTOR shall not be allowed an extension of the Contract Times (or Milestones) because of any delay in the performance of the Work attributable to the exercise by OWNER of OWNER's rights and remedies under this paragraph 13.09.

ARTICLE 14 - PAYMENTS TO CONTRACTOR AND COMPLETION

14.01 *Schedule of Values*

A. The schedule of values established as provided in paragraph 2.07.A will serve as the basis for progress payments and will be incorporated into a form of Application for Payment acceptable to ENGINEER. Progress payments on account of Unit Price Work will be based on the number of units completed.

14.02 *Progress Payments*

A. *Applications for Payments*

1. At least 20 days before the date established for each progress payment (but not more often than once a month), CONTRACTOR shall submit to ENGINEER for review an Application for Payment filled out and signed by CONTRACTOR covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at the Site or at another location agreed to in writing, the Application for Payment shall also be accompanied by a bill of sale, invoice, or other documentation warranting that OWNER has received the materials and equipment free and clear of all Liens and evidence that the materials and equipment are covered by appropriate property insurance or other arrangements to protect OWNER's interest therein, all of which must be satisfactory to OWNER.

2. Beginning with the second Application for Payment, each Application shall include an affidavit of CONTRACTOR stating that all previous progress payments received on account of the Work have been applied on account to discharge CONTRACTOR's legitimate obligations associated with prior Applications for Payment.

3. The amount of retainage with respect to pro-gress payments will be as stipulated in the Agreement.

B. *Review of Applications*

1. ENGINEER will, within 10 days after receipt of each Application for Payment, either indicate in writing a recommendation of payment and present the Application to OWNER or return the Application to CONTRACTOR indicating in writing ENGINEER's reasons for refusing to recommend payment. In the latter case, CONTRACTOR may make the necessary corrections and resubmit the Application.

2. ENGINEER's recommendation of any payment requested in an Application for Payment will constitute a representation by ENGINEER to OWNER, based on ENGINEER's observations on the Site of the executed Work as an experienced and qualified design professional and on ENGINEER's review of the Application for Payment and the accompanying data and schedules, that to the best of ENGINEER's knowledge, information and belief:

a. the Work has progressed to the point indicated;

b. the quality of the Work is generally in accordance with the Contract Documents (subject to an evaluation of the Work as a functioning whole prior to or upon Substantial Comple tion, to the results of any subsequent tests called for in the Contract Documents, to a final determination of quantities and classifications for Unit Price Work under paragraph 9.08, and to any other qualifications stated in the recommendation); and

c. the conditions precedent to CONTRACTOR's being entitled to such payment appear to have been fulfilled in so far as it is ENGINEER's responsibility to observe the Work.

3. By recommending any such payment ENGINEER will not thereby be deemed to have represented that: (i) inspections made to check the quality or the quantity of the Work as it has been performed have been exhaustive, extended to every aspect of the Work in progress, or involved detailed inspections of the Work beyond the responsibilities specifically assigned to ENGINEER in the Contract Documents; or (ii) that there may not be other matters or issues between the parties

that might entitle CONTRACTOR to be paid additionally by OWNER or entitle OWNER to withhold payment to CONTRACTOR.

4. Neither ENGINEER's review of CONTRACTOR's Work for the purposes of recommending payments nor ENGINEER's recommendation of any payment, including final payment, will impose responsibility on ENGINEER to supervise, direct, or control the Work or for the means, methods, techniques, sequences, or procedures of construction, or the safety precautions and programs incident thereto, or for CONTRACTOR's failure to comply with Laws and Regulations applicable to CONTRACTOR's performance of the Work. Additionally, said review or recommendation will not impose responsibility on ENGINEER to make any examination to ascertain how or for what purposes CONTRACTOR has used the moneys paid on account of the Contract Price, or to determine that title to any of the Work, materials, or equipment has passed to OWNER free and clear of any Liens.

5. ENGINEER may refuse to recommend the whole or any part of any payment if, in ENGINEER's opinion, it would be incorrect to make the representations to OWNER referred to in paragraph 14.02.B.2. ENGINEER may also refuse to recommend any such payment or, because of subsequently discovered evidence or the results of subsequent inspections or tests, revise or revoke any such payment recommendation previously made, to such extent as may be necessary in ENGINEER's opinion to protect OWNER from loss because:

a. the Work is defective, or completed Work has been damaged, requiring correction or replacement;

b. the Contract Price has been reduced by Written Amendment or Change Orders;

c. OWNER has been required to correct defective Work or complete Work in accordance with paragraph 13.09; or

d. ENGINEER has actual knowledge of the occurrence of any of the events enumerated in paragraph 15.02.A.

C. *Payment Becomes Due*

1. Ten days after presentation of the Application for Payment to OWNER with ENGINEER's recommendation, the amount recommended will (subject to the provisions of paragraph 14.02.D) become due, and when due will be paid by OWNER to CONTRACTOR.

D. *Reduction in Payment*

1. OWNER may refuse to make payment of the full amount recommended by ENGINEER because:

a. claims have been made against OWNER on account of CONTRACTOR's performance or furnishing of the Work;

b. Liens have been filed in connection with the Work, except where CONTRACTOR has delivered a specific Bond satisfactory to OWNER to secure the satisfaction and discharge of such Liens;

c. there are other items entitling OWNER to a set-off against the amount recommended; or

d. OWNER has actual knowledge of the occurrence of any of the events enumerated in paragraphs 14.02.B.5.a through 14.02.B.5.c or paragraph 15.02.A.

2. If OWNER refuses to make payment of the full amount recommended by ENGINEER, OWNER must give CONTRACTOR immediate written notice (with a copy to ENGINEER) stating the reasons for such action and promptly pay CONTRACTOR any amount remaining after deduction of the amount so withheld. OWNER shall promptly pay CONTRACTOR the amount so withheld, or any adjustment thereto agreed to by OWNER and CONTRACTOR, when CONTRACTOR corrects to OWNER's satisfaction the reasons for such action.

3. If it is subsequently determined that OWNER's refusal of payment was not justified, the amount wrongfully withheld shall be treated as an amount due as determined by paragraph 14.02.C.1.

14.03 *CONTRACTOR's Warranty of Title*

A. CONTRACTOR warrants and guarantees that title to all Work, materials, and equipment covered by any Application for Payment, whether incorporated in the Project or not, will pass to OWNER no later than the time of payment free and clear of all Liens.

14.04 *Substantial Completion*

A. When CONTRACTOR considers the entire Work ready for its intended use CONTRACTOR shall notify OWNER and ENGINEER in writing that the entire Work is substantially complete (except for items specifically listed by CONTRACTOR as incomplete) and request that ENGINEER issue a certificate of Substantial Completion. Promptly thereafter, OWNER, CONTRACTOR, and ENGINEER shall make an inspection of the Work to determine the status of completion. If ENGINEER does not consider the Work substantially complete, ENGINEER will notify CONTRACTOR in writing giving the reasons therefor. If ENGINEER considers the Work substantially complete, ENGINEER will prepare and deliver to OWNER a tentative certificate of Substantial Completion which shall fix the date of Substantial Completion. There shall be attached to the certificate a tentative list of items to be completed or corrected before final payment. OWNER shall have seven days after receipt of the tentative certificate during which to make written objection to ENGINEER as to any provisions of the certificate or attached list. If, after considering such objections, ENGINEER concludes that the Work is not substantially complete, ENGINEER will within 14 days after submission of the tentative certificate to OWNER notify CONTRACTOR in writing, stating the reasons therefor. If, after consideration of OWNER's objections, ENGINEER considers the Work substantially complete, ENGINEER will within said 14 days execute and deliver to OWNER and CONTRACTOR a definitive certificate of Substantial Completion (with a revised tentative list of items to be completed or corrected) reflecting such changes from the tentative certificate as ENGINEER believes justified after consideration of any objections from OWNER. At the time of delivery of the tentative certificate of Substantial Completion ENGINEER will deliver to OWNER and CONTRACTOR a written recommendation as to division of responsibilities pending final payment between OWNER and CONTRACTOR with respect to security, operation, safety, and protection of the Work, maintenance, heat, utilities, insurance, and warranties and guarantees. Unless OWNER and CONTRACTOR agree otherwise in writing and so inform ENGINEER in writing prior to ENGINEER's issuing the definitive certificate of Substantial Completion, ENGINEER's aforesaid recommendation will be binding on OWNER and CONTRACTOR until final payment.

B. OWNER shall have the right to exclude CONTRACTOR from the Site after the date of Substantial Completion, but OWNER shall allow CONTRACTOR reasonable access to complete or correct items on the tentative list.

14.05 *Partial Utilization*

A. Use by OWNER at OWNER's option of any substantially completed part of the Work which has specifically been identified in the Contract Documents, or which OWNER, ENGINEER, and CONTRACTOR agree constitutes a separately functioning and usable part of the Work that can be used by OWNER for its intended purpose without significant interference with CONTRACTOR's performance of the remainder of the Work, may be accomplished prior to Substantial Completion of all the Work subject to the following conditions.

1. OWNER at any time may request CONTRACTOR in writing to permit OWNER to use any such part of the Work which OWNER believes to be ready for its intended use and substantially complete. If CONTRACTOR agrees that such part of the Work is substantially complete, CONTRACTOR will certify to OWNER and ENGINEER that such part of the Work is substantially complete and request ENGINEER to issue a certificate of Substantial Completion for that part of the Work. CONTRACTOR at any time may notify OWNER and ENGINEER in writing that CONTRACTOR considers any such part of the Work ready for its intended use and substantially complete and request ENGINEER to issue a certificate of Substantial Completion for that part of the Work. Within a reasonable time after either such request, OWNER, CONTRACTOR, and ENGINEER shall make an inspection of that part of the Work to determine its status of completion. If ENGINEER does not consider that part of the Work to be substantially complete, ENGINEER will notify OWNER and CONTRACTOR in writing giving the reasons therefor. If ENGINEER considers that part of the Work to be substantially complete, the provisions of paragraph 14.04 will apply with respect to certification of Substantial Completion of that part of the Work and the division of responsibility in respect thereof and access thereto.

2. No occupancy or separate operation of part of the Work may occur prior to compliance with the requirements of paragraph 5.10 regarding property insurance.

14.06 *Final Inspection*

A. Upon written notice from CONTRACTOR that the entire Work or an agreed portion thereof is complete, ENGINEER will promptly make a final inspection with OWNER and CONTRACTOR and will notify CONTRACTOR in writing of all particulars in which this inspection reveals that the Work is incomplete or defective. CONTRACTOR shall immediately take such measures as are necessary to complete such Work or remedy such deficiencies.

14.07 *Final Payment*

A. *Application for Payment*

1. After CONTRACTOR has, in the opinion of ENGINEER, satisfactorily completed all corrections identified during the final inspection and has delivered, in accordance with the Contract Documents, all maintenance and operating instructions, schedules, guarantees, Bonds, certificates or other evidence of insurance certificates of inspection, marked-up record documents (as provided in paragraph 6.12), and other documents, CONTRACTOR may make application for final payment following the procedure for progress payments.

2. The final Application for Payment shall be accompanied (except as previously delivered) by: (i) all documentation called for in the Contract Documents, including but not limited to the evidence of insurance required by subparagraph 5.04.B.7; (ii) consent of the surety, if any, to final payment; and (iii) complete and legally effective releases or waivers (satisfactory to OWNER) of all Lien rights arising out of or Liens filed in connection with the Work.

3. In lieu of the releases or waivers of Liens specified in paragraph 14.07.A.2 and as approved by OWNER, CONTRACTOR may furnish receipts or releases in full and an affidavit of CONTRACTOR that: (i) the releases and receipts include all labor, services, material, and equipment for which a Lien could be filed; and (ii) all payrolls, material and equipment bills, and other indebtedness connected with the Work for which OWNER or OWNER's property might in any way be responsible have been paid or otherwise satisfied. If any Subcontractor or Supplier fails to furnish such a release or receipt in full, CONTRACTOR may furnish a Bond or other collateral satisfactory to OWNER to indemnify OWNER against any Lien.

B. *Review of Application and Acceptance*

1. If, on the basis of ENGINEER's observation of the Work during construction and final inspection, and ENGINEER's review of the final Application for Payment and accompanying documentation as required by the Contract Documents, ENGINEER is satisfied that the Work has been completed and CONTRACTOR's other obligations under the Contract Documents have been fulfilled, ENGINEER will, within ten days after receipt of the final Application for Payment, indicate in writing ENGINEER's recommendation of payment and present the Application for Payment to OWNER for payment. At the same time ENGINEER will also give written notice to OWNER and CONTRACTOR that the Work is acceptable subject to the provisions of paragraph 14.09. Otherwise, ENGINEER will return the Application for Payment to CONTRACTOR, indicating in writing the reasons for refusing to recommend final payment, in which case CONTRACTOR shall make the necessary corrections and resubmit the Application for Payment.

C. *Payment Becomes Due*

1. Thirty days after the presentation to OWNER of the Application for Payment and accompanying documentation, the amount recommended by ENGINEER will become due and, when due, will be paid by OWNER to CONTRACTOR.

14.08 *Final Completion Delayed*

A. If, through no fault of CONTRACTOR, final completion of the Work is significantly delayed, and if ENGINEER so confirms, OWNER shall, upon receipt of CONTRACTOR's final Application for Payment and recommendation of ENGINEER, and without terminating the Agreement, make payment of the balance due for that portion of the Work fully completed and accepted. If the remaining balance to be held by OWNER for Work not

fully completed or corrected is less than the retainage stipulated in the Agreement, and if Bonds have been furnished as required in paragraph 5.01, the written consent of the surety to the payment of the balance due for that portion of the Work fully completed and accepted shall be submitted by CONTRACTOR to ENGINEER with the Application for such payment. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of Claims.

14.09 *Waiver of Claims*

A. The making and acceptance of final payment will constitute:

1. a waiver of all Claims by OWNER against CONTRACTOR, except Claims arising from unsettled Liens, from defective Work appearing after final inspection pursuant to paragraph 14.06, from failure to comply with the Contract Documents or the terms of any special guarantees specified therein, or from CONTRACTOR's continuing obligations under the Contract Documents; and

2. a waiver of all Claims by CONTRACTOR against OWNER other than those previously made in writing which are still unsettled.

ARTICLE 15 - SUSPENSION OF WORK AND TERMINATION

15.01 OWNER May Suspend Work

A. At any time and without cause, OWNER may suspend the Work or any portion thereof for a period of not more than 90 consecutive days by notice in writing to CONTRACTOR and ENGINEER which will fix the date on which Work will be resumed. CONTRACTOR shall resume the Work on the date so fixed. CONTRACTOR shall be allowed an adjustment in the Contract Price or an extension of the Contract Times, or both, directly attributable to any such suspension if CONTRACTOR makes a Claim therefor as provided in paragraph 10.05.

15.02 *OWNER May Terminate for Cause*

A. The occurrence of any one or more of the following events will justify termination for cause:

1. CONTRACTOR's persistent failure to perform the Work in accordance with the Contract Documents (including, but not limited to, failure to supply sufficient skilled workers or suitable materials or equipment or failure to adhere to the progress schedule established under paragraph 2.07 as adjusted from time to time pursuant to paragraph 6.04);

2. CONTRACTOR's disregard of Laws or Regulations of any public body having jurisdiction;

3. CONTRACTOR's disregard of the authority of ENGINEER; or

4. CONTRACTOR's violation in any substantial way of any provisions of the Contract Documents.

B. If one or more of the events identified in paragraph 15.02.A occur, OWNER may, after giving CONTRACTOR (and the surety, if any) seven days written notice, terminate the services of CONTRACTOR, exclude CONTRACTOR from the Site, and take possession of the Work and of all CONTRACTOR's tools, appliances, construction equipment, and machinery at the Site, and use the same to the full extent they could be used by CONTRACTOR (without liability to CONTRACTOR for trespass or conversion), incorporate in the Work all materials and equipment stored at the Site or for which OWNER has paid CONTRACTOR but which are stored elsewhere, and finish the Work as OWNER may deem expedient. In such case, CONTRACTOR shall not be entitled to receive any further payment until the Work is finished. If the unpaid balance of the Contract Price exceeds all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) sustained by OWNER arising out of or relating to completing the Work, such excess will be paid to CONTRACTOR. If such claims, costs, losses, and damages exceed such unpaid balance, CONTRACTOR shall pay the difference to OWNER. Such claims, costs, losses, and damages incurred by OWNER will be reviewed by ENGINEER as to their reasonableness and, when so approved by ENGINEER, incorporated in a Change Order. When exercising any rights or remedies under this paragraph OWNER shall not be required to obtain the lowest price for the Work performed.

C. Where CONTRACTOR's services have been so terminated by OWNER, the termination will not affect any rights or remedies of OWNER against CONTRACTOR then existing or which may thereafter accrue. Any retention or payment of moneys due CONTRACTOR by OWNER will not release CONTRACTOR from liability.

15.03 *OWNER May Terminate For Convenience*

A. Upon seven days written notice to CONTRACTOR and ENGINEER, OWNER may, without cause and without prejudice to any other right or remedy of OWNER, elect to terminate the Contract. In such case, CONTRACTOR shall be paid (without duplication of any items):

1. for completed and acceptable Work executed in accordance with the Contract Documents prior to the effective date of termination, including fair and reasonable sums for overhead and profit on such Work;

2. for expenses sustained prior to the effective date of termination in performing services and furnishing labor, materials, or equipment as required by the Contract Documents in connection with uncompleted Work, plus fair and reasonable sums for overhead and profit on such expenses;

3. for all claims, costs, losses, and damages (including but not limited to all fees and charges of engineers, architects, attorneys, and other professionals and all court or arbitration or other dispute resolution costs) incurred in settlement of terminated contracts with Subcontractors, Suppliers, and others; and

4. for reasonable expenses directly attributable to termination.

B. CONTRACTOR shall not be paid on account of loss of anticipated profits or revenue or other economic loss arising out of or resulting from such termination.

15.04 *CONTRACTOR May Stop Work or Terminate*

A. If, through no act or fault of CONTRACTOR, the Work is suspended for more than 90 consecutive days by OWNER or under an order of court or other public authority, or ENGINEER fails to act on any Application for Payment within 30 days after it is submitted, or OWNER fails for 30 days to pay CONTRACTOR any sum finally determined to be due, then CONTRACTOR may, upon seven days written notice to OWNER and ENGINEER, and provided OWNER or ENGINEER do not remedy such suspension or failure within that time, terminate the Contract and recover from OWNER payment on the same terms as provided in paragraph 15.03. In lieu of terminating the Contract and without prejudice to any other right or remedy, if ENGINEER has failed to act on an Application for Payment within 30 days after it is submitted, or OWNER has failed for 30 days to pay CONTRACTOR any sum finally determined to be due, CONTRACTOR may, seven days after written notice to OWNER and ENGINEER, stop the Work until payment is made of all such amounts due CONTRACTOR, including interest thereon. The provisions of this paragraph 15.04 are not intended to preclude CONTRACTOR from making a Claim under paragraph 10.05 for an adjustment in Contract Price or Contract Times or otherwise for expenses or damage directly attributable to CONTRACTOR's stopping the Work as permitted by this paragraph.

ARTICLE 16 - DISPUTE RESOLUTION

16.01 *Methods and Procedures*

A. Dispute resolution methods and procedures, if any, shall be as set forth in the Supplementary Conditions. If no method and procedure has been set forth, and subject to the provisions of paragraphs 9.09 and 10.05, OWNER and CONTRACTOR may exercise such rights or remedies as either may otherwise have under the Contract Documents or by Laws or Regulations in respect of any dispute.

ARTICLE 17 - MISCELLANEOUS

17.01 *Giving Notice*

A. Whenever any provision of the Contract Documents requires the giving of written notice, it will be deemed to have been validly given if delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, or if delivered at or sent by registered or certified mail, postage prepaid, to the last business address known to the giver of the notice.

17.02 *Computation of Times*

A. When any period of time is referred to in the Contract Documents by days, it will be computed to

exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day will be omitted from the computation.

17.03 *Cumulative Remedies*

A. The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto are in addition to, and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee, or by other provisions of the Contract Documents, and the provisions of this paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty, obligation, right, and remedy to which they apply.

17.04 *Survival of Obligations*

A. All representations, indemnifications, warranties, and guarantees made in, required by, or given in accordance with the Contract Documents, as well as all continuing obligations indicated in the Contract Documents, will survive final payment, completion, and acceptance of the Work or termination or completion of the Agreement.

17.05 *Controlling Law*

A. This Contract is to be governed by the law of the state in which the Project is located.

II.2 SUPPLEMENTAL GENERAL CONDITIONS

These Supplementary Conditions amend or supplement the Standard General Conditions of the Construction Contract (No. 1910-8, 1996 Edition) and other provisions of the Contract Documents as indicated below. All provisions, which are not so amended or supplemental, remain in full force and effect.

The terms used in these Supplementary Conditions will have the meanings indicated in the General Conditions. Additional terms used in these Supplementary Conditions have the meanings indicated below, which are applicable to both the singular and plural thereof.

SC-6.10 Delete paragraph 6.10 in its entirety and insert the following in its place:

*The **owner** qualifies for the state and local tax exemption in the purchase of certain materials and equipment, the **Contractor** shall utilize the form provided herewith exhibit "D".*

SC-11.01 Delete paragraph 11.01 in its entirety.

SC-11.02 Delete paragraph 11.02 in its entirety.

SC-12.01B.25 & B.3 Delete paragraph 12.01B.2 & B.3 in its entirety.

SC-12.01.C.2 Delete paragraph 12.01.C.2 in its entirety.

SC Article 14.02 C.1 Replace "**Ten days**" with "**Thirty days**" to read as follows: Thirty days after presentation of the Application for Payment to OWNER with ENGINEER'S recommendation, the amount recommended will (subject to the provisions of paragraph 14.02.D) become due, and when due will be paid by the OWNER TO CONTRACTOR.

SC Article 16 Add the following languague at the end of the paragraph of Article 16:

There are no dispute resolution methods and procedures set forth in the Supplemental Conditions:

GENERAL PREVAILING WAGE LEGAL REQUIREMENTS

The **Contractor**'s attention is called to Texas Government Code Chapter 2258, which must be complied with attached herewith as Exhibit "C"

II.3 GOVERNING SPECIFICATIONS

The following specifications and special provisions are those under which payment is to be made. These, together with such other pertinent items, if any, as may be referred to in the specifications and below, and including the special provisions listed below, constitute the governing specifications for this Contract.

STANDARD SPECIFICATIONS

Item 4
Scope of Work

1. CONTRACT INTENT

The intent of the Contract is to describe the completed work to be performed. Furnish materials, supplies, tools, equipment, labor, and other incidentals necessary for the proper prosecution and completion of the work in accordance with Contract documents.

2. PRECONSTRUCTION CONFERENCE

Before starting work, schedule and attend a preconstruction conference with the Engineer. Failure to schedule and attend a preconstruction conference is not grounds for delaying the beginning of working day charges. The preconstruction conference may be scheduled with the safety preconstruction meeting described in Section 7.2.2., "Safety Preconstruction Meeting" and the railroad coordination meeting described in Article 5.8, "Cooperation With Railroads". Work with the Engineer to resolve or escalate all issues. Execute the project pledge and establish an issue escalation ladder.

2.1. **Project Pledge**. Contractor representatives at the level of foreman and above will certify in writing they will approach the construction of this project in a manner consistent with delivering a high quality project in a safe, cost-effective, and timely manner, and they will be committed to not allowing personality conflicts or personal interests to interfere with providing the public with a quality project. Failure to uphold this commitment may result in grounds for removal from the project.

2.2. **Issue Resolution Process**. An issue is any aspect of the Contract where parties of the Contract do not agree. The individuals identified at the lowest level of the issue escalation ladder will initiate the issue resolution process by escalating any issue that remains unresolved within the time frame outlined in the issue escalation ladder.

Work with the Engineer to resolve all issues during the course of the Contract. Refer to Article 4.7., "Dispute or Claims Procedure" for all unresolved issues.

3. PARTNERING

The intent of this section is to promote an environment of trust, mutual respect, integrity, and fair-dealing between the Department and the Contractor.

Informal partnering does not make use of a facilitator, while formal partnering uses the services of a facilitator (internal or external).

3.1. **Procedures for Partnering Meetings and Format**. Informal partnering is required, unless formal partnering is mutually agreed to in lieu of the informal partnering.

3.2. **Facilitators**. The facilitator is to act as a neutral party seeking to initiate cooperative working relationships. This individual must have the technical knowledge and ability to lead and guide discussions. Choose either an internal or external facilitator. The facilitator must be acceptable to the Engineer.

3.2.1. **Internal Facilitators**. A Department or Contractor staff member may be selected as the facilitator at no additional cost to either party.

3.2.2. **External Facilitators**. A private firm or individual that is independent of the Contractor and the Department may be selected as the facilitator. Submit the facilitator's name and estimated fees for approval before contracting with the facilitator.

3.3. **Meetings and Arrangements**. Coordinate with the Engineer for meeting dates and times, locations including third party facilities, and other needs and appurtenances including but not limited to audio or visual equipment. Make all meeting arrangements for formal partnering. Use Department facilities or facilities in the vicinity of the project if available. Submit the estimated meeting costs for approval before finalizing arrangements.

Coordinate facilitator discussions before the partnering meeting to allow the facilitator time to prepare an appropriate agenda. Prepare a list of attendees with job titles and include critical Contractor, subcontractor, and supplier staff in the list. Provide the facilitator the list of attendees and invite the attendees listed.

The Department will invite and provide a list of attendees that includes but is not limited to Department, City, County, law enforcement, railroad, and utility representatives.

Participate in additional partnering meetings as mutually agreed.

3.4. **Payment**. Expenses for labor, Contractor equipment, or overhead will not be allowed. Markups as prescribed in Article 9.7., "Payment for Extra Work and Force Account Method," will not be allowed.

Informal partnering will be conducted with each party responsible for their own costs.

For formal partnering using internal facilitators, the Contractor will be responsible for arrangements and for expenses incurred by its internal facilitator, including but not limited to meals, travel, and lodging. Department facilitators may be used at no additional cost.

For formal partnering using external facilitators, submit an invoice to the Engineer for reimbursement. The Department will reimburse the Contractor for half of the eligible expenses as approved. For external facilitators not approved by the Department but used at the Contractor's option, the Contractor will be responsible for all costs of the external facilitator.

For meeting facilities and appurtenances, submit an invoice to the Engineer for reimbursement. The Department will reimburse the Contractor for half of the eligible expenses as approved.

4. CHANGES IN THE WORK

The Engineer reserves the right to make changes in the work including addition, reduction, or elimination of quantities and alterations needed to complete the Contract. Perform the work as altered. These changes will not invalidate the Contract nor release the Surety. The Contractor is responsible for notifying the sureties of any changes to the Contract.

If the changes in quantities or the alterations do not significantly change the character of the work under the Contract, the altered work will be paid for at the Contract unit price. If the changes in quantities or the alterations significantly change the character of the work, the Contract will be amended by a change order. If no unit prices exist, this will be considered extra work and the Contract will be amended by a change order. Provide cost justification as requested, in an acceptable format. Payment will not be made for anticipated profits on work that is eliminated.

Agree on the scope of work and the basis of payment for the change order before beginning the work. If there is no agreement, the Engineer may order the work to proceed under Article 9.7., "Payment for Extra Work and Force Account Method," or by making an interim adjustment to the Contract. In the case of an adjustment, the Engineer will consider modifying the compensation after the work is performed.

A significant change in the character of the work occurs when:

- the character of the work for any item as altered differs materially in kind or nature from that in the Contract, or
- a major item of work varies by more than 25% from the original Contract quantity, except for non-site-specific Contracts.

When the quantity of work to be done under any major item of the Contract is more than 125% of the original quantity stated in the Contract, then either party to the Contract may request an adjustment to the unit price on the portion of the work that is above 125%.

When the quantity of work to be done under any major item of the Contract is less than 75% of the original quantity stated in the Contract, then either party to the Contract may request an adjustment to the unit price. Adjust the unit price by multiplying the Contract unit price by the factor in Table 1.

Table 1
Quantity-Based Price Adjustment Factors

% of Original Quantity	Factor
≥ 50 and < 75	1.05
≥ 25 and < 50	1.15
< 25	1.25

If the changes require additional working days to complete the Contract, Contract working days will be adjusted in accordance with Item 8, "Prosecution and Progress."

5. DIFFERING SITE CONDITIONS

During the progress of the work, differing subsurface or latent physical conditions may be encountered at the site. The 2 types of differing site conditions are defined as:

- those that differ materially from those indicated in the Contract, and
- 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.

Notify the Engineer in writing when differing site conditions are encountered. The Engineer will notify the Contractor when the Department discovers differing site conditions. Unless directed otherwise, suspend work on the affected items and leave the site undisturbed. The Engineer will investigate the conditions and determine whether differing site conditions exist. If the differing site conditions cause an increase or decrease in the cost or number of working days specified for the performance of the Contract, the Engineer will make adjustments, excluding the loss of anticipated profits, in accordance with the Contract. Additional compensation will be made only if the required written notice has been provided.

6. REQUESTS FOR ADDITIONAL COMPENSATION AND DAMAGES

Notify the Engineer in writing of any intent to request additional compensation once there is knowledge of the basis for the request. An assessment of damages is not required to be part of this notice but is desirable. The intent of the written notice requirement is to provide the Engineer an opportunity to evaluate the request and to keep an accurate account of the actual costs that may arise. Minimize impacts and costs.

If written notice is not given, the Contractor waives the right to additional compensation unless the circumstances could have reasonably prevented the Contractor from knowing the cost impact before performing the work. Notice of the request and the documentation of the costs will not be construed as proof or substantiation of the validity of the request. Submit the request in enough detail to enable the Engineer to determine the basis for entitlement, adjustment in the number of working days specified in the Contract, and compensation.

Damages occur when impacts that are the responsibility of the Department result in additional costs to the Contractor that could not have been reasonably anticipated at the time of letting. Costs of performing

additional work are not considered damages. For Contractor damages, the intent is to reimburse the Contractor for actual expenses arising out of a compensable impact. No profit or markups, other than labor burden, will be allowed. For damages, labor burden will be reimbursed at 35% unless the Contractor can justify higher actual cost. Justification for a higher percentage must be in accordance with the methodology provided by the Department, submitted separately for project overhead labor and direct labor, and determined and submitted by a Certified Public Accountant (CPA). Submit CPA-prepared labor burden rates directly to the Construction Division for approval.

The Department will not consider fees and interest on requests for additional compensation and damages. Fees include, but are not limited to: preparation, attorney, printing, shipping, and various other fees.

If the Contractor requests compensation for damages and the damages are determined to be compensable, then standby equipment costs and project overhead compensation will be based on the duration of the compensable damage and will be limited as follows:

6.1. **Standby Equipment Costs**. Payment will be made in accordance with Section 9.7.1.4.3., "Standby Equipment Costs."

6.2. **Project Overhead**. Project overhead is defined as the administrative and supervisory expenses incurred at the work locations. When delay to project completion occurs, reimbursement for project overhead for the Contractor will be made using the following options:

- reimbursed at 6% (computed as daily cost by dividing 6% of the original Contract amount by the number of original Contract work days), or
- actual documented costs for the impacted period.

Project overhead for delays impacting subcontractors will be determined from actual documented costs submitted by the Contractor.

Time extensions and suspensions alone will not be justification for reimbursement for project overhead.

6.3. **Home Office Overhead**. The Department will not compensate the Contractor for home office overhead.

7. DISPUTE OR CLAIMS PROCEDURE

The dispute resolution policy promotes a cooperative attitude between the Engineer and Contractor. Emphasis is placed on resolving issues while they are still current, at the area office or the district office, and in an informal manner. Open sharing of information is encouraged by all parties involved so the information provided completely and accurately reflects the issues and facts. If information is not shared, decisions may be limited to relying on the documentation that is available for review.

It is the Department's goal to have a dispute settled in the District before elevating it to the Contract Claim Committee (CCC) as a claim. The Construction Division can assist in the resolution of a dispute with a Contractor when requested by the District. The Contractor may request that a District ask for assistance of the Construction Division; however, the request for a recommendation prepared by the Construction Division to settle a dispute must come from the District.

If a dispute cannot be resolved, initiate the Contract claim procedure by submitting a claim to the District Engineer, the Director of the Construction Division, or the CCC.

The Department's Contract claim procedure has been established in accordance with Title 43 of the Texas Administrative Code, Part 1, Chapter 9, Subchapter A, Rule §9.2, *Contract Claim Procedure*. Detailed instructions for submitting a claim and its components can be found on the Department's website.

If a claim has been submitted and the Contractor wishes to resume negotiations with the District, notify the CCC in writing of the intent to resume negotiations at the District level and request review of the claim be suspended by the CCC pending the outcome of the negotiations.

File a claim after completion of the Contract or when required for orderly performance of the Contract. For a claim resulting from enforcement of a warranty period, file the claim no later than one year after expiration of the warranty period. For all other claims, file the claim no later than the date the Department issues notice to the Contractor that they are in default, the date the Department terminates the Contract, or one year after the date of final acceptance of the Contract. It is the Contractor's responsibility to submit requests in a timely manner.

Item 5

Control of the Work

1. AUTHORITY OF ENGINEER

The Engineer has the authority to observe, test, inspect, approve, and accept the work. The Engineer decides all questions about the quality and acceptability of materials, work performed, work progress, Contract interpretations, and acceptable Contract fulfillment. The Engineer has the authority to enforce and make effective these decisions.

The Engineer acts as a referee in all questions arising under the terms of the Contract. The Engineer's decisions will be final and binding.

The Engineer may pursue actions against the Contractor, including but not limited to the withholding of estimates and suspending the work, for noncompliance of the Contract.

The Engineer may suspend the work without suspending working day charges for noncompliance of the Contract.

2. PLANS AND WORKING DRAWINGS

When required, provide working drawings to supplement the plans with all necessary details not included on the Contract plans. Prepare and furnish working drawings in a timely manner and obtain approval, if required, before the beginning of the associated work. For all working drawing submittal requirements, the Engineer may allow electronic and other alternative submission procedures. Have a licensed professional engineer sign, seal, and date the working drawings as indicated in Table 1.

Prepare working drawings using United States standard measures in the English language. The routing of submittals for review and approval will be established at the preconstruction conference. The Contractor is responsible for the accuracy, coordination, and conformity of the various components and details of the working drawings. Department approval of the Contractor's working drawings will not relieve the Contractor of any responsibility under the Contract. The work performed under this Article will not be measured or paid for directly but will be subsidiary to pertinent Items.

Table 1
Signature and Approval Requirements for Working Drawings

Working Drawings For		Requires Licensed Professional Engineer's Signature, Seal, and Date	Requires Departmental Approval
1. Alternate or optional designs submitted by Contractor		Yes	Yes
2. Supplementary shop and fabrication drawings for structural Items		No unless required on the plans	See applicable Item
3. Contractor-proposed temporary facilities that affect the public safety, not included on the plans		Yes	Yes
4. Form and falsework details	Bridges, retaining walls, and other major structures	Yes unless otherwise shown on the plans	No[1]
	Minor structures	No unless otherwise shown on the plans	No
5. Erection drawings		Yes	No[1,2]
6. Contractor-proposed major modifications to traffic control plan		Yes	Yes

1. The Engineer may require that the Contractor have a licensed professional engineer certify that the temporary works are constructed according to the sealed drawings.
2. Approval is required for items spanning over live traffic or where safety of the traveling public is affected, in the opinion of the Engineer.

Submit shop drawings electronically for the fabrication of structural items as documented in the *Guide to Electronic Shop Drawing Submittal* available on the internet at ftp://ftp.dot.state.tx.us/pub/txdot-info/library/pubs/bus/bridge/e_submit_guide.pdf and as directed for other items required by the Contract. References to 11 × 17-in. sheets in individual specifications for structural items imply electronic computer aided design sheets.

3. CONFORMITY WITH PLANS, SPECIFICATIONS, AND SPECIAL PROVISIONS

Furnish materials and perform work in reasonably close conformity with the lines, grades, cross-sections, dimensions, details, gradations, physical and chemical characteristics of materials, and other requirements shown in the Contract. Reasonably close conformity limits will be as defined in the respective Items of the Contract or, if not defined, as determined by the Engineer. Obtain approval before deviating from the plans and approved working drawings. Do not perform work beyond the lines and grades shown on the plans or any extra work without the Engineer's authority. Work performed beyond the lines and grades shown on the plans or any extra work performed without authority is considered unauthorized and excluded from pay consideration. The Department will not pay for material rejected due to improper fabrication, excess quantity, or any other reasons within the Contractor's control.

3.1. **Acceptance of Defective or Unauthorized Work**. When work fails to meet Contract requirements, but is adequate to serve the design purpose, the Engineer will decide the extent to which the work will be accepted and remain in place. The Engineer will document the basis of acceptance by a letter and may adjust the Contract price.

3.2. **Correction of Defective or Unauthorized Work**. When work fails to meet Contract requirements and is inadequate to serve the design purpose it will be considered defective. Correct, or remove and replace, the work at the Contractor's expense, as directed.

The Department has the authority to correct or to remove and replace defective or unauthorized work. The cost may be deducted from any money due or to become due to the Contractor.

4. COORDINATION OF PLANS, SPECIFICATIONS, AND SPECIAL PROVISIONS

The specifications, accompanying plans, special provisions, change orders, and supplemental agreements are intended to work together and be interpreted as a whole.

Numerical dimensions govern over scaled dimensions. Special provisions govern over plans (including general notes), which govern over standard specifications and special specifications. Job-specific plan sheets govern over standard plan sheets.

However, in the case of conflict between plans (including general notes) and specifications regarding responsibilities for hazardous materials and traffic control in Items 1 through 9, "General Requirements and Conditions and Item 502, "Barricades, Signs, and Traffic Handling," special provisions govern over standard specifications and special specifications, which govern over the plans.

Notify the Engineer promptly of any omissions, errors, or discrepancies discovered so that necessary corrections and interpretations can be made. Failure to promptly notify the Engineer will constitute a waiver of all claims for misunderstandings or ambiguities that result from the errors, omissions, or discrepancies discovered.

5. COOPERATION OF CONTRACTOR

Cooperate with the Engineer. Respond promptly to instructions from the Engineer. Provide all information necessary for the successful completion of the Contract.

Designate in writing a competent, English-speaking Superintendent employed by the Contractor. The Superintendent must be experienced with the work being performed and capable of reading and understanding the Contract. Ensure the Superintendent is available at all times and able to receive instructions from the Engineer or authorized Department representatives and to act for the Contractor. The Engineer may suspend work without suspending working day charges if a Superintendent is not available or does not meet the above criteria.

At the written request of the Engineer, immediately remove from the project any employee or representative of the Contractor or a subcontractor who, in the opinion of the Engineer, does not perform work in a proper and skillful manner or who is disrespectful, intemperate, disorderly, uncooperative, or otherwise objectionable. Do not reinstate these individuals without the written consent of the Engineer.

Furnish suitable machinery, equipment, and construction forces for the proper prosecution of the work. Provide adequate lighting to address quality requirements and inspection of nighttime work.

6. COOPERATING WITH UTILITIES

Use established safety practices when working near utilities. Consult with the appropriate utilities before beginning work. Notify the Engineer immediately of utility conflicts. The Engineer will decide whether to adjust utilities or adjust the work to eliminate or lessen the conflict. Unless otherwise shown on the plans, the Engineer will make necessary arrangements with the utility owner when utility adjustments are required.

Use work procedures that protect utilities or appurtenances that remain in place during construction. Cooperate with utilities to remove and rearrange utilities to avoid service interruption or duplicate work by the utilities. Allow utilities access to the right of way.

Immediately notify the appropriate utility of service interruptions resulting from damage due to construction activities. Cooperate with utilities until service is restored. Maintain access to fire hydrants when necessary.

7. COOPERATION BETWEEN CONTRACTORS

Cooperate and coordinate with other Contractors working within the limits or adjacent to the limits.

8. COOPERATION WITH RAILROADS

Plan and prosecute portions of the work involving a railway to avoid interference with or hindrance to the railroad company.

If the work is on railroad right of way, do not interfere with the operation of the railroad company's trains or other property.

8.1. **Railroad Coordination Meeting**. When shown on the plans or directed by the Engineer, schedule and attend a railroad coordination meeting with the Engineer before beginning work or as agreed (may be a part of the preconstruction conference described in Article 4.2., "Preconstruction Conference"). Prepare a list of attendees and invite personnel that includes but is not limited to Department, Contractor, subcontractor, and railroad representatives.

Provide the invite to the railroad representatives at least 21 calendar days before the railroad coordination meeting.

8.2. **Project-Specific Information**. Refer to project-specific plan sheets in the Contract for specific information concerning the work to be completed by both the Contractor and the railroad within railroad right of way; railroad right of way locations impacted by construction; percentage of contract work at each location; train movements at each location; and requirements for railroad insurance, flagging, and Right of Entry (ROE) Agreements.

8.3. **Right of Entry Agreement by the Department**. When shown on the plans, the process for obtaining a fully executed ROE Agreement is as follows:

- The Department will send the unexecuted ROE Agreement to the Contractor with the unexecuted Contract.
- Partially execute the ROE Agreement and return it to the Department with the partially executed Contract and required insurance.
- The Department will coordinate with the railroad company regarding the further execution of the ROE Agreement and associated fees. The Department will pay any ROE Agreement fees directly to the railroad company.
- Once the Department has received the fully-executed ROE Agreement from the railroad company, the Department will forward the fully-executed ROE Agreement to the Contractor.

8.4. **Right of Entry Agreement by the Contractor.** When shown on the plans, contact the railroad company to obtain the ROE Agreement before beginning work on the Contract.

Provide the required insurance to the Department before beginning work on the Contract.

Execute the ROE Agreement and pay any associated fees to the railroad company. Provide a copy of the fully-executed ROE Agreement to the Department.

9. CONSTRUCTION SURVEYING

Use Method C unless otherwise specified in the Contract. Upon request, the Engineer will allow the Contractor to copy available earthwork cross-sections, computer printouts or data files, and other information necessary to establish and control work. Maintain the integrity of control points. Preserve all control points, stakes, marks, and right of way markers. Assume cost and responsibility of replacing disturbed control points, stakes, marks, and right of way markers damaged by the Contractor's or its subcontractor operations. If the Department repairs disturbed control points, stakes, marks, or right of way markers, the cost of repair may be deducted from money due or to become due to the Contractor. Replace right of way markers under the direction of a RPLS. This work performed under this Article will not be measured or paid for directly but will be considered subsidiary to pertinent Items.

The Engineer reserves the right to make measurements and surveys to determine the accuracy of the work and determine pay quantities. The Engineer's measurements and surveys do not relieve the Contractor's responsibility for accuracy of work. Allow the Engineer adequate time to verify the surveying.

9.1. **Method A**. The Engineer will set control points for establishing lines, slopes, grades, and centerlines and for providing both vertical and horizontal control.

At a minimum, provide a controlling pair of monument points at both the beginning and end of construction project for projects less than 2 mi. in length. For projects greater than 2 mi. in length, monuments will be set in pairs of 2 at a minimum of 2 mi. based on the overall length of the project. Use these control points as reference to perform the work.

Furnish materials, equipment, and qualified workforce necessary for the construction survey work. Place construction points, stakes, and marks at intervals sufficient to control work to established tolerances. Place construction stakes at intervals of no more than 100 ft., or as directed. Place stakes and marks so as not to interfere with normal maintenance operations.

9.2. **Method B**. The Engineer will set adequate control points, stakes, and marks to establish lines, slopes, grades, and centerlines. Furnish additional work, stakes, materials, and templates necessary for marking and maintaining points and lines.

9.3. **Method C**. Set adequate control points, stakes, and marks to establish lines, slopes, grades, and centerlines.

10. INSPECTION

Inspectors are authorized representatives of the Engineer. Inspectors are authorized to examine all work performed and materials furnished, including preparation, fabrication, and material manufacture. Inspectors inform the Contractor of failures to meet Contract requirements. Inspectors may reject work or materials and may suspend work until any issues can be referred to and decided by the Engineer. Inspectors cannot alter, add, or waive Contract provisions, issue instructions contrary to the Contract, act as foremen for the Contractor, or interfere with the management of the work. Inspection or lack of inspection will not relieve the Contractor from obligation to provide materials or perform the work in accordance with the Contract.

Provide safe access to all parts of the work and provide information and assistance to the Engineer to allow a complete and detailed inspection. Give the Engineer sufficient notice to inspect the work. Work performed without suitable inspection, as determined by the Engineer, may be ordered removed and replaced at Contractor's expense. Remove or uncover portions of finished work as directed. Once inspected, restore work to Contract requirements. If the uncovered work is acceptable, the costs to uncover, remove, and replace or make good the parts removed will be paid for in accordance with Article 4.4., "Changes in the Work." If the work is unacceptable, assume all costs associated with repair or replacement, including the costs to uncover, remove, and replace or make good the parts removed.

When a government entity, utility, railroad company, or other entity accepts or pays a portion of the Contract, that organization's representatives may inspect the work but cannot direct the Contractor. The right of inspection does not make that entity a party to the Contract and does not interfere with the rights of the parties to the Contract.

11. FINAL CLEANUP

Upon completion of the work, remove litter, debris, objectionable material, temporary structures, excess materials, and equipment from the work locations. Clean and restore property damaged by the Contractor's operations during the prosecution of the work. Leave the work locations in a neat and presentable condition.

Remove from the right of way cofferdams, construction buildings, material and fabrication plants, temporary structures, excess materials, and debris resulting from construction. Where work is in a stream, remove

debris to the ground line of the bed of the stream. Leave stream channels and rights of way in a neat and presentable condition. Clean structures to the flow line or the elevation of the outfall channel, whichever is higher. Dispose of all excess material in accordance with federal, state, and local regulations.

The work performed under this Article will not be paid for directly but will be considered subsidiary to Items of the Contract.

12. FINAL ACCEPTANCE

12.1. **Routine Maintenance Contracts**. The Engineer will perform final acceptance and notify the Contractor of acceptance. The Engineer may use final acceptance procedures shown for construction Contracts.

12.2. **Construction Contracts**. Final acceptance is made when all work is complete and the Engineer, in writing, accepts all work for the work locations in the Contract. Final acceptance relieves the Contractor from further Contract responsibilities.

12.2.1. **Work Completed**. Work completed must include work for vegetative establishment and maintenance, test, and performance periods and work to meet the requirements of Article 5.11., "Final Cleanup."

12.2.2. **Final Inspection**. After all work is complete, the Engineer in charge of the work will request a final inspection by the Engineer authorized to accept the work.

The final inspection will be made as soon as possible and not later than 10 calendar days after the request. No working day charges will be made between the date of request and final inspection.

After the final inspection, if the work is satisfactory, the Engineer will notify the Contractor in writing of the final acceptance of the work. If the final inspection finds any work to be unsatisfactory, the Engineer will identify in writing all deficiencies in the work requiring correction. Correct the deficiencies identified. Working day charges will resume if these deficiencies are not corrected within 7 calendar days, unless otherwise authorized by the Engineer. Upon correction, the Engineer will make an inspection to verify that all deficiencies were corrected satisfactorily. The Engineer will provide written notice of the final acceptance.

12.2.3. **Final Measurement**. Final measurements and pay quantity adjustments may be made after final acceptance.

12.2.4. **Removal of Traffic Control Devices**. Remove construction traffic control devices and advance warning signs upon final acceptance or as directed.

12.3. **Multiple Work Orders**. For Contracts with multiple work orders, final acceptance may be made upon completion of the work for each work order, in accordance with Section 5.12.1., "Routine Maintenance Contracts."

Item 6
Control of Materials

1. SOURCE CONTROL

Use only materials that meet Contract requirements. Unless otherwise specified or approved, use new materials for the work. Secure the Engineer's approval of the proposed source of materials to be used before their delivery. Materials can be approved at a supply source or staging area but may be inspected in accordance with Article 6.4., "Sampling, Testing, and Inspection."

1.1. **Buy America**. Comply with the latest provisions of Buy America as listed at 23 CFR 635.410. Use steel or iron materials manufactured in the United States except when:

- the cost of materials, including delivery, does not exceed 0.1% of the total Contract cost or $2,500, whichever is greater,
- the Contract contains an alternate item for a foreign source steel or iron product and the Contract is awarded based on the alternate item, or
- the materials are temporarily installed.

Submit a notarized original of the FORM D-9-USA-1 (Department Form 1818) with the proper attachments for verification of compliance.

Manufacturing is any process that modifies the chemical content, physical shape or size, or final finish of a product. Manufacturing begins with initial melting and mixing and continues through fabrication (cutting, drilling, welding, bending, etc.) and coating (paint, galvanizing, epoxy, etc.).

1.2. **Buy Texas**. For construction or maintenance Contracts without federal funds, buy materials produced in Texas when the materials are available at a comparable price and in a comparable period of time. Provide documentation of purchases or a description of good-faith efforts on request.

2. MATERIAL QUALITY

Correct or remove materials that fail to meet Contract requirements or that do not produce satisfactory results. Reimburse the Department for cost incurred if additional sampling and testing is required by a change of source.

Materials not meeting Contract requirements will be rejected, unless the Engineer approves corrective actions. Upon rejection, immediately remove and replace rejected materials.

If the Contractor does not comply with this Article, the Department may remove and replace defective material. The cost of testing, removal, and replacement will be deducted from the payments due to the Contractor.

3. MANUFACTURER WARRANTIES

Transfer to the Department warranties and guarantees required by the Contract or received as part of normal trade practice.

4. SAMPLING, TESTING, AND INSPECTION

Incorporate into the work only material that has been inspected, tested, and accepted by the Department. Remove, at the Contractor's expense, materials from the work locations that are used without prior testing and approval or written permission of the Engineer.

The material requirements and standard test methods in effect at the time the proposed Contract is advertised govern. Unless otherwise noted, the Department will perform testing at its expense. In addition to facilities and equipment required by the Contract, furnish facilities and calibrated equipment required for tests to control the manufacture of construction items. If requested, provide a complete written statement of the origin, composition, and manufacture of materials.

All materials used are subject to inspection or testing at any time during preparation or use. Material which has been tested and approved at a supply source or staging area may be inspected or tested before or during incorporation into the work, and rejected if it does not meet Contract requirements. Copies of test results are available upon request. Do not use material that, after approval, becomes unfit for use.

Unless otherwise noted in the Contract, all testing must be performed within the United States and witnessed by the Engineer. If materials or processes require testing outside the contiguous 48 United States, reimburse the Department for inspection expenses.

5. PLANT INSPECTION AND TESTING

The Engineer may but is not obligated to inspect materials at the acquisition or manufacturing source. Material samples will be obtained and tested for compliance with quality requirements. Materials produced under Department inspection are for Department use only unless released in writing by the Engineer.

If inspection is at the plant, meet the following conditions unless otherwise specified:

- cooperate fully and assist the Engineer during the inspection,
- ensure the Engineer has full access to all parts of the plant used to manufacture or produce materials,
- provide a facility at the plant for use by the Engineer as an office or laboratory,
- provide and maintain adequate safety measures and restroom facilities, and
- furnish and calibrate scales, measuring devices, and other necessary equipment.

The Engineer may provide inspection for periods other than daylight hours if:

- continuous production of materials for Department use is necessary due to the production volume being handled at the plant, and
- the lighting is adequate to allow satisfactory inspection.

6. STORAGE OF MATERIALS

Store and handle materials to preserve their quality and fitness for the work. Store materials so that they can be easily inspected and retested. Place materials under cover, on wooden platforms, or on other hard, clean surfaces as necessary or when directed.

Obtain approval to store materials on the right of way. Storage space off the right of way is at the Contractor's expense.

7. DEPARTMENT-FURNISHED MATERIAL

The Department will supply materials as shown on the plans. The cost of handling and placing materials supplied by the Department will not be paid for directly but will be subsidiary to the Item in which they are used. Assume responsibility for materials upon receipt.

8. USE OF MATERIALS FOUND ON THE RIGHT OF WAY

Material found in the excavation areas and meeting the Department's specifications may be used in the work. This material will be paid for at the Contract bid price for excavation and under the Item for which the material is used.

Do not excavate or remove any material from within the right of way that is not within the limits of the excavation without written permission. If excavation is allowed within a right of way project-specific location, replace the removed material with suitable material at no cost to the Department as directed.

9. RECYCLED MATERIALS

The Department will not allow hazardous wastes, as defined in 30 TAC 335, proposed for recycling. Use nonhazardous recyclable materials (NRMs) only if the specification for the Item does not disallow or restrict use. Determine if NRMs are regulated under 30 TAC 312, 330, 332, 334, or 335, and comply with all general prohibitions and requirements. Use NRMs in accordance with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines," and furnish all documentation in the manner prescribed by the Department.

10. HAZARDOUS MATERIALS

Comply with the requirements of Article 7.12., "Responsibility for Hazardous Materials."

The Department is responsible for testing, removing, and disposing of hazardous materials not introduced by the Contractor, except for paint removal associated with Item 446, "Field Cleaning and Painting Steel," Item 776, "Metal Rail Repair," and Item 784, "Steel Member Repair." The plans will indicate locations where paint on steel is suspected to contain hazardous materials. The Engineer may suspend work wholly or in part during the testing, removing, or disposing of hazardous materials, except in the case where hazardous materials are introduced by the Contractor.

Use materials that are free of hazardous materials. Notify the Engineer immediately if materials are suspected to contain hazardous materials. If materials delivered to the project by the Contractor are suspected to contain hazardous materials, have an approved commercial laboratory test the materials for contamination. Remove, remediate, and dispose of any of these materials found to be contaminated. The work required to comply with this section will be at the Contractor's expense. Working day charges will not be suspended and extensions of working days will not be granted for activities related to handling hazardous material introduced by the Contractor.

10.1. **Painted Steel Requirements**. Paint containing hazardous materials will be removed as shown on the plans.

10.1.1. **Paint Removed by Third Party.** The Department will provide a third party to remove paint containing hazardous materials where paint must be removed to perform work when dismantling steel under Item 496, "Removing Structures."

10.1.2. **Paint Removed by the Contractor.** This work may only be performed by a firm or company with one of the following certifications unless otherwise shown on the plans:

- SSPC-QP2 Category A certification for lead painting operations, or
- Certified Lead Firm by the Texas Department of State Health Services.

Maintain certifications for the duration of the Contract. Provide copies of audits and certification to the Engineer.

Comply with worker and public safety regulations including but not limited to 29 CFR Parts 1910, 1925, and 1926. Monitor permissible exposure limits in accordance with OSHA requirements.

Remove paint containing hazardous materials from designated areas shown on the plans or as directed by the Engineer. Comply with access limitations shown on the plans.

Provide power hand tools, equipped with high-efficiency particulate air filter vacuums to mechanically remove paint unless otherwise approved.

Contain, collect, store, transport, and dispose of all waste generated by cleaning operation in accordance with local, state and federal requirements including 40 CFR 302. Properly characterize and dispose of all wastes. Manage wastes in accordance with regulatory requirements and dispose in a facility authorized to accept such wastes. Provide copies of disposal manifests to the Engineer.

Refer to Item 446, "Field Cleaning and Painting Steel" for measurement and payment.

10.2. **Removal and Disposal of Painted Steel**. Painted steel will be disposed of at a steel recycling or smelting facility unless otherwise shown on the plans. If the paint contains hazardous materials, maintain and make available to the Engineer invoices and other records obtained from the facility showing the received weight of the steel and the facility name.

Refer to Item 496, "Removing Structures" and Item 497, "Sale of Salvageable Material" for measurement and payment.

10.3. **Asbestos Requirements**. The plans will indicate locations or elements where asbestos containing materials (ACM) are present. Notify the Engineer of proposed dates of demolition or removal of structural elements with ACM at least 60 days before beginning work.

The Department of State Health Services (DSHS), Asbestos Programs Branch, is responsible for administering the requirements of the National Emissions Standards for Hazardous Air Pollutants, 40 CFR Part 61, Subpart M and the Texas Asbestos Health Protection Rules (TAHPR). Based on EPA guidance and regulatory background information, bridges are considered to be a regulated "facility" under NESHAP. Therefore, federal standards for demolition and renovation apply.

The Department is required to notify the DSHS at least 10 working days (by postmarked date) before initiating demolition or renovation of each structure or load bearing member shown on the plans. If the actual demolition or renovation date is changed or delayed, notify the Engineer in writing of the revised dates in sufficient time to allow for the Department's notification to DSHS to be postmarked at least 10 days in advance of the actual work.

Failure to provide the above information may require the temporary suspension of work under Article 8.4., "Temporary Suspension of Work or Working Day Charges," due to reasons under the control of the Contractor. The Department retains the right to determine the actual advance notice needed for the change in date to address post office business days and staff availability.

10.3.1. **Asbestos Removed by Third Party.** At locations where unknown ACM is discovered, the Department will arrange for abatement by a third party.

10.3.2. **Asbestos Removed by the Contractor.** Maintain certification as Asbestos Abatement Contractor by the Texas Department of State Health Services for the duration of the Contract. Provide copies of audits and certification to the Engineer.

10.4. **Work Performed by a Third Party**. When the work for removal of paint or asbestos abatement is to be provided by a third party, coordinate and cooperate with the third party and the Department. Continue other work detailed in the plans not directly involved in the paint removal or asbestos abatement work. Provide notice to the Department regarding the progress of the work to allow the Department sufficient time to schedule the third party work.

11. SURPLUS MATERIALS

Take ownership of surplus materials unless otherwise shown on the plans or directed. Remove and dispose of materials in accordance with federal, state, and local regulations. If requested, provide an appropriate level of documentation to verify proper disposal. When materials are disposed of on private property, provide written authorization from the property owner for the use of the property for this purpose upon request.

Item 7

Legal Relations and Responsibilities

1. ETHICS

Honor the Department's ethics policy. The Department's ethics policy has been established in accordance with Title 43 of the Texas Administrative Code, Part 1, Chapter 10. A complete copy of the Department's ethics policy can be found on the Department's website.

By entering into Contract, the Contractor certifies that the Contractor has read and understands the Department's ethics policy.

Failure to honor this policy may result in action by the Department, which includes but is not limited to verbal warning, removal of project personnel, termination of the Contract, and sanctions under the Texas Administrative Code.

2. SAFETY

2.1. **Safety Point of Contact.** Designate in writing, a Contractor Safety Point of Contact (CSPOC). The Department will assign a Department employee for their point of contact designated as DSPOC. The CSPOC will ensure that the Contractor's and Subcontractor's employees' use the appropriate personal protection equipment (hard hats, safety vests, protective toe footwear, etc.).

The CSPOC will ensure that crew leaders and foremen (including subcontractors) have attended the required training.

2.2. **Safety Preconstruction Meeting**. In cooperation with the Engineer, schedule and attend a safety preconstruction meeting (may be a part of the preconstruction conference in Article 4.2., "Preconstruction Conference"). Attendees for this safety preconstruction meeting will be:

- the Contractor,
- subcontractors,
- Department,
- local law enforcement, and
- other personnel that play an active role on the project.

2.3. **Safety Contingency**. In order to improve the effectiveness of traffic handling and enhancing safety during the course of this project, a safety contingency fund may have been included in the project budget for traffic control plan adjustments and other safety-related improvements.

Costs associated with the adjustments or improvements will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Article 9.7., "Payment for Extra Work and Force Account Method" is not intended to be used in lieu of bid items established by the Contract.

2.4. **Public Safety and Convenience**. Ensure the safety and convenience of the public and property as provided in the Contract and as directed. Keep existing roadways open to traffic or construct and maintain detours and temporary structures for safe public travel. Manage construction to minimize disruption to traffic. Maintain the roadway in a good and passable condition, including proper drainage and provide for ingress and egress to adjacent property.

Store all equipment not in use in a manner and at locations that will not interfere with the safe passage of traffic.

If the Engineer determines that any of the requirements of this Article have not been met, the Engineer may take corrective action. This will not change the legal responsibilities set forth in the Contract. The cost to the Department for this work will be deducted from any money due or to become due to the Contractor.

2.5. **Use of Blue Warning Lights**. Texas Transportation Code 547.105 authorizes the use of warning lights to promote safety and provides an effective means of gaining the travelling public's attention as they drive in areas where construction crews are present. In order to influence the public to move over when high risk construction activities are taking place, minimize the utilization of blue warning lights. These lights must be used only while performing work on or near the travel lanes or shoulder where the travelling public encounters construction crews that are not protected by a standard work zone set up such as a lane closure, shoulder closure, or one-way traffic control. Refrain from leaving the warning lights engaged while travelling from one work location to another or while parked on the right of way away from the pavement or a work zone.

2.6. **Barricades, Signs, and Traffic Handling**. Comply with the requirements of Item 502 "Barricades, Signs, and Traffic Handling," and as directed. Provide traffic control devices that conform to the details shown on the plans, the TMUTCD, and the Department's Compliant Work Zone Traffic Control Device List (CWZTCDL) maintained by the Traffic Operations Division. In cases of disagreement between these documents, the CWXTDL governs over the plans, and the TMUTCD governs over both the CWZTDL and the plans. When authorized or directed, provide additional signs or traffic control devices not required by the plans.

If an unexpected situation arises that causes the Contractor to believe that the traffic control should be changed, make all reasonable efforts to promptly contact the Engineer. Take prudent actions until the Engineer can be contacted.

The Engineer will make an inspection of the traffic control devices. Comply with the results of the inspection in the prescribed time frame.

The work performed and materials furnished in accordance with this section and Item 502 have no bearing on the prosecution of Items 1 through 9, "General Requirements and Covenants" of the Contract. This includes, but is not limited to installing, relocating, and removing project limit advance warning signs.

2.6.1. **Contractor Responsible Person and Alternate.** Designate in writing, a Contractor's Responsible Person (CRP) and an alternate to be the representative of the Contractor who is responsible for taking or directing corrective measures regarding the traffic control. The CRP or alternate must be accessible by phone 24 hr. per day and able to respond when notified. The CRP and alternate must comply with the requirements of Section 7.2.6.5., "Training."

2.6.2. **Flaggers.** Designate in writing, a flagger instructor who will serve as a flagging supervisor and is responsible for training and assuring that all flaggers are qualified to perform flagging duties. Before beginning work, provide a list of flaggers certified to perform flagging duties.

Provide flaggers as directed. Flaggers must be courteous and able to effectively communicate with the public. When directing traffic, flaggers must dress appropriately, wear high-visibility safety apparel, use flags, signs, stop-slow paddles, and other hand-signaling devices, and follow the flagging procedures in the TMUTCD. Comply with the requirements of Section 7.2.6.5., "Training."

2.6.3. **Law Enforcement Personnel.** Provide uniformed law enforcement personnel with patrol vehicles as directed. Document the work zone traffic services provided in the manner prescribed by the Department. Law enforcement personnel providing work zone traffic services must be trained for the service they perform. Comply with Section 7.2.6.5., "Training."

2.6.4. **Other Work Zone Personnel.** Workers involved with traffic control, including the maintenance of the traffic control, must comply with the requirements of Section 7.2.6.5., "Training."

2.6.5. **Training.** Workers involved with the traffic control must be trained using Department-approved training, except in the case of Section 7.2.6.4, "Other Work Zone Personnel" who may be trained using Contractor-developed Training in lieu of Department-approved Training.

Provide a copy of the certification of completion to the Engineer, except in the case of Contractor-developed Training. Ensure the certification of completion includes the following:

- name of provider and course title,
- name of participant,
- date of completion, and
- date of expiration.

For Contractor developed-Training, maintain a log of attendees. Make the log available upon request. Ensure the log is legible and includes the following:

- print name and signature of participant,
- name and title of trainer, and
- date of training.

3. LAWS TO BE OBSERVED

Comply with all federal, state, and local laws, ordinances, and regulations that affect the performance of the work. The Contractor is not required to comply with city electrical ordinances not included in this Contract. Indemnify and save harmless the State and its representatives against any claim arising from violation by the Contractor of any law, ordinance, or regulation.

This Contract is between the Department and the Contractor only. No person or entity may claim third-party beneficiary status under this Contract or any of its provisions, nor may any non-party sue for personal injuries or property damage under this Contract.

4. PERMITS, LICENSES, AND TAXES

Procure all permits and licenses; pay all charges, fees, and taxes; and give all notices necessary and incidental to the due and lawful prosecution of work, except for permits provided by the Department and as specified in Article 7.7., "Preservation of Cultural and Natural Resources and the Environment."

5. PATENTED DEVICES, MATERIAL, AND PROCESSES

Indemnify and save harmless the State from any claims for infringement from the Contractor's use of any patented design, device, material, process, trademark, or copyright selected by the Contractor and used in connection with the work. Indemnify and save harmless the State against any costs, expenses, or damages that it may be obliged to pay, by reason of this infringement, at any time during the prosecution or after the completion of the work.

6. PERSONAL LIABILITY OF PUBLIC OFFICIALS

Department employees are agents and representatives of the State and will incur no liability, personal or otherwise, in carrying out the provisions of the Contract or in exercising any power or authority granted under the Contract.

7. PRESERVATION OF CULTURAL AND NATURAL RESOURCES AND THE ENVIRONMENT

7.1. **Cultural Resources**. Cease all work immediately if a site, building, or location of historical, archeological, educational, or scientific interest is discovered within the right of way. The site, building, or location will be investigated and evaluated by the Department.

7.2. **Texas Pollutant Discharge Elimination System (TPDES) Permits and Storm Water Pollution Prevention Plans (SWP3)**. The Department will file the Notice of Intent (NOI) and the Notice of Termination (NOT) for work shown on the plans in the right of way. Adhere to all requirements of the SWP3.

7.3. **Work in Waters of the United States**. For work in the right of way, the Department will obtain any required Section 404 permits from the U.S. Army Corps of Engineers before work begins. Adhere to all agreements, mitigation plans, and standard best management practices required by the permit. When Contractor-initiated changes in the construction method changes the impacts to waters of the U.S., obtain new or revised Section 404 permits.

7.4. **Work in Navigable Waters of the United States**. For work in the right of way, the Department will obtain any required Section 9 permits from the U.S. Coast Guard before work begins. Adhere to the stipulations of the permits and associated best management practices. When Contractor-initiated changes in the construction method changes the impacts to navigable waters of the U.S., obtain new or revised Section 9 permits.

7.5. **Work Over the Recharge or Contributing Zone of Protected Aquifers**. Make every reasonable effort to minimize the degradation of water quality resulting from impacts relating to work over the recharge or contributing zones of protected aquifers, as defined and delineated by the TCEQ. Use best management practices and perform work in accordance with Contract requirements.

7.6. **Project-Specific Locations**. For all project-specific locations (PSLs) on or off the right of way (material sources, waste sites, parking areas, storage areas, field offices, staging areas, haul roads, etc.), signing the Contract certifies compliance with all applicable laws, rules, and regulations pertaining to the preservation of cultural resources, natural resources, and the environment as issued by the following or other agencies:

- Occupational Safety and Health Administration,
- Texas Commission on Environmental Quality,
- Texas Department of Transportation,
- Texas Historical Commission,
- Texas Parks and Wildlife Department,
- Texas Railroad Commission,
- U.S. Army Corps of Engineers,
- U.S. Department of Energy,
- U.S. Department of Transportation,
- U.S. Environmental Protection Agency,
- U.S. Federal Emergency Management Agency, and
- U.S. Fish and Wildlife Service.

All subcontractors must also comply with applicable environmental laws, rules, regulations, and requirements in the Contract. Maintain documentation of certification activities including environmental consultant reports, Contractor documentation on certification decisions and contacts, and correspondence with the resource agencies. Provide documentation upon request.

Obtain written approval from the Engineer for all PSLs in the right of way not specifically addressed on the plans. Prepare an SWP3 for all Contractor facilities, such as asphalt or concrete plants located within Department right of way. Comply with all TCEQ permit requirements for portable facilities, such as concrete batch plants, rock crushers, asphalt plants, etc. Address all environmental issues, such as Section 404

permits, wetland delineation, endangered species consultation requirements, or archeological and historic site impacts. Obtain all permits and clearances in advance.

7.7. **Contractor Responsibility**. If the Contractor initiates changes to the Contract and the Department approves the changes, the Contractor is responsible for obtaining clearances and coordinating with the appropriate regulatory agencies.

8. AGRICULTURAL IRRIGATION

Regulate the sequence of work and make provisions as necessary to provide for agricultural irrigation or drainage during the work. Meet with the service provider or land owner to determine the proper time and sequence when irrigation demands will permit shutting-off water flows to perform work.

Unless otherwise provided on the plans, the work performed under this Article will not be measured or paid for directly but will be subsidiary to pertinent Items.

9. SANITARY PROVISIONS

Provide and maintain adequate, neat, and sanitary toilet accommodations for employees, including State employees, in compliance with the requirements and regulations of the Texas Department of Health or other authorities having jurisdiction.

10. ABATEMENT AND MITIGATION OF EXCESSIVE OR UNNECESSARY NOISE

Minimize noise throughout all phases of the Contract. Exercise particular and special efforts to avoid the creation of unnecessary noise impact on adjacent noise sensitive receptors in the placement of non-mobile equipment such as air compressors, generators, pumps, etc. Place mobile and stationary equipment to cause the least disruption of normal adjacent activities.

All equipment associated with the work must be equipped with components to suppress excessive noise and these components must be maintained in their original operating condition considering normal depreciation. Noise-attenuation devices installed by the manufacturer such as mufflers, engine covers, insulation, etc. must not be removed nor rendered ineffectual nor be permitted to remain off the equipment while the equipment is in use.

11. USING EXPLOSIVES

Do not endanger life or property. When required by the plans or requested, provide a written blasting plan. The Department retains the right to reject the blasting plan. Store all explosives securely and clearly mark all storage places with "DANGER – EXPLOSIVES." Store, handle, and use explosives and highly flammable material in compliance with federal, state, and local laws, ordinances, and regulations. Assume liability for property damage, injury, or death resulting from the use of explosives.

Give at least a 48-hr. advance notice to the appropriate railroad representative before doing any blasting work involving the use of electric blasting caps within 200 ft. of any railroad track.

12. RESPONSIBILITY FOR HAZARDOUS MATERIALS

Comply with the requirements of Article 6.10., "Hazardous Materials". Indemnify and save harmless the State and its agents and employees from all suits, actions, or claims and from all liability and damages for any injury or damage to any person or property arising from the generation or disposition of hazardous materials introduced by the Contractor on any work done by the Contractor on State-owned or controlled sites. Indemnify and save harmless the State and its representatives from any liability or responsibility arising out of the Contractor's generation or disposition of any hazardous materials obtained, processed, stored,

shipped, etc., on sites not owned or controlled by the State. Reimburse the State for all payments, fees, or restitution the State is required to make as a result of the Contractor's actions.

13. RESTORING SURFACES OPENED BY PERMISSION

Do not authorize anyone to make an opening in the highway for utilities, drainage, or any other reason without written permission from the Engineer. Repair all openings as directed. Payment for repair of surfaces opened by permission will be made in accordance with pertinent Items or Article 4.4., "Changes in the Work." Costs associated with openings made with Contractor authorization but without Department approval will not be paid.

14. PROTECTING ADJACENT PROPERTY

Protect adjacent property from damage. If any damage results from an act or omission on the part of or on behalf of the Contractor, take corrective action to restore the damaged property to a condition similar or equal to that existing before the damage was done.

15. RESPONSIBILITY FOR DAMAGE CLAIMS

Indemnify and save harmless the State and its agents and employees from all suits, actions, or claims and from all liability and damages for any injury or damage to any person or property due to the Contractor's negligence in the performance of the work and from any claims arising or amounts recovered under any laws, including workers' compensation and the Texas Tort Claims Act. Indemnify and save harmless the State and assume responsibility for all damages and injury to property of any character occurring during the prosecution of the work resulting from any act, omission, neglect, or misconduct on the Contractor's part in the manner or method of executing the work; from failure to properly execute the work; or from defective work or material.

Pipelines and other underground installations that may or may not be shown on the plans may be located within the right of way. Indemnify and save harmless the State from any suits or claims resulting from damage by the Contractor's operations to any pipeline or underground installation. Make available the scheduled sequence of work to the respective utility owners so that they may coordinate and schedule adjustments of their utilities that conflict with the proposed work.

If the Contractor asserts any claim or brings any type of legal action (including an original action, third-party action, or cross-claim) against any member of the Commission or individual employee of the Department for any cause of action or claim for alleged negligence arising from the Contract, the Contractor will be ineligible to bid on any proposed Contract with the Department during the pendency of the claim or legal action.

16. HAULING AND LOADS ON ROADWAYS AND STRUCTURES

Comply with federal and state laws concerning legal gross and axle weights. Except for the designated Interstate system, vehicles with a valid yearly overweight tolerance permit may haul materials to the work locations at the permitted load. Provide copies of the yearly overweight tolerance permits to the Engineer upon request. Construction equipment is not exempt from oversize or overweight permitting requirements on roadways open to the traveling public.

Protect existing bridges and other structures that will remain in use by the traveling public during and after the completion of the Contract. Construction traffic on roadways, bridges, and culverts within the limits of the work, including any structures under construction that will remain in service during and after completion of the Contract is subject to legal size and weight limitations.

Additional temporary fill may be required by the Engineer for hauling purposes for the protection of certain structures. This additional fill will not be paid for directly but will be subsidiary to pertinent Items.

Replace or restore to original condition any structure damaged by the Contractor's operations.

The Engineer may allow equipment with oversize or non-divisible overweight loads to operate without a permit within the work locations on pavement structures not open to the traveling public. Submit Contractor-proposed changes to traffic control plans for approval, in accordance with Item 502, "Barricades, Signs, and Traffic Handling." The following sections further address overweight allowances. The Department will make available to the Contractor any available plans and material reports for existing structures.

16.1. **Overweight Construction Traffic Crossing Structures**. The Engineer may allow crossing of a structure not open to the public within the work locations, when divisible or non-divisible loads exceed legal weight limitations, including limits for load-posted bridges. Obtain written permission to make these crossings. Submit for approval a structural analysis by a licensed professional engineer indicating that the excessive loads should be allowed. Provide a manufacturer's certificate of equipment weight that includes the weight distribution on the various axles and any additional parts such as counterweights, the configuration of the axles, or other information necessary for the analysis. Submit the structural analysis and supporting documentation sufficiently in advance of the move to allow for review by the Engineer. Permission may be granted if the Engineer finds that no damage or overstresses in excess of those normally allowed for occasional overweight loads will result to structures that will remain in use after Contract completion. Provide temporary matting or other protective measures as directed.

Schedule loads so that only one vehicle is on any span or continuous unit at any time. Use barricades, fences, or other positive methods to prevent other vehicular access to structures at any time the overweight load is on any span or continuous unit.

16.2. **Construction Equipment Operating on Structures**. Cranes and other construction equipment used to perform construction operations that exceed legal weight limits may be allowed on structures. Before any operation that may require placement of equipment on a structure, submit for approval a detailed structural analysis prepared by a licensed professional engineer.

Submit the structural analysis and supporting documentation sufficiently in advance of the use to allow for review by the Engineer. Include all axle loads and configurations, spacing of tracks or wheels, tire loads, outrigger placements, center of gravity, equipment weight, and predicted loads on tires and outriggers for all planned movements, swings, or boom reaches. The analysis must demonstrate that no overstresses will occur in excess of those normally allowed for occasional overweight loads.

16.3. **Loads on Structures**. Do not store or stockpile material on bridge structures without written permission. If required, submit a structural analysis and supporting documentation by a licensed professional engineer for review by the Engineer. Permission may be granted if the Engineer finds that no damage or overstresses in excess of those normally allowed for occasional overweight loads will result to structures that will remain in use after Contract completion. Provide temporary matting or other protective measures as directed.

16.4. **Hauling Divisible Overweight Loads on Pavement Within the Work Locations**. The Engineer may allow divisible overweight loads on pavement structures within the work locations not open to the traveling public. Obtain written approval before hauling the overweight loads. Include calculations to demonstrate that there will be no damage or overstress to the pavement structure.

17. CONTRACTOR'S RESPONSIBILITY FOR WORK

Until final acceptance of the Contract, take every precaution against injury or damage to any part of the work by the action of the elements or by any other cause, whether arising from the execution or from the non-execution of the work. Protect all materials to be used in the work at all times, including periods of suspension.

When any roadway or portion of the roadway is in suitable condition for travel, it may be opened to traffic as directed. Opening of the roadway to traffic does not constitute final acceptance.

Repair damage to all work until final acceptance. Repair damage to existing facilities in accordance with the Contract or as directed by the Engineer. Repair damage to existing facilities or work caused by Contractor operations at the Contractor's expense. Repair work for damage that was not due to the Contractor's operations will not be paid for except as provided below.

17.1. **Reimbursable Repair**. Except for damage to appurtenances listed in Section 7.17.2.1., "Unreimbursed Repair," the Contractor will be reimbursed for repair of damage caused by:

- motor vehicle, watercraft, aircraft, or railroad-train incident,
- vandalism, or
- Acts of God, such as earthquake, tidal wave, tornado, hurricane, or other cataclysmic phenomena of nature.

17.2. **Appurtenances**.

17.2.1. **Unreimbursed Repair**. Except for destruction (not reusable) due to Acts of God, reimbursement will not be made for repair of damage to the following temporary appurtenances, regardless of cause:

- signs,
- barricades,
- changeable message signs, and
- other work zone traffic control devices.

Crash cushion attenuators and guardrail end treatments are reimbursed in accordance with Section 7.17.2.2., "Reimbursed Repair."

Where the Contractor retains replaced appurtenances after completion of the project, the Department will limit the reimbursement to the cost that is above the salvage value at the end of the project.

17.2.2. **Reimbursed Repair**. Reimbursement will be made for repair of damage due to the causes listed in Section 7.17.1, "Reimbursable Repair."

17.3. **Roadways and Structures**. Until final acceptance, the Contractor is responsible for all work constructed under the Contract. The Department will not reimburse the Contractor for repair work to new construction, unless the failure or damage is due to one of the causes listed in Section 7.17.1, "Reimbursable Repair."

The Department will be responsible for the cost for repair of damage to existing roadways and structures not caused by the Contractor's operations.

17.4. **Detours**. The Contractor will be responsible for the cost of maintenance of detours constructed under the Contract, unless the failure or damage is due to one of the causes listed in Section 7.17.1., "Reimbursable Repair." The Engineer may consider failures beyond the Contractor's control when determining reimbursement for repairs to detours constructed. The Department will be responsible for the cost of maintenance of existing streets and roadways used for detours or handling traffic.

17.5. **Relief from Maintenance**. The Engineer may relieve the Contractor from responsibility of maintenance as outlined in this Section. This relief does not release the Contractor from responsibility for defective materials or work or constitute final acceptance.

17.5.1. **Isolated Work Locations**. For isolated work locations, when all work is completed, including work for Article 5.11., "Final Cleanup," the Engineer may relieve the Contractor from responsibility for maintenance.

17.5.2. **Work Except for Vegetative Establishment and Test Periods**. When all work for all or isolated work locations has been completed, including work for Article 5.11., "Final Cleanup," with the exception of vegetative establishment and maintenance periods and test and performance periods, the Engineer may relieve the Contractor from responsibility for maintenance of completed portions of work.

17.5.3. **Work Suspension**. When all work is suspended for an extended period of time, the Engineer may relieve the Contractor from responsibility for maintenance of completed portions of work during the period of suspension.

17.5.4. **When Directed by the Engineer**. The Engineer may relieve the Contractor from the responsibility for maintenance when directed.

17.6. **Basis of Payment**. When reimbursement for repair work is allowed and performed, payment will be made in accordance with pertinent Items or Article 4.4., "Changes in the Work."

18. ELECTRICAL REQUIREMENTS

18.1. **Definitions**.

18.1.1. **Electrical Work.** Electrical work is work performed for:

- Item 610, "Roadway Illumination Assemblies,"
- Item 614, "High Mast Illumination Assemblies,"
- Item 616, "Performance Testing of Lighting Systems,"
- Item 617, "Temporary Roadway Illumination,"
- Item 618, "Conduit,"
- Item 620, "Electrical Conductors,"
- Item 621, "Tray Cable,"
- Item 622, "Duct Cable,"
- Item 628, "Electrical Services,"
- Item 680, "Highway Traffic Signals,"
- Item 681, "Temporary Traffic Signals,"
- Item 684, "Traffic Signal Cables,"
- Item 685, "Roadside Flashing Beacon Assemblies,"
- other Items that involve either the distribution of electrical power greater than 50 volts or the installation of conduit and duct banks,
- the installation of conduit and wiring associated with Item 624, "Ground Boxes" and Item 656, "Foundations for Traffic Control Devices," and
- the installation of the conduit system for communication and fiber optic cable.

Electrical work does not include the installation of communications or fiber optic cable, or the connections for low voltage and inherently power limited circuits such as electronic or communications equipment. Assembly and placement of poles, structures, cabinets, enclosures, manholes, or other hardware will not be considered electrical work as long as no wiring, wiring connections, or conduit work is done at the time of assembly and placement.

18.1.2. **Specialized Electrical Work**. Specialized electrical work is work that includes the electrical service and feeders, sub-feeders, branch circuits, controls, raceways, and enclosures for the following:

- pump stations,
- moveable bridges,
- ferry slips,
- motor control centers,
- facilities required under Item 504, "Field Office and Laboratory,"
- rest area or other public buildings,
- weigh-in-motion stations,
- electrical services larger than 200 amps,
- electrical services with main or branch circuit breaker sizes not shown in the Contract, and
- any 3-phase electrical power.

18.1.3. **Certified Person**. A certified person is a person who has passed the test from the Department's course TRF450, "TxDOT Roadway Illumination and Electrical Installations," or other courses as approved by the Traffic Operations Division. Submit a current and valid TRF certification upon request. Texas A&M Engineering Extension Service (TEEX) certifications for "TxDOT Electrical Systems" course will not be accepted.

18.1.4. **Licensed Electrician**. A licensed electrician is a person with a current and valid unrestricted master electrical license, or unrestricted journeyman electrical license that is supervised or directed by an unrestricted master electrician. An unrestricted master electrician need not be on the work locations at all times electrical work is being done, but the unrestricted master electrician must approve work performed by the unrestricted journeyman. Licensed electrician requirements by city ordinances do not apply to on state system work.

The unrestricted journeyman and unrestricted master electrical licenses must be issued by the Texas Department of Licensing and Regulation or by a city in Texas with a population of 50,000 or greater that issues licenses based on passing a written test and demonstrating experience.

The Engineer may accept other states' electrical licenses. Submit documentation of the requirements for obtaining that license. Acceptance of the license will be based on sufficient evidence that the license was issued based on:

- passing a test based on the NEC similar to that used by Texas licensing officials, and
- sufficient electrical experience commensurate with general standards for an unrestricted master and unrestricted journeyman electrician in the State of Texas.

18.2. **Work Requirements**. The qualifications required to perform electrical work and specialized electrical work are listed in Table 2.

Table 2
Work Requirements

Type of Work	Qualifications to Perform Work
Electrical work with plans	Licensed electrician, certified person, or workers directly supervised by a licensed electrician or certified person
Electrical work without plans	Licensed electrician or workers directly supervised by a licensed electrician
Specialized electrical work	Licensed electrician or workers directly supervised by a licensed electrician
Replace lamps, starting aids, and changing fixtures	Licensed electrician, certified person, or workers directly supervised by a licensed electrician or certified person
Conduit in precast section with approved working drawings	Inspection by licensed electrician or certified person
Conduit in cast-in-place section	Inspection by licensed electrician or certified person
All other electrical work (troubleshooting, repairs, component replacement,	Licensed electrician or workers directly supervised by a licensed electrician

"Directly supervised by a licensed electrician" means that a licensed electrician is physically present during all electrical work. "Directly supervised by a licensed electrician or certified person" means that a licensed electrician or certified person is physically present during all electrical work.

A non-certified person may install conduit in cast-in-place concrete sections if the work is verified by a certified person before concrete placement.

When the plans specify IMSA certification, the requirements of Table 2 will still apply to the installation of the conduit, ground boxes, electrical services, pole grounding, and electrical conductors installed under Item 620, "Electrical Conductors."

19. PAYROLLS

Ensure that employees, contract labor, and any subcontractor's employees are paid at least the predetermined wage rates shown on the Contract.

Payroll records must contain the information required by law. As an option, form WH-347, "Payroll" is provided by the U.S. Department of Labor.

Maintain payroll and related records during the course of the Contract and preserve these records for a period of 3 years following the completion of the Contract or as required by law.

19.1 **Minimum Wage Requirements for Federally Funded Contracts**. Comply with the requirements of FHWA-1273, "Required Contract Provisions Federal-Aid Construction Contracts."

Submit payroll records to the Engineer in the manner prescribed by the Department.

19.2 **Minimum Wage Requirements for State Funded Contracts**. Comply with the requirements of 29 USC 206 unless otherwise shown in the Contract.

Upon request, submit payroll records to the Engineer in the manner prescribed by the Department.

final payment will reflect the entire sum due, less any sums previously paid.

Item 9
Measurement and Payment

1. MEASUREMENT OF QUANTITIES

The Engineer will measure all completed work using United States standard measures, unless otherwise specified.

1.1. **Linear Measurement**. Unless otherwise specified, all longitudinal measurements for surface areas will be made along the actual surface of the roadway and not horizontally. No deduction will be made for structures in the roadway having an area of 9 sq. ft. or less. For all transverse measurements for areas of base courses, surface courses, and pavements, the dimensions to be used in calculating the pay areas will be the neat dimensions and will not exceed those shown on the plans, unless otherwise directed.

1.2. **Volume Measurement**. Transport materials measured for payment by volume in approved hauling vehicles. Display a unique identification mark on each vehicle. Furnish information necessary to calculate the volume capacity of each vehicle. The Engineer may require verification of volume through weight measurement. Use body shapes that allow the capacity to be verified. Load and level the load to the equipment's approved capacity. Loads not hauled in approved vehicles may be rejected.

1.3. **Weight Measurement**. Transport materials measured for payment by weight or truck measure in approved hauling vehicles. Furnish certified measurements, tare weights, and legal gross weight calculations for all haul units. Affix a permanent, legible number on the truck and on the trailer to correspond with the certified information. Furnish certified weights of loaded haul units transporting material if requested.

The material will be measured at the point of delivery. The cost of supplying these volume and weight capacities is subsidiary to the pertinent Item. For measurement by the ton, in the field, provide measurements in accordance with Item 520, "Weighing and Measuring Equipment," except for Items where ton measurements are measured by standard tables.

The Engineer may reject loads and suspend hauling operations for overloading.

1.3.1. **Hauling on Routes Accessible to the Traveling Public**. For payment purposes on haul routes accessible to the traveling public, the net weight of the load will be calculated as follows:

- If the gross vehicle weight is less than the maximum allowed by state law, including applicable yearly weight tolerance permit, the net weight of the load will be determined by deducting the tare weight of the vehicle from the gross weight.
- If the gross vehicle weight is more than the maximum allowed by state law, including applicable yearly weight tolerance permit, the net weight of the load will be determined by deducting the tare weight of the vehicle from the maximum gross weight allowed.

1.3.2. **Hauling on Routes Not Accessible to the Traveling Public**. For payment purposes on haul routes that are not accessible to the traveling public where advance permission is obtained in writing from the Engineer.

- If the gross vehicle weight is less than the maximum allowed by the Engineer, including applicable yearly weight tolerance permit, the net weight of the load will be determined by deducting the tare weight of the vehicle from the gross weight.
- If the gross vehicle weight is more than the maximum allowed by the Engineer, the net weight of the load will be determined by deducting the tare weight of the vehicle from the maximum gross weight allowed.

2. PLANS QUANTITY MEASUREMENT

Plans quantities may or may not represent the exact quantity of work performed or material moved, handled, or placed during the execution of the Contract. The estimated bid quantities are designated as final payment quantities, unless revised by the governing specifications or this Article.

If the quantity measured as outlined under "Measurement" varies by more than 5% (or as stipulated under "Measurement" for specific Items) from the total estimated quantity for an individual Item originally shown in the Contract, an adjustment may be made to the quantity of authorized work done for payment purposes.

When quantities are revised by a change in design approved by the Department, by change order, or to correct an error on the plans, the plans quantity will be increased or decreased by the amount involved in the change, and the 5% variance will apply to the new plans quantity.

If the total Contract quantity multiplied by the unit bid price for an individual Item is less than $250 and the Item is not originally a plans quantity Item, then the Item may be paid as a plans quantity Item if the Engineer and Contractor agree in writing to fix the final quantity as a plans quantity.

For Contracts with callout work and work orders, plans quantity measurement requirements are not applicable.

3. ADJUSTMENT OF QUANTITIES

The party to the Contract requesting the adjustment will provide field measurements and calculations showing the revised quantity. When approved, this revised quantity will constitute the final quantity for which payment will be made. Payment for revised quantity will be made at the unit price bid for that Item, except as provided for in Article 4.4., "Changes in the Work."

4. SCOPE OF PAYMENT

Payment of the Contract unit price is full compensation for all materials, equipment, labor, tools, and supplies necessary to complete the Item of work under the Contract. Until final acceptance in accordance with Article 5.12., "Final Acceptance," assume liability for completing the work according to the plans and specifications and any loss or damage arising from the performance of the work or from the action of the elements, infringement of patent, trademark, or copyright, except as provided elsewhere in the Contract.

The Department will only pay for material incorporated into the work in accordance with the Contract. Payment of progress estimates will in no way affect the Contractor's obligation under the Contract to repair or replace any defective parts in the construction or to replace any defective materials used in the construction and to be responsible for all damages due to defects if the defects and damages are discovered on or before final inspection and acceptance of the work.

5. PROGRESS PAYMENTS

The Engineer will prepare a monthly estimate of the amount of work performed, including materials in place. Incomplete items of work may be paid at an agreed upon percentage approved by the Engineer. Payment of the monthly estimate is determined at the Contract item prices less any withholdings or deductions in accordance with the Contract. Progress payments may be withheld for failure to comply with the Contract.

6. PAYMENT FOR MATERIAL ON HAND (MOH)

If payment for MOH is desired, request compensation for the invoice cost of acceptable nonperishable materials that have not been used in the work before the request, and that have been delivered to the work location or are in acceptable storage places. Nonperishable materials are those that do not have a shelf life or whose characteristics do not materially change when exposed to the elements. Include only materials that

have been sampled, tested, approved, or certified, and are ready for incorporation into the work. Only materials which are completely constructed or fabricated on the Contractor's order for a specific Contract and are so marked and on which an approved test report has been issued are eligible. Payment for MOH may include the following types of items: concrete traffic barrier, precast concrete box culverts, concrete piling, reinforced concrete pipe, and illumination poles. Any repairs required after fabricated materials have been approved for storage will require approval of the Engineer before being made and will be made at the Contractor's expense. Include only those materials that have an invoice cost of at least $1,000 in the request for MOH payment.

For Contracts with callout work and work orders, payment for MOH will only be made for materials authorized for purchase by the work order or by written approval of the Engineer.

If the request is acceptable, the Engineer will include payment for MOH in a progress payment. Payment for MOH does not constitute acceptance of the materials. Payment will not exceed the actual cost of the material as established by invoice, or the total cost for the associated item less reasonable placement costs, whichever is less. Materials for which the Contractor does not have a paid invoice within 60 days will not be eligible for payment and will be removed from the estimate. Payment may be limited to a portion of the invoice cost or unit price if shown elsewhere in the Contract. Payment for precast products fabricated or constructed by the Contractor for which invoices or freight bills are not available may be made based on statements of actual cost.

Submit the request on forms provided by the Department. These forms may be electronically reproduced, provided they are in the same format and contain all the required information and certifications. Continue to submit monthly MOH forms until the total value of MOH is $0.

By submitting a request for MOH payment, the Contractor expressly authorizes the Department to audit MOH records, and to perform process reviews of the record-keeping system. If the Department determines noncompliance with any of the requirements of this provision, the Department may exclude payment for any or all MOH for the duration of the Contract.

Maintain all records relating to MOH payment until final acceptance. Provide these records to the Engineer upon request.

7. PAYMENT FOR EXTRA WORK AND FORCE ACCOUNT METHOD

Payment for extra work directed, performed, and accepted will be made in accordance with Article 4.4., "Changes in the Work." Payment for extra work may be established by agreed unit prices or by Force Account Method.

Agreed unit prices are unit prices that include markups and are comparable to recent bid prices for the same character of work. These unit prices may be established without additional breakdown justification.

When using Force Account Method, determine an estimated cost for the proposed work and establish labor and equipment rates and material costs. Maintain daily records of extra work and provide copies of these records daily, signed by the Contractor's representative, for verification by the Department. Request payment for the extra work no later than the 10th day of the month following the month in which the work was performed. Include copies of all applicable invoices. If the extra work to be performed has an estimated cost of less than $10,000, submit for approval and payment an invoice of actual cost for materials, equipment, labor, tools, and incidentals necessary to complete the extra work.

7.1. **Markups**. Payment for extra work may include markups as compensation for the use of small tools, overhead expense, and profit.

7.1.1. **Labor**. Compensation will be made for payroll rates for each hour that the labor and foremen or others approved by the Engineer are actually engaged in the work. In no case will the rate of wages be less than the

minimum shown in the Contract for a particular category. An additional 25% of this sum will be paid as compensation for overhead, superintendence, profit, and small tools.

7.1.2. **Insurance and Taxes**. An additional 55% of the labor cost, excluding the 25% compensation provided in Section 9.7.1.1., "Labor," will be paid as compensation for labor insurance and labor taxes including the cost of premiums on non-project specific liability (excluding vehicular) insurance, workers compensation insurance, Social Security, unemployment insurance taxes, and fringe benefits.

7.1.3. **Materials**. Compensation will be made for materials associated with the work based on actual delivered invoice costs, less any discount. An additional 25% of this sum will be paid as compensation for overhead and profit.

7.1.4. **Equipment**. Payment will be made for the established equipment hourly rates for each hour that the equipment is involved in the work. An additional 15% of this sum will be paid as compensation for overhead and profit not included in the rates.

Transportation cost for mobilizing equipment will be included if the equipment is mobilized from an off-site location.

7.1.4.1. **Contractor-Owned Equipment**. For Contractor-owned machinery, trucks, power tools, or other equipment, use the FHWA rental rates found in the *Rental Rate Blue Book* multiplied by the regional adjustment factor and the rate adjustment factor to establish hourly rates. Use the rates in effect for each section of the *Rental Rate Blue Book* at the time of use.

If a rate has not been established for a particular piece of equipment in the *Rental Rate Blue Book*, the Engineer will allow a reasonable hourly rate. This price will include operating costs.

Payment for equipment will be made for the actual hours used in the work. The Department reserves the right to withhold payment for low production or lack of progress. Payment will not be made for time lost for equipment breakdowns, time spent to repair equipment, or time after equipment is no longer needed.

If equipment is used intermittently while dedicated solely to the work, payment will be made for the duration the equipment is assigned to the work but no more than 8 hr. will be paid during a 24-hr. day, nor more than 40 hr. per week, nor more than 176 hr. per month, except when time is computed using a 6-day or 7-day workweek. When using a 6-day workweek, no more than 8 hr. will be paid during a 24-hr. day, nor more than 48 hr. per week, nor more than 211 hr. per month. When using a 7-day workweek, no more than 8 hr. will be paid during a 24-hr. day, nor more than 56 hr. per week, nor more than 246 hr. per month.

7.1.4.2. **Equipment Not Owned by the Contractor**. For equipment rented from a third party not owned by the Contractor, payment will be made at the invoice daily rental rate for each day the equipment is needed for the work. The Department reserves the right to limit the daily rate to comparable FHWA rental rates found in the *Rental Rate Blue Book* multiplied by the regional adjustment factor and the rate adjustment factor. When the invoice specifies that the rental rate does not include fuel, lubricants, repairs, and servicing, the *Rental Rate Blue Book* hourly operating cost for each hour the equipment is operated will be added.

When the invoice specifies equipment operators as a component of the equipment rental, payment will be made at the invoice rate for each operator for each day the equipment is needed for the work.

7.1.4.3. **Standby Equipment Costs**. Payment for standby equipment will be made in accordance with Section 9.7.1.4., "Equipment," except that:

7.1.4.3.1. **Contractor-Owned Equipment**. For Contractor-owned machinery, trucks, power tools, or other equipment:

- Standby will be paid at 50% (to remove operating cost) of the FHWA rental rates found in the *Rental Rate Blue Book* multiplied by the regional adjustment factor and the rate adjustment factor.
- Standby costs will not be allowed during periods when the equipment would have otherwise been idle.

7.1.4.3.2. **Equipment Not Owned by the Contractor**. For equipment rented from a third party not owned by the Contractor:

- Standby will be paid at the invoice daily rental rate, excluding operating cost, which includes fuel, lubricants, repairs, and servicing. The Department reserves the right to limit the daily standby rate to comparable FHWA rental rates found in the *Rental Rate Blue Book* multiplied by the regional adjustment factor and the rate adjustment factor.
- Standby will be paid for equipment operators when included on the invoice and equipment operators are actually on standby.
- Standby costs will not be allowed during periods when the equipment would have otherwise been idle.

7.1.5. **Subcontracting**. An additional 5% of the actual invoice cost will be paid to the Contractor as compensation for administrative cost, superintendence, and profit.

7.1.6. **Law Enforcement Personnel**. An additional 5% of the actual invoice cost will be paid as compensation for administrative costs, superintendence, and profit.

7.1.7. **Railroad Flaggers**. An additional 5% of the actual invoice cost will be paid as compensation for administrative cost, superintendence, and profit.

7.1.8. **Bond Cost**. An additional 1% of the total compensation provided in Article 9.7., "Payment for Extra Work and Force Account Method," will be paid for the increase in bond.

8. RETAINAGE

The Department will not withhold retainage on the Contractor. The Contractor may withhold retainage on subcontractors in accordance with state and federal regulations.

9. PAYMENT PROVISIONS FOR SUBCONTRACTORS

For the purposes of this Article only, the term subcontractor includes suppliers and the term work includes materials provided by suppliers at a location approved by the Department.

These requirements apply to all tiers of subcontractors. Incorporate the provisions of this Article into all subcontract or material purchase agreements.

Pay subcontractors for work performed within 10 days after receiving payment from the Department.

Pay any retainage on a subcontractor's work within 10 days after satisfactory completion of all of the subcontractor's work. Completed subcontractor work includes vegetative establishment, test, maintenance, performance, and other similar periods that are the responsibility of the subcontractor.

For the purpose of this Section, satisfactory completion is accomplished when:

- the subcontractor has fulfilled the Contract requirements of both the Department and the subcontract for the subcontracted work, including the submittal of all information required by the Contract and the Department, and
- the work done by the subcontractor has been inspected, approved, and paid by the Department.

Provide a certification of prompt payment to certify that all subcontractors and suppliers were paid from the previous months payments and retainage was released for those whose work is complete. Submit the certification in the manner prescribed by the Department each month and the month following the month when final acceptance occurred.

The inspection and approval of a subcontractor's work does not eliminate the Contractor's responsibilities for the work as defined in Article 7.17., "Contractor's Responsibility for Work."

10. FINAL PAYMENT

When the Contract has been completed, all work has been approved, final acceptance has been made in accordance with Article 5.12., "Final Acceptance," and Contractor submittals have been received, the Engineer will prepare a final estimate for payment showing the total quantity of work completed and the money owed the Contractor. The final payment will reflect the entire sum due, less any sums previously paid.

Item 100
Preparing Right of Way

1. DESCRIPTION

Prepare the right of way and designated easements for construction operations by removing and disposing of all obstructions when removal of such obstructions is not specifically shown on the plans to be paid by other Items.

2. CONSTRUCTION

Protect designated features on the right of way and prune trees and shrubs as directed. Do not park equipment, service equipment, store materials, or disturb the root area under the branches of trees designated for preservation. Treat cuts on trees with an approved tree wound dressing within 20 min. of making a pruning cut or otherwise causing damage to the tree when shown on the plans. Follow all local and state regulations when burning. Pile and burn brush at approved locations as directed. Coordinate work with state and federal authorities when working in state or national forests or parks. Test, remove, and dispose of hazardous materials in accordance with Article 6.10., "Hazardous Materials."

Clear areas shown on the plans of all obstructions, except those landscape features that are to be preserved. Such obstructions include remains of houses and other structures, foundations, floor slabs, concrete, brick, lumber, plaster, septic tank drain fields, basements, abandoned utility pipes or conduits, equipment, fences, retaining walls, and other items as specified on the plans. Remove vegetation and other landscape features not designated for preservation, curb and gutter, driveways, paved parking areas, miscellaneous stone, sidewalks, drainage structures, manholes, inlets, abandoned railroad tracks, scrap iron, and debris, whether above or below ground. Removal of live utility facilities is not included in this Item. Remove culverts, storm sewers, manholes, and inlets in proper sequence to maintain traffic and drainage.

Notify the Engineer in writing when items not shown on the plans and not reasonably detectable (buried with no obvious indication of presence) are encountered and required to be removed. These items will be handled in accordance with Article 4.5., "Differing Site Conditions."

Remove obstructions not designated for preservation to 2 ft. below natural ground in areas receiving embankment. Remove obstructions to 2 ft. below the excavation level in areas to be excavated. Remove obstructions to 1 ft. below natural ground in all other areas. Cut trees and stumps off to ground level when allowed by the plans or directed. Plug the remaining ends of abandoned underground structures over 3 in. in diameter with concrete to form a tight closure. Backfill, compact, and restore areas where obstructions have been removed unless otherwise directed. Use approved material for backfilling. Dispose of wells in accordance with Item 103, "Disposal of Wells."

Accept ownership, unless otherwise directed, and dispose of removed materials and debris at locations off the right of way in accordance with local, state, and federal requirements.

3. MEASUREMENT

This Item will be measured by the acre; by the 100-ft. station, regardless of the width of the right of way; or by each tree removed.

4. PAYMENT

For "acre" and "station" measurement, the work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Preparing Right of Way." For "each"

measurement, the work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Preparing Right of Way (Tree)" of the diameter specified. This price is full compensation for pruning of designated trees and shrubs; removal and disposal of structures and obstructions; backfilling of holes; furnishing and placing concrete for plugs; and equipment, labor, tools, and incidentals.

Total payment of this Item will not exceed 10% of the original contract amount until final acceptance. The remainder will be paid on the estimate after the final acceptance under Article 5.12., "Final Acceptance."

Item 103
Disposal of Wells

1. DESCRIPTION

Remove and dispose of contaminated and uncontaminated water, petroleum, or sulfur wells. Remove appurtenances, seal and plug wells, and restore the area. Prepare and file required documents with applicable agencies.

2. CONSTRUCTION

Follow legal responsibilities, construction requirements, and methods in accordance with Article 7.6., "Laws to be Observed," and Article 7.7., "Permits, Licenses, and Taxes."

Remove all pump equipment to 3 ft. below the finished subgrade or the existing grade, whichever is lower, and within construction limits. Pump equipment includes pump, piping, motor, housing, well structures, foundations, flumes, windmills, casing, and other projecting objects associated with the well.

All removed items and appurtenances become the property of the Contractor, excluding existing contaminated soil and liquids, after necessary cleaning and disassembling. Dispose of these items in accordance with applicable laws and regulations. Test, remove, and dispose of hazardous materials in accordance with Article 6.10., "Hazardous Materials."

Cap remaining pipe. Submit a "Plugging Report" to the appropriate agency when required by the TCEQ, the TDLR, or the RRC. Furnish a copy to the Engineer. Backfill in accordance with Article 100.2., "Construction," after removing all appurtenances.

2.1. **Water Wells**. Remove all removable casing from water wells, including dry wells and abandoned wells. Pressure-fill the well with a mixture of hydraulic cement and water at a rate of not more than 7 gal. of water per sack of cement from the bottom of the well to the natural ground surface or 3 ft. below the finished subgrade, whichever is lower, according to the requirements of the TDLR. Obtain written approval from TDLR and the Engineer for alternative procedures.

Plug any well located in a cut section up to the proposed earthwork elevation before excavating the cut. Backfill the remainder of the well above the proposed earthwork elevation with earth immediately after plugging a well in a cut section.

2.2. **Petroleum and Sulfur Wells**. Have a contractor from the RRC-approved list plug the well. Empty the contents of petroleum or sulfur wells into approved containers according to applicable regulations. Transport and dispose of the filled containers at an approved disposal facility or recycling center according to applicable regulations. Approved plugging methods include protecting water-bearing strata with cement plugs when shown on the plans, or completely cementing the well.

3. MEASUREMENT

This Item will be measured by each properly plugged and disposed well.

4. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Disposal of Water Wells" or "Disposal of Petroleum or

Sulfur Wells." This price is full compensation for removing and disposing of appurtenances; plugging; furnishing records; furnishing and placing any material or items; site restoration; and equipment, labor, tools, and incidentals.

Item 104
Removing Concrete

1. DESCRIPTION

Break, remove, and salvage or dispose of existing hydraulic cement concrete.

2. CONSTRUCTION

Remove existing hydraulic cement concrete from locations shown on the plans. Avoid damaging concrete that will remain in place. Saw-cut and remove the existing concrete to neat lines. Replace any concrete damaged by the Contractor at no expense to the Department. Accept ownership and properly dispose of broken concrete in accordance with federal, state, and local regulations unless otherwise shown on the plans.

3. MEASUREMENT

Removing concrete pavement, floors, porches, patios, riprap, medians, foundations, sidewalks, driveways, and other appurtenances will be measured by the square yard (regardless of thickness) or by the cubic yard of calculated volume, in its original position.

Removing curb, curb and gutter, and concrete traffic barrier will be measured by the foot in its original position. The removal of monolithic concrete curb or dowelled concrete curb will be included in the concrete pavement measurement.

Removing retaining walls will be measured by the square yard along the front face from the top of the wall to the top of the footing.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

4. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Removing Concrete" of the type specified. This price is full compensation for breaking the concrete; loading, hauling, and salvaging or disposing of the material; and equipment, labor, tools, and incidentals.

Removing retaining wall footings will not be paid for directly but will be considered subsidiary to this Item.

Item 105

Removing Treated and Untreated Base and Asphalt Pavement

1. DESCRIPTION

Break, remove, and store or dispose of existing asphalt pavement, including surface treatments, and treated or untreated base materials.

2. CONSTRUCTION

Break material retained by the Department into pieces not larger than 24 in. unless otherwise shown on the plans. Remove existing asphalt pavement before disturbing stabilized base. Avoid contamination of the asphalt materials and damage to adjacent areas. Repair material damaged by operations outside the designated locations.

Stockpile materials designated salvageable at designated sites when shown on the plans or as directed. Prepare stockpile site by removing vegetation and trash and by providing for proper drainage. Material not designated to be salvaged will become the property of the Contractor. When this material is disposed of, do so in accordance with federal, state, and local regulations.

3. MEASUREMENT

This Item will be measured by the 100-ft. station along the baseline of each roadbed, by the square yard of existing treated or untreated base and asphalt pavement in its original position, or by the cubic yard of existing treated or untreated base and asphalt pavement in its original position, as calculated by the average end area method. Square yard and cubic yard measurement will be established by the widths and depths shown on the plans and the lengths measured in the field.

4. PAYMENT

The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Removing Treated and Untreated Base and Asphalt Pavement" of the depth specified. This price is full compensation for breaking the material, loading, hauling, unloading, stockpiling or disposing; repair to areas outside designated locations for removal; and equipment, labor, tools, and incidentals.

Item 110
Excavation

1. DESCRIPTION

Excavate areas as shown on the plans or as directed. Remove materials encountered to the lines, grades, and typical sections shown on the plans and cross-sections.

2. CONSTRUCTION

Accept ownership of unsuitable or excess material and dispose of material in accordance with local, state, and federal regulations at locations outside the right of way.

Maintain drainage in the excavated area to avoid damage to the roadway section. Correct any damage to the subgrade caused by weather at no additional cost to the Department.

Shape slopes to avoid loosening material below or outside the proposed grades. Remove and dispose of slides as directed.

2.1. **Rock Cuts**. Excavate to finish subgrade. Manipulate and compact subgrade in accordance with Section 132.3.4., "Compaction Methods," unless excavation is to clean homogenous rock at finish subgrade elevation. Use approved embankment material compacted in accordance with Section 132.3.4., "Compaction Methods," to replace undercut material at no additional cost if excavation extends below finish subgrade.

2.2. **Earth Cuts**. Excavate to finish subgrade. Scarify subgrade to a uniform depth at least 6 in. below finish subgrade elevation in areas where base or pavement structure will be placed on subgrade. Manipulate and compact subgrade in accordance with Section 132.3.4., "Compaction Methods."

Take corrective measures as directed if unsuitable material is encountered below subgrade elevations.

2.3. **Subgrade Tolerances**. Excavate to within 1/2 in. in cross-section and 1/2 in. in 16 ft. measured longitudinally for turnkey construction. Excavate to within 0.1 ft. in cross-section and 0.1 ft. in 16 ft. measured longitudinally for staged construction.

3. MEASUREMENT

This Item will be measured by the cubic yard in its original position as computed by the method of average end areas.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

Limits of measurement for excavation in retaining wall areas will be as shown on the plans.

Shrinkage or swelling factors will not be considered in determining the calculated quantities.

4. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Excavation (Roadway)," "Excavation (Channel),"

"Excavation (Special)," or "Excavation (Roadway and Channel)." This price is full compensation for authorized excavation; drying; undercutting subgrade and reworking or replacing the undercut material in rock cuts; hauling; disposal of material not used elsewhere on the project; scarification and compaction; and equipment, labor, materials, tools, and incidentals.

Drying required deeper than 6 in. below subgrade elevation will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Excavation and replacement of unsuitable material below subgrade elevations will be performed and paid for in accordance with the applicable bid items. However, if Item 132, "Embankment," is not included in the Contract, payment for replacement of unsuitable material will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

When a slide not due to the Contractor's negligence or operation occurs, payments for removal and disposal of the slide material will be in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Excavation in backfill areas of retaining walls will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 132
Embankment

1. DESCRIPTION

Furnish, place, and compact materials for construction of roadways, embankments, levees, dikes, or any designated section of the roadway where additional material is required.

2. MATERIALS

Furnish approved material capable of forming a stable embankment from required excavation in the areas shown on the plans or from sources outside the right of way. Provide one or more of the following types as shown on the plans:

- **Type A**. Granular material that is free from vegetation or other objectionable material and meets the requirements of Table 1.

Table 1
Testing Requirements

Property	Test Method	Specification Limit
Liquid limit	Tex-104-E	≤ 45
Plasticity index (PI)	Tex-106-E	≤ 15
Bar linear shrinkage	Tex-107-E	≥ 2

Perform the Linear Shrinkage test only as indicated in Tex-104-E.

- **Type B**. Materials such as rock, loam, clay, or other approved materials.
- **Type C**. Material meeting the specification requirements shown on the plans. Type C may be further designated as Type C1, C2, etc.
- **Type D**. Material from required excavation areas shown on the plans.

Meet the requirements of the pertinent retaining wall Items for retaining wall backfill material.

3. CONSTRUCTION

Meet the requirements of Item 7, "Legal Relations and Responsibilities," when off right of way sources are used. Notify the Engineer before opening a material source to allow for required testing. Complete preparation of the right of way in accordance with Item 100, "Preparing Right of Way," for areas to receive embankment.

Backfill tree-stump holes or other minor excavations with approved material and tamp. Restore the ground surface, including any material disked loose or washed out, to its original slope. Compact the ground surface by sprinkling in accordance with Item 204, "Sprinkling," and by rolling using equipment complying with Item 210, "Rolling," when directed.

Scarify and loosen the unpaved surface areas, except rock, to a depth of at least 6 in. unless otherwise shown on the plans. Bench slopes before placing material. Begin placement of material at the toe of slopes. Do not place trees, stumps, roots, vegetation, or other objectionable material in the embankment. Simultaneously recompact scarified material with the placed embankment material. Do not exceed the layer depth specified in Section 132.3.4., "Compaction Methods."

Construct embankments to the grade and sections shown on the plans. Construct the embankment in layers approximately parallel to the finished grade for the full width of the individual roadway cross-sections unless

otherwise shown on the plans. Ensure that each section of the embankment conforms to the detailed sections or slopes. Maintain the finished section, density, and grade until the project is accepted.

3.1. **Earth Embankments**. Earth embankment is mainly composed of material other than rock. Construct embankments in successive layers, evenly distributing materials in lengths suited for sprinkling and rolling.

Treat material with calcium-based additives in accordance with Section 260.2.3., "Flexible Base," when required. Obtain approval to incorporate rock and broken concrete produced by the construction project in the lower layers of the embankment. Place the rock and concrete outside the limits of the completed roadbed when the size of approved rock or broken concrete exceeds the layer thickness requirements in Section 132.3.4., "Compaction Methods." Cut and remove all exposed reinforcing steel from the broken concrete.

Move the material dumped in piles or windrows by blading or by similar methods and incorporate it into uniform layers. Featheredge or mix abutting layers of dissimilar material for at least 100 ft. to ensure there are no abrupt changes in the material. Break down clods or lumps of material and mix embankment until a uniform material is attained.

Apply water free of industrial wastes and other objectionable matter to achieve the uniform moisture content specified for compaction.

Roll and sprinkle each embankment layer in accordance with Section 132.3.4.1., "Ordinary Compaction," when ordinary compaction is specified. Compact the layer to the required density in accordance with Section 132.3.4.2., "Density Control," when density control is specified.

3.2. **Rock Embankments**. Rock embankment is mainly composed of rock. Construct rock embankments in successive layers for the full width of the roadway cross-section with a depth of 18 in. or less. Increase the layer depth for large rock sizes as approved. Do not exceed a depth of 2-1/2 ft. in any case. Fill voids created by the large stone matrix with smaller stones during the placement and filling operations.

Ensure the depth of the embankment layer is greater than the maximum dimension of any rock. Do not place rock greater than 2 ft. in its maximum dimension, unless otherwise approved. Construct the final layer with graded material so that the density and uniformity is in accordance with Section 132.3.4., "Compaction Methods." Break up exposed oversized material as approved.

Roll and sprinkle each embankment layer in accordance with Section 132.3.4.1., "Ordinary Compaction," when ordinary compaction is specified. Compact each layer to the required density in accordance with Section 132.3.4.2., "Density Control," when density control is specified. Proof-roll each rock layer as directed, where density testing is not possible, in accordance with Item 216, "Proof Rolling," to ensure proper compaction.

3.3. **Embankments Adjacent to Culverts and Bridges**. Compact embankments adjacent to culverts and bridges in accordance with Item 400, "Excavation and Backfill for Structures."

3.4. **Compaction Methods**. Begin rolling longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least 1/2 the width of the roller. Begin rolling at the lower side and progress toward the high side on super elevated curves. Alternate roller trips to attain slightly different lengths. Compact embankments in accordance with Section 132.4.1., "Ordinary Compaction," or Section 132.3.4.2., "Density Control," as shown on the plans.

3.4.1. **Ordinary Compaction**. Use approved rolling equipment complying with Item 210, "Rolling," to compact each layer. Use specific equipment when required by the plans or the Engineer. Do not allow the loose depth of any layer to exceed 8 in., unless otherwise approved. Bring each layer to the moisture content directed before and during rolling operations. Compact each layer until there is no evidence of further consolidation. Maintain a level layer to ensure uniform compaction. Recompact and refinish the subgrade at no additional expense to the Department if the required stability or finish is lost for any reason.

3.4.2. **Density Control**. Compact each layer to the required density using equipment complying with Item 210, "Rolling." Determine the maximum lift thickness based on the ability of the compacting operation and equipment to meet the required density. Do not exceed layer thickness of 16 in. loose or 12 in. compacted material unless otherwise approved. Maintain a level layer to ensure uniform compaction.

The Engineer will use Tex-114-E to determine the maximum dry density (D_a) and optimum moisture content (W_{opt}). Meet the requirements for field density and moisture content in Table 2 unless otherwise shown on the plans.

Table 2
Field Density Control Requirements

Description	Density	Moisture Content
	Tex-115-E	
PI ≤ 15	≥ 98% D_a	
15 < PI ≤ 35	≥ 98% D_a and ≤ 102% D_a	≥ W_{opt}
PI > 35	≥ 95% D_a and ≤ 100% D_a	≥ W_{opt}

Each layer is subject to testing by the Engineer for density and moisture content. During compaction, the moisture content of the soil should not exceed the value shown on the moisture-density curve, above optimum, required to achieve:

- 98% dry density for soils with a PI greater than 15 but less than or equal to 35 or
- 95% dry density for soils with PI greater than 35.

Remove small areas of the layer to allow for density tests as required. Replace the removed material and recompact at no additional expense to the Department. Proof-roll in accordance with Item 216, "Proof Rolling," when shown on the plans or as directed. Correct soft spots as directed.

3.5. **Maintenance of Moisture and Reworking**. Maintain the density and moisture content once all requirements in Table 2 are met. Maintain the moisture content no lower than 4% below optimum for soils with a PI greater than 15. Rework the material to obtain the specified compaction when the material loses the required stability, density, moisture, or finish. Alter the compaction methods and procedures on subsequent work to obtain specified density as directed.

3.6. **Acceptance Criteria**.

3.6.1. **Grade Tolerances**.

3.6.1.1. **Staged Construction**. Grade to within 0.1 ft. in the cross-section and 0.1 ft. in 16 ft. measured longitudinally.

3.6.1.2. **Turnkey Construction**. Grade to within 1/2 in. in the cross-section and 1/2 in. in 16 ft. measured longitudinally.

3.6.2. **Gradation Tolerances**. Ensure no more than 1 of the 5 most recent gradation tests is outside the specified limits on any individual sieve by more than 5% when gradation requirements are shown on the plans.

3.6.3. **Density Tolerances**. Ensure no more than 1 of the 5 most recent density tests for compaction work is outside the specified density limits, and no test is outside the limits by more than 3 pcf.

3.6.4. **Plasticity Tolerances**. Ensure no more than 1 of the 5 most recent PI tests for material is outside the specified limit by more than 2 points.

4. MEASUREMENT

Embankment will be measured by the cubic yard. Measurement will be further defined for payment as follows:

4.1. **Final**. The cubic yard will be measured in its final position using the average end area method. The volume is computed between the original ground surface or the surface upon which the embankment is to be constructed and the lines, grades, and slopes of the embankment. In areas of salvaged topsoil, payment for embankment will be made in accordance with Item 160, "Topsoil." Shrinkage or swell factors will not be considered in determining the calculated quantities.

4.2. **Original**. The cubic yard will be measured in its original and natural position using the average end area method.

4.3. **Vehicle**. The cubic yard will be measured in vehicles at the point of delivery.

When measured by the cubic yard in its final position, this is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

Shrinkage or swell factors are the Contractor's responsibility. When shown on the plans, factors are for informational purposes only.

Measurement of retaining wall backfill in embankment areas is paid for as embankment unless otherwise shown on the plans. Limits of measurement for embankment in retaining wall areas are shown on the plans.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Embankment (Final)," "Embankment (Original)," or "Embankment (Vehicle)" of the compaction method and type specified. This price is full compensation for furnishing embankment; hauling; placing, compacting, finishing, and reworking; disposal of waste material; and equipment, labor, tools, and incidentals.

When proof rolling is directed, it will be paid for in accordance with Item 216, "Proof Rolling."

All sprinkling and rolling, except proof rolling, will not be paid for directly but will be considered subsidiary to this Item, unless otherwise shown on the plans.

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade will be at the Contractor's expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade will be paid in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

Item 160
Topsoil

1. DESCRIPTION

Furnish and place topsoil to the depths and on the areas shown on the plans.

2. MATERIALS

Use easily cultivated, fertile topsoil that is free from objectionable material and resists erosion. Obtain topsoil from the right of way at sites of proposed excavation or embankment when specified on the plans, or as directed. Secure additional topsoil, if necessary, from approved sources outside the right of way in accordance with the requirements of Article 7.10., "Preservation of Cultural and Natural Resources and the Environment." Ensure that the topsoil obtained from sites outside the right of way has a pH of 5.5 to 8.5, per Tex-128-E. Topsoil is subject to testing by the Engineer. Furnish water in accordance with Article 168.2., "Materials."

3. CONSTRUCTION

Remove and dispose of objectionable material from the topsoil source before beginning the work. Stockpile topsoil, when necessary, in a windrow at designated locations along the right of way line or as directed. Keep source and stockpile areas drained during the period of topsoil removal and leave them in a neat condition when removal is complete. Cultivate the area to a depth of 4 in. before placing topsoil. Spread the topsoil to a uniform loose cover at the thickness specified. Place and shape the topsoil as directed. Water and roll the topsoil with a light roller or other suitable equipment.

4. MEASUREMENT

This Item will be measured by the 100-ft. station along the baseline of each roadbed, by the square yard complete in place, or by the cubic yard in vehicles at the point of delivery.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Furnishing and Placing Topsoil" of the depth specified on the plans (except for measurement by the cubic yard). This price is full compensation for securing necessary sources and royalties; furnishing topsoil; excavation, loading, hauling, stockpiling and placing; watering; rolling; and equipment, labor, materials, tools, and incidentals. Limits of excavation and embankment for payment are shown in Figure 1.

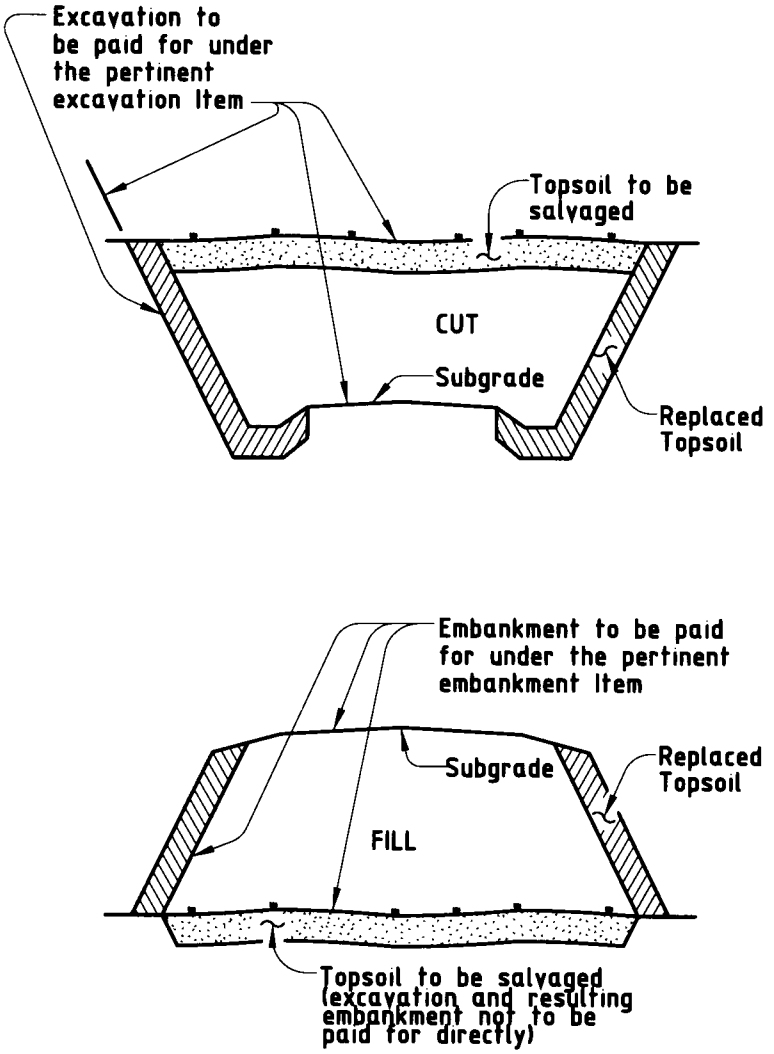


Figure 1
Roadway Cross-Sections Showing Payment for Excavation and Embankment

Item 162
Sodding for Erosion Control

1. DESCRIPTION

Provide and install grass sod as shown on the plans or as directed.

2. MATERIALS

Use live, growing grass sod of the type specified on the plans. Use grass sod with a healthy root system and dense matted roots throughout the soil of the sod for a minimum thickness of 1 in. Do not use sod from areas where the grass is thinned out. Keep sod material moist from the time it is dug until it is planted. Grass sod with dried roots is unacceptable.

2.1. **Block Sod**. Use block, rolled, or solid sod free from noxious weeds, Johnson grass, other grasses, or any matter deleterious to the growth and subsistence of the sod.

2.2. **Mulch Sod**. Use mulch sod from an approved source, free from noxious weeds, Johnson grass, other grasses, or any matter deleterious to the growth and subsistence of the sod.

2.3. **Fertilizer**. Furnish fertilizer in accordance with Article 166.2., "Materials."

2.4. **Water**. Furnish water in accordance with Article 168.2., "Materials."

2.5. **Mulch**. Use straw mulch consisting of oat, wheat, or rice straw or hay mulch of either Bermudagrass or prairie grasses. Use straw or hay mulch free of Johnson grass and other noxious and foreign materials. Keep the mulch dry and do not use molded or rotted material.

2.6. **Tacking Methods**. Use a tacking agent applied in accordance with the manufacturer's recommendations or a crimping method on all straw or hay mulch operations. Use tacking agents as approved or as specified on the plans.

3. CONSTRUCTION

Cultivate the area to a depth of 4 in. before placing the sod. Plant the sod specified and mulch, if required, after the area has been completed to lines and grades as shown on the plans. Apply fertilizer uniformly over the entire area in accordance with Article 166.3., "Construction," and water in accordance with Article 168.3., "Construction." Plant between the average date of the last freeze in the Spring and 6 weeks before the average date for the first freeze in the Fall according to the Texas Almanac for the project area.

3.1. **Sodding Types**.

3.1.1. **Spot Sodding**. Use only Bermudagrass sod. Create furrows parallel to the roadway, approximately 5 in. deep and on 18-in. centers. Sod a continuous row not less than 3 in. wide in the 2 furrows adjacent to the roadway. Place 3-in. squares of sod on 15-in. centers in the remaining furrows. Place sod so that the root system will be completely covered by the soil. Firm all sides of the sod with the soil without covering the sod with soil.

3.1.2. **Block Sodding**. Place sod over the prepared area. Roll or tamp the sodded area to form a thoroughly compacted, solid mat filling all voids in the sodded area with additional sod. Trim and remove all visible netting and backing materials. Keep sod along edges of curbs, driveways, walkways, etc., trimmed until acceptance.

3.1.3. **Mulch Sodding**. Mow sod source to no shorter than 4 in., rake and remove cuttings. Disk the sod in 2 directions, cutting the sod to a minimum of 4 in. Excavate the sod material to a depth of no more than 6 in. Keep excavated material moist or it will be rejected. Distribute the mulch sod uniformly over the area to a depth of 6 in. loose, unless otherwise shown on the plans, and roll with a light roller or other suitable equipment.

Add or reshape the mulch sod to meet the requirements of Section 162.3.2., "Finishing."

3.2. **Finishing**. Smooth and shape the area after planting to conform to the desired cross-sections. Spread any excess soil uniformly over adjacent areas or dispose of the excess soil as directed.

3.3. **Straw or Hay Mulch**. Apply straw or hay mulch for "Spot Sodding" and "Mulch Sodding" uniformly over the area as shown on the plans. Apply straw mulch at 2 to 2-1/2 tons per acre. Apply hay mulch at 1-1/2 to 2 tons per acre. Use a tacking method over the mulched area.

4. MEASUREMENT

"Spot Sodding," "Block Sodding," and "Straw or Hay Mulch" will be measured by the square yard in its final position. "Mulch Sodding" will be measured by the square yard in its final position or by the cubic yard in vehicles as delivered to the planting site.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Spot Sodding," "Block Sodding," "Straw or Hay Mulch," or "Mulch Sodding." This price is full compensation for securing a source, excavation, loading, hauling, placing, rolling, finishing, furnishing materials, equipment, labor, tools, supplies, and incidentals. Fertilizer will not be paid for directly but will be subsidiary to this Item.

Unless otherwise specified on the plans, water, except for that used for maintaining and preparing the sod before planting, will be measured and paid for in accordance with Item 168, "Vegetative Watering."

Item 164
Seeding for Erosion Control

1. DESCRIPTION

Provide and install temporary or permanent seeding for erosion control as shown on the plans or as directed.

2. MATERIALS

2.1. **Seed**. Provide seed from the previous season's crop meeting the requirements of the Texas Seed Law, including the testing and labeling for pure live seed (PLS = Purity × Germination). Furnish seed of the designated species, in labeled unopened bags or containers to the Engineer before planting. Use within 12 mo. from the date of the analysis. When Buffalograss is specified, use seed that is treated with KNO_3 (potassium nitrate) to overcome dormancy.

Use Tables 1–4 to determine the appropriate seed mix and rates as specified on the plans. If a plant species is not available by the producers, the other plant species in the recommended seed mixture will be increased proportionally by the PLS/acre of the missing plant species.

Table 1
Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
1 (Paris) Feb. 1–May 15	Green Sprangletop Sideoats Grama (Haskell) Bermudagrass Little Bluestem (Native) Illinois Bundleflower	0.3 3.2 1.8 1.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Weeping Lovegrass (Ermelo) Partridge Pea	0.3 1.5 6.0 0.6 0.8 1.0
2 (Ft. Worth) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
3 (Wichita Falls) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Awnless Bushsunflower (Plateau)	0.6 1.0 1.0 0.4 0.2 0.8 0.4 1.2 0.6 0.75 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 0.6 0.8 0.75 0.3
4 (Amarillo) Feb. 15–May 15	Green Sprangletop Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka) Illinois Bundleflower	0.3 3.6 1.2 1.6 1.0	Green Sprangletop Weeping Lovegrass (Ermelo) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Sand Bluestem Purple Prairie Clover	0.3 0.8 1.0 0.3 1.8 0.5

Table 1 (continued)
Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
5 (Lubbock) Feb. 15–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Buffalograss (Texoka) Illinois Bundleflower	0.3 3.6 1.2 1.6 1.0	Green Sprangletop Weeping Lovegrass (Ermelo) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Sand Bluestem Purple Prairie Clover	0.3 0.8 1.0 0.3 1.8 0.5
6 (Odessa) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Blue Grama (Hachita) Galleta Grass (Viva) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Alkali Sacaton (Saltalk) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Whiplash Pappusgrass (Webb) Arizona Cottontop (La Salle)	1.0 1.0 0.4 0.6 0.2 0.6 0.2 0.2 0.1 0.6 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Blue Grama (Hachita) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Indian Ricegrass (Rim Rock) Sand Bluestem (Cottle County) Little Bluestem (Pastura) Purple Prairie Clover (Cuero)	1.0 0.2 0.4 0.4 0.2 0.2 1.6 1.2 0.8 0.3
7 (San Angelo) Feb. 1–May 1	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Illinois Bundleflower (Sabine)	1.0 1.0 1.0 0.4 0.2 0.4 0.4 1.2 0.6 0.75 1.0	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Sand Bluestem (Cottle County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 1.2 0.6 0.8 0.75 0.3
8 (Abilene) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Illinois Bundleflower (Sabine)	1.0 1.0 1.0 0.4 0.2 0.4 0.4 1.2 0.6 0.75 1.0	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Sand Bluestem (Cottle County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 1.2 0.6 0.8 0.75 0.3
9 (Waco) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
10 (Tyler) Feb. 1–May 15	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sideoats Grama (Haskell) Illinois Bundleflower	0.3 1.8 9.0 2.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Weeping Lovegrass (Ermelo) Sand Lovegrass Lance-Leaf Coreopsis	0.3 1.8 9.0 0.5 0.5 1.0
11 (Lufkin) Feb. 1–May 15	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sideoats Grama (Haskell) Illinois Bundleflower	0.3 1.8 9.0 2.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Lance-Leaf Coreopsis	0.3 2.1 9.0 0.5 1.0

Table 1 (continued)

Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
12 (Houston) Jan. 15–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Little Bluestem (Native) Illinois Bundleflower	0.3 2.1 3.2 1.4 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Weeping Lovegrass (Ermelo) Lance-Leaf Coreopsis	0.3 2.4 10.5 1.0 1.0
13 (Yoakum) Jan. 15–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) Canada Wildrye (Lavaca) Illinois Bundleflower (Sabine) Purple Prairie Clover (Cuero)	1.0 1.0 1.5 1.0 0.3 0.2 0.2 2.0 1.3 0.6	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Purple Prairie Clover (Cuero) Partridge Pea (Comanche) Englemann Daisy (Eldorado)	1.0 0.4 1.0 0.8 0.2 0.6 0.6 1.0
14 (Austin) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower (Sabine) Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
15 (San Antonio) Feb. 1–May 1	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhoades Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
16 (Corpus Christi) Jan. 1–May 1	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhodes Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
17 (Bryan) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Little Bluestem (Native) Illinois Bundleflower	0.3 1.5 3.6 1.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Weeping Lovegrass (Ermelo) Sand Lovegrass Lance-Leaf Coreopsis	0.3 1.5 7.5 0.6 0.6 1.0

Table 1 (continued)
Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
18 (Dallas) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
19 (Atlanta) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Illinois Bundleflower	0.3 2.4 4.5 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Lance-Leaf Coreopsis	0.3 2.1 7.5 0.6 1.0
20 (Beaumont) Jan. 15–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Illinois Bundleflower	0.3 2.7 4.1 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Lance-Leaf Coreopsis	0.3 2.1 7.5 0.6 1.0
21 (Pharr) Jan. 15–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhoades Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
22 (Laredo) Jan. 15–May 1	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhoades Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
23 (Brownwood) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Awnless Bushsunflower (Plateau)	0.6 1.0 1.0 0.4 0.2 0.8 0.4 1.2 0.6 0.75 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 0.6 0.8 0.75 0.3

Table 1 (continued)
Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
24 (El Paso) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Blue Grama (Hachita) Galleta Grass (Viva) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Alkali Sacaton (Saltalk) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Whiplash Pappusgrass (Webb) Arizona Cottontop (La Salle)	1.0 1.0 0.4 0.6 0.2 0.6 0.2 0.2 0.1 0.6 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Blue Grama (Hachita) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Indian Ricegrass (Rim Rock) Sand Bluestem (Cottle County) Little Bluestem (Pastura) Purple Prairie Clover (Cuero)	1.0 0.2 0.4 0.4 0.2 0.2 1.6 1.2 0.8 0.3
25 (Childress) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Western Wheatgrass Galleta Illinois Bundleflower	0.3 2.7 0.9 2.1 1.6 1.0	Green Sprangletop Weeping Lovegrass (Ermelo) Sand Dropseed (Borden Co.) Sand Lovegrass Purple Prairie Clover	0.3 1.2 0.5 0.8 0.5

Table 2
Permanent Urban Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
1 (Paris) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell)	0.3 2.4 4.5	Green Sprangletop Bermudagrass	0.3 5.4
2 (Ft. Worth) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Buffalograss (Texoka)	0.3 3.6 2.4 1.6	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Sand Dropseed (Borden Co.)	0.3 3.6 2.1 0.3
3 (Wichita Falls) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Buffalograss (Texoka)	0.3 4.5 1.8 1.6	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Sand Dropseed (Borden Co.)	0.3 3.6 1.8 0.4
4 (Amarillo) Feb. 15–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Buffalograss (Texoka)	0.3 2.7 0.9 0.4 1.6
5 (Lubbock) Feb. 15–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Buffalograss (Texoka)	0.3 2.7 0.9 0.4 1.6
6 (Odessa) Feb. 1–May 15	Green Sprangletop Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sideoats Grama (Haskell) Sand Dropseed (Borden Co.) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 2.7 0.4 0.9 1.6
7 (San Angelo) Feb. 1–May 1	Green Sprangletop Sideoats Grama (Haskell) Buffalograss (Texoka)	0.3 7.2 1.6	Green Sprangletop Sideoats Grama (Haskell) Sand Dropseed (Borden Co.) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.2 0.3 0.9 1.6
8 (Abilene) Feb. 1–May 15	Green Sprangletop Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sand Dropseed (Borden Co.) Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 0.3 3.6 0.8 1.6

Table 2 (continued)
Permanent Urban Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
9 (Waco)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Bermudagrass	1.8	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Sideoats Grama (Haskell)	4.5	Sand Dropseed (Borden Co.)	0.4
10 (Tyler)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
11 (Lufkin)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
12 (Houston)	Green Sprangletop	0.3	Green Sprangletop	0.3
Jan. 15–May 15	Sideoats Grama (Haskell)	4.5	Bermudagrass	5.4
	Bermudagrass	2.4		
13 (Yoakum)	Green Sprangletop	0.3	Green Sprangletop	0.3
Jan. 15–May 15	Sideoats Grama (South Texas)	4.5	Bermudagrass	5.4
	Bermudagrass	2.4		
14 (Austin)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Bermudagrass	2.4	Bermudagrass	4.8
	Sideoats Grama (South Texas)	3.6	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6		
15 (San Antonio)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 1	Sideoats Grama (South Texas)	3.6	Bermudagrass	4.8
	Bermudagrass	2.4	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6		
16 (Corpus Christi)	Green Sprangletop	0.3	Green Sprangletop	0.3
Jan. 1–May 1	Sideoats Grama (South Texas)	3.6	Bermudagrass	4.8
	Bermudagrass	2.4	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6		
17 (Bryan)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
18 (Dallas)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Sideoats Grama (El Reno)	3.6	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Bermudagrass	2.4	Sand Dropseed (Borden Co.)	0.4
19 (Atlanta)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
20 (Beaumont)	Green Sprangletop	0.3	Green Sprangletop	0.3
Jan. 15–May 15	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
21 (Pharr)	Green Sprangletop	0.3	Green Sprangletop	0.3
Jan. 15–May 15	Sideoats Grama (South Texas)	3.6	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Bermudagrass	2.4	Sand Dropseed (Borden Co.)	0.4
22 (Laredo)	Green Sprangletop	0.3	Green Sprangletop	0.3
Jan. 15–May 1	Sideoats Grama (South Texas)	4.5	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Bermudagrass	1.8	Sand Dropseed	0.4
23 (Brownwood)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Sideoats Grama (Haskell)	3.6	Buffalograss (Texoka)	1.6
	Bermudagrass	1.2	Bermudagrass	3.6
	Blue Grama (Hachita)	0.9	Sand Dropseed (Borden Co.)	0.4
24 (El Paso)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Sideoats Grama (South Texas)	3.6	Buffalograss (Texoka)	1.6
	Blue Grama (Hachita)	1.2	Sand Dropseed (Borden Co.)	0.4
	Buffalograss (Texoka)	1.6	Blue Grama (Hachita)	1.8
25 (Childress)	Green Sprangletop	0.3	Green Sprangletop	0.3
Feb. 1–May 15	Sideoats Grama (El Reno)	3.6	Sand Dropseed (Borden Co.)	0.4
	Blue Grama (Hachita)	1.2	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	1.8

Table 3
Temporary Cool Season Seeding

Districts	Dates	Seed Mix and Rates (lb. PLS/acre)	
Paris (1), Amarillo (4), Lubbock (5), Dallas (18)	September 1–November 30	Tall Fescue Western Wheatgrass Wheat (Red, Winter)	4.5 5.6 34
Odessa (6), San Angelo (7), El Paso (24)	September 1–November 30	Western Wheatgrass Wheat (Red, Winter)	8.4 50
Waco (9), Tyler (10), Lufkin (11), Austin (14), San Antonio (15), Bryan (17), Atlanta (19)	September 1–November 30	Tall Fescue Oats Wheat	4.5 24 34
Houston (12), Yoakum (13), Corpus Christi (16), Beaumont (20), Pharr (21), Laredo (22)	September 1–November 30	Oats	72
Ft. Worth (2), Wichita Falls (3), Abilene (8), Brownwood (23), Childress (25)	September 1–November 30	Tall Fescue Western Wheatgrass Cereal Rye	4.5 5.6 34

Table 4
Temporary Warm Season Seeding

Districts	Dates	Seed Mix and Rates (lb. PLS/acre)	
All	May 1–August 31	Foxtail Millet	34

2.2. **Fertilizer**. Use fertilizer in conformance with Article 166.2., "Materials."

2.3. **Vegetative Watering**. Use water that is clean and free of industrial wastes and other substances harmful to the growth of vegetation.

2.4. **Mulch**.

2.4.1. **Straw or Hay Mulch**. Use straw or hay mulch in conformance with Section 162.2.5., "Mulch."

Cellulose Fiber Mulch. Use only cellulose fiber mulches that are on the Approved Products List, *Erosion Control Approved Products*. (http://www.txdot.gov/business/resources/erosion-control.html) Submit one full set of manufacturer's literature for the selected material. Keep mulch dry until applied. Do not use molded or rotted material.

2.5. **Tacking Methods**. Use a tacking agent applied in accordance with the manufacturer's recommendations or a crimping method on all straw or hay mulch operations. Use tacking agents as approved or as specified on the plans.

3. CONSTRUCTION

Cultivate the area to a depth of 4 in. before placing the seed unless otherwise directed. Use approved equipment to vertically track the seedbed as shown on the plans or as directed. Cultivate the seedbed to a depth of 4 in. or mow the area before placement of the permanent seed when performing permanent seeding after an established temporary seeding. Plant the seed specified and mulch, if required, after the area has been completed to lines and grades as shown on the plans.

3.1. **Broadcast Seeding**. Distribute the seed or seed mixture uniformly over the areas shown on the plans using hand or mechanical distribution or hydro-seeding on top of the soil unless otherwise directed. Apply the mixture to the area to be seeded within 30 min. of placement of components in the equipment when seed and water are to be distributed as a slurry during hydro-seeding. Roll the planted area with a light roller or other suitable equipment. Roll sloped areas along the contour of the slopes.

3.2. **Straw or Hay Mulch Seeding**. Plant seed according to Section 164.3.1., "Broadcast Seeding." Apply straw or hay mulch uniformly over the seeded area immediately after planting the seed or seed mixture. Apply

straw mulch at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.

3.3. **Cellulose Fiber Mulch Seeding**. Plant seed in accordance with Section 164.3.1., "Broadcast Seeding." Apply cellulose fiber mulch uniformly over the seeded area immediately after planting the seed or seed mixture at the following rates.

- Sandy soils with slopes of 3:1 or less—2,500 lb. per acre.
- Sandy soils with slopes greater than 3:1—3,000 lb. per acre.
- Clay soils with slopes of 3:1 or less—2,000 lb. per acre.
- Clay soils with slopes greater than 3:1—2,300 lb. per acre.

Cellulose fiber mulch rates are based on dry weight of mulch per acre. Mix cellulose fiber mulch and water to make a slurry and apply uniformly over the seeded area using suitable equipment.

3.4. **Drill Seeding**. Plant seed or seed mixture uniformly over the area shown on the plans at a depth of 1/4 to 1/3 in. using a pasture or rangeland type drill unless otherwise directed. Plant seed along the contour of the slopes.

3.5. **Straw or Hay Mulching**. Apply straw or hay mulch uniformly over the area as shown on the plans. Apply straw mulch at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.

Apply fertilizer in conformance with Article 166.3., "Construction." Seed and fertilizer may be distributed simultaneously during "Broadcast Seeding" operations, provided each component is applied at the specified rate. Apply half of the required fertilizer during the temporary seeding operation and the other half during the permanent seeding operation when temporary and permanent seeding are both specified for the same area.

Water the seeded areas at the rates and frequencies as shown on the plans or as directed.

4. MEASUREMENT

This Item will be measured by the square yard or by the acre.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Broadcast Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Broadcast Seeding (Temp)" of warm or cool season specified, "Straw or Hay Mulch Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Straw or Hay Mulch Seeding (Temp)" of warm or cool season specified, "Cellulose Fiber Mulch Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Cellulose Fiber Mulch Seeding (Temp)" of warm or cool season specified, "Drill Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Drill Seeding (Temp)" of warm or cool season specified, and "Straw or Hay Mulching." This price is full compensation for furnishing materials, including water for hydro-seeding and hydro-mulching operations, mowing, labor, equipment, tools, supplies, and incidentals. Fertilizer will not be paid for directly but will be subsidiary to this Item. Water for irrigating the seeded area, when specified, will be paid for under Item 168, "Vegetative Watering."

Item 166
Fertilizer

1. DESCRIPTION

Provide and distribute fertilizer over areas specified on the plans.

2. MATERIALS

Use a complete fertilizer containing nitrogen (N), phosphoric acid (P), and potash (K) nutrients unless otherwise specified on the plans. Ensure at least 50% of the nitrogen component is a slow-release sulfur-coated urea. Ensure that fertilizer is in an acceptable condition for distribution in containers labeled with the analysis. Fertilizer is subject to testing by the Texas A&M Feed and Fertilizer Control Service in accordance with the Texas Fertilizer Law.

3. CONSTRUCTION

Deliver and apply the complete fertilizer uniformly at a rate equal to 60 lb. of nitrogen per acre or at the analysis and rate specified on the plans.

Apply fertilizer as a dry material and do not mix with water to form a slurry.

Incorporate fertilizer during seedbed preparation as specified on the plans.

4. MEASUREMENT

When fertilizer is specified on the plans to be a pay item, measurement will be by the acre of surface area covered or by the ton (2,000 lb.). Measurement by the ton will use guaranteed weight of bags or containers as shown by the manufacturer or certified scales meeting the requirements of Item 520, "Weighing and Measuring Equipment," unless otherwise approved.

5. PAYMENT

Unless otherwise specified on the plans, the work performed, materials furnished, equipment, labor, tools, and incidentals will not be paid for directly but will be subsidiary to pertinent bid items.

When fertilizer is specified on the plans to be a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Fertilizer." This price is full compensation for furnishing materials and performing operations.

Item 168
Vegetative Watering

1. DESCRIPTION

Provide and distribute water to promote growth of vegetation as directed.

2. MATERIALS

Use water that is clean and free of industrial wastes and other substances harmful to the growth of vegetation.

3. CONSTRUCTION

Apply water when directed. Furnish and operate equipment to distribute water at a uniform and controllable rate. Ensure that watering does not erode soil or plantings. Apply water in the required quantity where shown on the plans or as directed.

4. MEASUREMENT

This Item will be measured by the 1,000 gal. as applied.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Vegetative Watering." This price is full compensation for furnishing and operating watering equipment and measuring devices and for furnishing and applying water, including hauling, equipment, labor, and incidentals.

Item 204
Sprinkling

1. DESCRIPTION

Apply water for dust control, earthwork, or base construction.

2. MATERIALS

Furnish water free of industrial wastes and other objectionable matter.

3. EQUIPMENT

Use sprinklers and spray bars equipped with positive and rapidly working cut-off valves.

4. CONSTRUCTION

Apply water at a uniform rate and in the required quantity, or as directed.

5. MEASUREMENT

This Item will be measured by the 1,000 gal. applied.

6. PAYMENT

Unless sprinkling is specified as a pay item, the work performed and materials furnished in accordance with this Item will not be paid for directly but will be subsidiary to pertinent Items.

When sprinkling is specified on the plans as a pay item, the work performed and water furnished will be paid for at the unit price bid for "Sprinkling (Base)," "Sprinkling (Earthwork)," or "Sprinkling (Dust Control)." This price is full compensation for furnishing and applying water; furnishing and operating sprinklers and measuring devices; and hauling, equipment, labor, fuel, materials, tools, and incidentals.

Item 210
Rolling

1. DESCRIPTION

Compact embankment, subgrade, base, surface treatments, broken concrete pavement, or asphalt pavement using rollers. Break up asphalt mats, pit run material, or base materials.

2. EQUIPMENT

Use any type of roller to meet the production rates and quality requirements of the Contract unless otherwise shown on the plans or directed. Use equipment that meets the requirements of Table 1 when specific types of equipment are required. The Engineer may allow the use of rollers that operate in one direction only when turning does not affect the quality of work or encroach on traffic.

Table 1
Roller Requirements[1]

Roller Type	Materials to be Compacted	Load (tons)	Contact Pressure	Roller Speed (mph)
Steel wheel	Embankment, subgrade, base, asphalt concrete	≥ 10	≥ 325 lb. per inch of wheel width	2–3
Tamping	Embankment, subgrade	–	125–550 psi per tamping foot	2–3
Heavy tamping	Embankment, subgrade	–	≥ 550 psi per tamping foot	2–3
Vibratory	Embankment, subgrade, base, asphalt concrete	Type A < 6 Type B > 6 Type C as shown on the plans	Per equipment specification and as approved	As approved
Light pneumatic	Embankment, subgrade, surface treatment	4.5–9.0	≥ 45 psi	2–6
	Asphalt Concrete			4–12
Medium pneumatic	Embankment, subgrade, base, surface treatment	12–25	≥ 80 psi, as directed	2–6
	Asphalt Concrete			4–12
Heavy pneumatic	Embankment, subgrade, base, previously broken concrete pavement, other pavements	≥ 25	≤ 150 psi	2–6
Grid	Embankment, breaking up existing asphalt mats or base	5–13	–	2–3

1. Unless otherwise specified in the Contract.

2.1. **Static Steel Wheel Rollers**. Furnish single, double, or triple steel wheel, self-propelled power rollers weighing at least 10 tons capable of operating in a forward and backward motion. Ensure all wheels are flat. The Contractor may use vibratory rollers in the static mode when static steel wheel rollers are required.

For single steel wheel rollers, pneumatic rear wheels are allowed for embankment, subgrade, and base. Provide rear wheels for triple steel wheel rollers with a minimum diameter of 48 in., a minimum width of 20 in., and a minimum compression of 325 lb. per inch of wheel width.

2.2. **Tamping Rollers**. Furnish self-propelled rollers with at least one self-cleaning metal tamping drum capable of operating in a forward or backward motion with a minimum effective rolling width of 5 ft. Mount drums in a frame so that each drum moves independently of the other for rollers with more than one drum. Operate rollers in static or vibratory mode.

2.2.1. **Tamping Roller (Minimum Requirement)**. Provide tamping feet that exert a static load of 125 to 550 psi and project at least 3 in. from the surface of the drum for all tamping rollers except for heavy tamping rollers.

2.2.2. **Heavy Tamping Roller**. Provide tamping rollers that have:

- 2 metal tamping drums, rolls, or shells, each with a 60-in. minimum diameter and a 5-ft. minimum width, or
- 1 rear and 2 forward drums, each with a 60-in. minimum diameter. Arrange drums so that the rear drum compacts the space between the 2 forward drums and the minimum overall rolling width is 10 ft.

Equip drums with tamping feet that:

- project at least 7 in. from the drum surface,
- have an area of 7 to 21 sq. in.,
- are self-cleaning,
- exert a static load of at least 550 psi, and
- are spaced at 1 tamping foot per 0.65 to 0.70 square feet of drum area.

2.3. **Vibratory Rollers**. Furnish self-propelled rollers with at least one drum equipped to vibrate. Select and maintain amplitude and frequency settings per manufacturer's specifications to deliver maximum compaction without material displacement or shoving, as approved. Furnish the equipment manufacturer's specifications concerning settings and controls for amplitude and frequency. Operate rollers at speeds that will produce at least 10 blows per foot unless otherwise shown on the plans or approved. Pneumatic rear wheels are allowed for embankment, subgrade, and base. Equip each vibrating drum with:

- separate frequency and amplitude controls,
- controls to manually start and stop vibration, and
- a mechanism to continuously clean the face of the drum.

For asphalt-stabilized base and asphalt concrete pavement, furnish a roller that also has the ability to:

- automatically reverse the direction of the rotating eccentric weight,
- stop vibration before the motion of the roller stops, and
- thoroughly moisten the drum with water or approved asphalt release agent.

2.3.1. **Drum (Type A)**. Furnish a roller with a static weight less than 6 tons and a vibratory drum.

2.3.2. **Drum (Type B)**. Furnish a roller with a minimum static weight of 6 tons and a vibratory drum.

2.3.3. **Drum (Type C)**. Furnish a roller as shown on the plans.

2.4. **Pneumatic Tire Rollers**. Pneumatic tire rollers consist of rubber tire wheels on axles mounted in a frame with either a loading platform or body suitable for ballast loading. Arrange the rear tires to cover the gaps between adjacent tires of the forward group. Furnish rollers capable of forward and backward motion.

Compact asphalt pavements and surface treatments with a roller equipped with smooth-tread tires. Compact without damaging the surface. Moisten the wheels with water or an approved asphalt release agent when necessary.

Select and maintain the operating load and tire air pressure within the range of the manufacturer's charts or tabulations to attain maximum compaction throughout the lift, as approved. Furnish the manufacturer's chart or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of loadings for the particular tires furnished. Maintain individual tire inflation pressures within 5 psi of each other. Provide uniform compression under all tires.

2.4.1. **Light Pneumatic Tire**. Furnish a unit:

- with at least 9 pneumatic tires,
- with an effective rolling width of approximately 5 ft.,
- capable of providing a total uniform load of 4.5 to 9 tons, and
- with tires capable of maintaining a minimum ground contact pressure of 45 psi.

2.4.2. **Medium Pneumatic Tire**. Furnish a unit:

- with at least 7 pneumatic tires,
- with an effective rolling width of approximately 7 ft.,
- capable of providing a total uniform load of 12 to 25 tons, and
- with tires capable of maintaining a minimum ground contact pressure of 80 psi or 90 psi as directed.

2.4.3. **Heavy Pneumatic Tire**. Furnish a unit:

- with at least 4 pneumatic-tired wheels mounted on axles carrying no more than 2 wheels,
- with wheels arranged to carry approximately equal loads on uneven surfaces,
- with a width between 8 and 10 ft. that can turn 180° in the crown width,
- capable of providing a total uniform load of at least 25 tons,
- with tires capable of maintaining a maximum ground contact pressure of 150 psi, and
- with liquid-filled tires inflated to such a level that liquid will flow from the valve stem when the stem is in the uppermost position.

2.5. **Grid Rollers**. Furnish rollers that have 2 cylindrical cages with a minimum diameter of 66 in. and a minimum width of 32 in. Mount cages in a rigid frame with weight boxes. Use a cage surface of cast or welded steel fabric grid with bars 1-1/2 in. wide, spaced on 5-in. centers in each direction, that undulate approximately 1 in. between the high and low points.

Furnish rollers capable of providing a total load of 5 to 13 tons and capable of being operated in a forward or backward motion.

2.6. **Alternate Equipment**. The Contractor may use alternate compaction equipment that produces results equivalent to the specified equipment as approved. Discontinue the use of the alternate equipment and furnish the specified equipment if the desired results are not achieved.

3. CONSTRUCTION

Perform this work in accordance with the applicable Items using equipment and roller speeds specified in Table 1. Use only rubber-tired equipment to push or pull compaction equipment on base courses. Use equipment that does not damage material being rolled.

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 216
Proof Rolling

1. DESCRIPTION

Proof-roll earthwork, base, or both to locate unstable areas.

2. EQUIPMENT

2.1. **Specified Equipment**. Furnish rollers that weigh at least 25 tons when loaded. The maximum acceptable load is 50 tons. Provide rollers that meet the requirements of Section 210.2.4., "Pneumatic Tire Rollers."

2.2. **Alternative Equipment**. The Contractor may use alternate compaction equipment that produces results equivalent to the specified equipment in the same period of time as approved. Discontinue the use of the alternative equipment and furnish the specified equipment if the desired results are not achieved.

3. CONSTRUCTION

Perform proof rolling as directed. Adjust the load and tire inflation pressures within the range of the manufacturer's charts or tabulations, as directed. Make at least 2 coverages with the proof roller. Offset each trip of the roller by at most one tire width. Operate rollers at a speed between 2 and 6 mph, as directed. Correct unstable or nonuniform areas, if found, in accordance with the applicable Item.

4. MEASUREMENT

Rolling will be measured by the hour operated on surfaces being tested.

5. PAYMENT

The work performed and equipment furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Proof Rolling." This price is full compensation for furnishing and operating equipment and for labor, materials, tools, and incidentals.

Item 247
Flexible Base

1. DESCRIPTION

Construct a foundation course composed of flexible base.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed material sources and of changes to material sources. The Engineer may sample and test project materials at any time before compaction throughout the duration of the project to assure specification compliance. Use Tex-100-E material definitions.

2.1. **Aggregate**. Furnish aggregate of the type and grade shown on the plans and meeting the requirements of Table 1. Each source must meet Table 1 requirements for liquid limit, plasticity index, and wet ball mill for the grade specified. Do not use additives, such as but not limited to lime, cement, or fly ash to modify aggregates to meet the requirements of Table 1 unless shown on the plans.

Table 1
Material Requirements

Property	Test Method	Grade 1–2	Grade 3	Grade 4[2]	Grade 5
Master gradation sieve size (cumulative % retained)	Tex-110-E			As shown on the plans	
2-1/2"		0	0		0
1-3/4"		0–10	0–10		0–5
7/8"		10–35	–		10–35
3/8"		30–65	–		35–65
#4		45–75	45–75		45–75
#40		65–90	50–85		70–90
Liquid Limit, % Max	Tex-104-E	40	40	As shown on the plans	35
Plasticity Index, Max[1]	Tex-106-E	10	12	As shown on the plans	10
Plasticity index, Min[1]		As shown on the plans	As shown on the plans	As shown on the plans	As shown on the plans
Wet ball mill, % Max	Tex-116-E	40	–	As shown on the plans	40
Wet ball mill, % Max increase passing the #40 sieve		20	–	As shown on the plans	20
Min compressive strength, psi	Tex-117-E			As shown on the plans	
lateral pressure 0 psi		35	–		–
lateral pressure 3 psi		–	–		90
lateral pressure 15 psi		175	–		175

1. Determine plastic index in accordance with Tex-107-E (linear shrinkage) when liquid limit is unattainable as defined in Tex-104-E.
2. Grade 4 may be further designated as Grade 4A, Grade 4B, etc.

2.1.1. **Material Tolerances**. The Engineer may accept material if no more than 1 of the 5 most recent gradation tests has an individual sieve outside the specified limits of the gradation.

When target grading is required by the plans, no single failing test may exceed the master grading by more than 5 percentage points on sieves No. 4 and larger or 3 percentage points on sieves smaller than No. 4.

The Engineer may accept material if no more than 1 of the 5 most recent plasticity index tests is outside the specified limit. No single failing test may exceed the allowable limit by more than 2 points.

2.1.2. **Material Types**. Do not use fillers or binders unless approved. Furnish the type specified on the plans in accordance with the following:

2.1.2.1. **Type A**. Crushed stone produced and graded from oversize quarried aggregate that originates from a single, naturally occurring source. Do not use gravel or multiple sources.

2.1.2.2. **Type B**. Crushed or uncrushed gravel. Blending of 2 or more sources is allowed.

2.1.2.3. **Type C**. Crushed gravel with a minimum of 60% of the particles retained on a No. 4 sieve with 2 or more crushed faces as determined by Tex-460-A, Part I. Blending of 2 or more sources is allowed.

2.1.2.4. **Type D**. Type A material or crushed concrete. Crushed concrete containing gravel will be considered Type D material. Crushed concrete must meet the requirements in Section 247.2.1.3.2., "Recycled Material (Including Crushed Concrete) Requirements," and be managed in a way to provide for uniform quality. The Engineer may require separate dedicated stockpiles in order to verify compliance.

2.1.2.5. **Type E**. Caliche, iron ore or as otherwise shown on the plans.

2.1.3. **Recycled Material**. Recycled asphalt pavement (RAP) and other recycled materials may be used when shown on the plans. Request approval to blend 2 or more sources of recycled materials.

2.1.3.1. **Limits on Percentage**. Do not exceed 20% RAP by weight, when RAP is allowed, unless otherwise shown on the plans. The percentage limitations for other recycled materials will be as shown on the plans.

2.1.3.2. **Recycled Material (Including Crushed Concrete) Requirements**.

2.1.3.2.1. **Contractor-Furnished Recycled Materials**. Provide recycled materials that have a maximum sulfate content of 3,000 ppm when tested in accordance with Tex-145-E. When the Contractor furnishes the recycled materials, including crushed concrete, the final product will be subject to the requirements of Table 1 for the grade specified. Certify compliance with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines," for Contractor furnished recycled materials. In addition, recycled materials must be free from reinforcing steel and other objectionable material and have at most 1.5% deleterious material when tested in accordance with Tex-413-A. For RAP, do not exceed a maximum percent loss from decantation of 5.0% when tested in accordance with Tex-406-A. Test RAP without removing the asphalt.

2.1.3.2.2. **Department-Furnished Required Recycled Materials**. When the Department furnishes and requires the use of recycled materials, unless otherwise shown on the plans:

- Department-required recycled material will not be subject to the requirements in Table 1,
- Contractor-furnished materials are subject to the requirements in Table 1 and this Item,
- the final product, blended, will be subject to the requirements in Table 1, and
- for final product, unblended (100% Department-furnished required recycled material), the liquid limit, plasticity index, wet ball mill, and compressive strength is waived.

Crush Department-furnished RAP so that 100% passes the 2 in. sieve. The Contractor is responsible for uniformly blending to meet the percentage required.

2.1.3.2.3. **Department-Furnished and Allowed Recycled Materials**. When the Department furnishes and allows the use of recycled materials or allows the Contractor to furnish recycled materials, the final blended product is subject to the requirements of Table 1 and the plans.

2.1.3.3. **Recycled Material Sources**. Department-owned recycled material is available to the Contractor only when shown on the plans. Return unused Department-owned recycled materials to the Department stockpile location designated by the Engineer unless otherwise shown on the plans.

The use of Contractor-owned recycled materials is allowed when shown on the plans. Contractor-owned surplus recycled materials remain the property of the Contractor. Remove Contractor-owned recycled materials from the project and dispose of them in accordance with federal, state, and local regulations before project acceptance. Do not intermingle Contractor-owned recycled material with Department-owned recycled material unless approved.

2.2. **Water**. Furnish water free of industrial wastes and other objectionable matter.

2.3. **Material Sources**. Expose the vertical faces of all strata of material proposed for use when non-commercial sources are used. Secure and process the material by successive vertical cuts extending through all exposed strata, when directed.

3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work.

3.1. Provide rollers in accordance with Item 210, "Rolling." Provide proof rollers in accordance with Item 216, "Proof Rolling," when required.

3.2. When ride quality measurement is required, provide a high speed or lightweight inertial profiler certified at the Texas A&M Transportation Institute. Provide equipment certification documentation. Display a current decal on the equipment indicating the certification expiration date.

4. CONSTRUCTION

Construct each layer uniformly, free of loose or segregated areas, and with the required density and moisture content. Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans or as directed.

Stockpile base material temporarily at an approved location before delivery to the roadway. Build stockpiles in layers no greater than 2 ft. thick. Stockpiles must have a total height between 10 and 16 ft. unless otherwise shown on the plans. After construction and acceptance of the stockpile, loading from the stockpile for delivery is allowed. Load by making successive vertical cuts through the entire depth of the stockpile.

Do not add or remove material from temporary stockpiles that require sampling and testing before delivery unless otherwise approved. Charges for additional sampling and testing required as a result of adding or removing material will be deducted from the Contractor's estimates.

Haul approved flexible base in clean trucks. Deliver the required quantity to each 100-ft. station or designated stockpile site as shown on the plans. Prepare stockpile sites as directed. When delivery is to the 100-ft. station, manipulate in accordance with the applicable Items.

4.1. **Preparation of Subgrade or Existing Base**. Remove or scarify existing asphalt concrete pavement in accordance with Item 105, "Removing Treated and Untreated Base and Asphalt Pavement," when shown on the plans or as directed. Shape the subgrade or existing base to conform to the typical sections shown on the plans or as directed.

When new base is required to be mixed with existing base, deliver, place, and spread the new flexible base in the required amount per station. Manipulate and thoroughly mix the new base with existing material to provide a uniform mixture to the specified depth before shaping.

Proof roll the roadbed in accordance with Item 216, "Proof Rolling," before pulverizing or scarifying when shown on the plans or directed. Correct soft spots as directed.

4.2. **Placing**. Spread and shape flexible base into a uniform layer with an approved spreader the same day as delivered unless otherwise approved. Construct layers to the thickness shown on the plans. Maintain the

shape of the course. Control dust by sprinkling, as directed. Correct or replace segregated areas as directed, at no additional expense to the Department.

Place successive base courses and finish courses using the same construction methods required for the first course.

4.3. **Compaction**. Compact using density control unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved. Bring each layer to the moisture content directed. When necessary, sprinkle the material in accordance with Item 204, "Sprinkling."

Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least 1/2 the width of the roller unit. Begin rolling at the low side and progress toward the high side on superelevated curves. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph as directed.

Rework, recompact, and refinish material that fails to meet or that loses required moisture, density, stability, or finish requirements before the next course is placed or the project is accepted. Continue work until specification requirements are met. Perform the work at no additional expense to the Department.

Before final acceptance, the Engineer will select the locations of tests and measure the flexible base depth in accordance with Tex-140-E. Correct areas deficient by more than 1/2 in. in thickness by scarifying, adding material as required, reshaping, recompacting, and refinishing at the Contractor's expense.

4.3.1. **Ordinary Compaction**. Roll with approved compaction equipment as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing approved material as required, reshaping, and recompacting.

4.3.2. **Density Control**. Compact to at least 100% of the maximum dry density determined by Tex-113-E, unless otherwise shown on the plans. Maintain moisture during compaction within ±2 percentage points of the optimum moisture content as determined by Tex-113-E. Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same day to the Engineer, unless otherwise shown on the plans or directed. Do not achieve density by drying the material after compaction.

The Engineer will determine roadway density and moisture content of completed sections in accordance with Tex-115-E. The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

4.4. **Finishing**. After completing compaction, clip, skin, or tight-blade the surface with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove loosened material and dispose of it at an approved location. Seal the clipped surface immediately by rolling with a pneumatic tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines, and grades as shown on the plans or as directed.

Correct grade deviations greater than 1/4 in. in 16 feet measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Correct by loosening and adding, or removing material. Reshape and re-compact in accordance with Section 247.4.3., "Compaction."

4.5. **Curing**. Cure the finished section until the moisture content is at least 2 percentage points below optimum or as directed before applying the next successive course or prime coat.

4.6. **Ride Quality**. This section applies to the final travel lanes that receive a 1 or 2 course surface treatment for the final surface, unless otherwise shown on the plans. Measure ride quality of the base course after placement of the prime coat and before placement of the surface treatment, unless otherwise approved. Use a certified profiler operator from the Department's MPL. When requested, furnish the Engineer documentation for the person certified to operate the profiler.

Provide all profile measurements to the Engineer in electronic data files within 3 days after placement of the prime coat using the format specified in Tex-1001-S. The Engineer will use Department software to evaluate longitudinal profiles to determine areas requiring corrective action. Correct 0.1-mi.sections having an average international roughness index (IRI) value greater than 100.0 in. per mile to an IRI value of 100.0 in. per mile or less for each wheelpath, unless otherwise shown on the plans.

Re-profile and correct sections that fail to maintain ride quality until placement of the next course, as directed. Correct re-profiled sections until specification requirements are met, as approved. Perform this work at no additional expense to the Department.

5. MEASUREMENT

Flexible base will be measured as follows:

- **Flexible Base (Complete In Place)**. The ton, square yard, or any cubic yard method.
- **Flexible Base (Roadway Delivery)**. The ton or any cubic yard method.
- **Flexible Base (Stockpile Delivery)**. The ton, cubic yard in vehicle, or cubic yard in stockpile.

Measurement by the cubic yard in final position and square yard is a plans quantity measurement. The quantity to be paid for is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

Measurement is further defined for payment as follows.

5.1. **Cubic Yard in Vehicle**. By the cubic yard in vehicles of uniform capacity at the point of delivery.

5.2. **Cubic Yard in Stockpile**. By the cubic yard in the final stockpile position by the method of average end areas.

5.3. **Cubic Yard in Final Position**. By the cubic yard in the completed and accepted final position. The volume of base course is computed in place by the method of average end areas between the original subgrade or existing base surfaces and the lines, grades, and slopes of the accepted base course as shown on the plans.

5.4. **Square Yard**. By the square yard of surface area in the completed and accepted final position. The surface area of the base course is based on the width of flexible base as shown on the plans.

5.5. **Ton**. By the ton of dry weight in vehicles as delivered. The dry weight is determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The Engineer will determine the moisture content in the material in accordance with Tex-103-E from samples taken at the time of weighing.

When material is measured in trucks, the weight of the material will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the types of work shown below. No additional payment will be made for thickness or width exceeding that shown on the typical section or provided on the plans for cubic yard in the final position or square yard measurement.

Sprinkling and rolling, except proof rolling, will not be paid for directly but will be subsidiary to this Item unless otherwise shown on the plans. When proof rolling is shown on the plans or directed, it will be paid for in accordance with Item 216, "Proof Rolling."

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade will be at the Contractor's expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade will be paid in accordance with pertinent Items or Article 4.4., "Changes in the Work."

6.1. **Flexible Base (Complete In Place)**. Payment will be made for the type and grade specified. For cubic yard measurement, "In Vehicle," "In Stockpile," or "In Final Position" will be specified. For square yard measurement, a depth will be specified. This price is full compensation for furnishing materials, temporary stockpiling, assistance provided in stockpile sampling and operations to level stockpiles for measurement, loading, hauling, delivery of materials, spreading, blading, mixing, shaping, placing, compacting, reworking, finishing, correcting locations where thickness is deficient, curing, furnishing scales and labor for weighing and measuring, and equipment, labor, tools, and incidentals.

6.2. **Flexible Base (Roadway Delivery)**. Payment will be made for the type and grade specified. For cubic yard measurement, "In Vehicle," "In Stockpile," or "In Final Position" will be specified. The unit price bid will not include processing at the roadway. This price is full compensation for furnishing materials, temporary stockpiling, assistance provided in stockpile sampling and operations to level stockpiles for measurement, loading, hauling, delivery of materials, furnishing scales and labor for weighing and measuring, and equipment, labor, tools, and incidentals.

6.3. **Flexible Base (Stockpile Delivery)**. Payment will be made for the type and grade specified. For cubic yard measurement, "In Vehicle" or "In Stockpile" will be specified. The unit price bid will not include processing at the roadway. This price is full compensation for furnishing and disposing of materials, preparing the stockpile area, temporary or permanent stockpiling, assistance provided in stockpile sampling and operations to level stockpiles for measurement, loading, hauling, delivery of materials to the stockpile, furnishing scales and labor for weighing and measuring, and equipment, labor, tools, and incidentals.

Item 260
Lime Treatment (Road-Mixed)

1. DESCRIPTION

Mix and compact lime, water, and subgrade or base (with or without asphaltic concrete pavement) in the roadway.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed material sources and of changes to material sources. Obtain verification from the Engineer that the specification requirements are met before using the sources. The Engineer may sample and test project materials at any time before compaction. Use Tex-100-E for material definitions.

2.1. **Lime**. Furnish lime that meets the requirements of DMS-6350 "Lime and Lime Slurry," and DMS-6330, "Pre-Qualification of Lime Sources." Use hydrated lime, commercial lime slurry, quicklime, or carbide lime slurry as shown on the plans. Do not use quicklime when sulfates are present in quantities greater than 3,000 ppm. When furnishing quicklime, provide it in bulk.

2.2. **Subgrade**. The Engineer will determine the sulfate content of the existing subgrade in accordance with Tex-145-E and organic content in accordance with Tex-148-E before lime treatment begins. Suspend operations when material to be treated has a sulfate content greater than 7,000 ppm or an organic content greater than 1.0% and proceed as directed.

2.3. **Flexible Base**. Unless otherwise shown on the plans, furnish base material that meets the requirements of Item 247, "Flexible Base," for the type and grade shown on the plans, before the addition of lime.

2.4. **Water**. Furnish water free of industrial wastes and other objectionable material.

2.5. **Asphalt**. When asphalt or emulsion is permitted for curing purposes, furnish materials that meet the requirements of Item 300, "Asphalts, Oils, and Emulsions," as shown on the plans or as directed.

2.6. **Mix Design**. The Engineer will determine the target lime content and optimum moisture content in accordance with Tex-121-E or prior experience with the project materials. The Contractor may propose a mix design developed in accordance with Tex-121-E. The Engineer will use Tex-121-E to verify the Contractor's proposed mix design before acceptance. Reimburse the Department for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor. Limit the amount of recycled asphalt pavement to no more than 50% of the mix unless otherwise shown on the plans or directed.

3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work. Provide rollers in accordance with Item 210, "Rolling." Provide proof rollers in accordance with Item 216, "Proof Rolling," when required.

3.1. **Storage Facility**. Store quicklime and dry hydrated lime in closed, weatherproof containers.

3.2. **Slurry Equipment**. Use slurry tanks equipped with agitation devices to slurry hydrated lime or quicklime on the project or other approved location. The Engineer may approve other slurrying methods.

3.3. Provide a pump for agitating the slurry when the distributor truck is not equipped with an agitator. Equip the distributor truck with a sampling device in accordance with Tex-600-J, Part I, when using commercial lime slurry or carbide lime slurry.

3.4. **Hydrated Lime Distribution Equipment**. Provide equipment to spread lime evenly across the area to be treated. Provide equipment with a rotary vane feeder to spread lime, when shown on the plans.

3.5. **Pulverization Equipment**. Provide pulverization equipment that:

- cuts and pulverizes material uniformly to the proper depth with cutters that plane to a uniform surface over the entire width of the cut,
- provides a visible indication of the depth of cut at all times, and
- uniformly mixes the materials.

4. CONSTRUCTION

Construct each layer uniformly, free of loose or segregated areas, and with the required density and moisture content. Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans or as directed.

4.1. **Preparation of Subgrade or Existing Base for Treatment**. Before treating, remove existing asphalt pavement in accordance with Item 105, "Removing Treated and Untreated Base and Asphalt Pavement," when shown on the plans or as directed. Shape existing material in accordance with applicable bid items to conform to typical sections shown on the plans and as directed.

Unless otherwise approved, proof roll the roadbed in accordance with Item 216, "Proof Rolling," before pulverizing or scarifying existing material. Correct soft spots as directed.

When material is imported from a borrow source, notify the Engineer of the location of the borrow source well in advance to allow time for testing and approval to avoid delay to the project. Stockpile as directed. The Engineer will test the borrow source and determine the sulfate and organic contents. When the borrow source has a sulfate content greater than 3,000 ppm or an organic content greater than 1.0%, proceed as directed.

When new base material is required to be mixed with existing base, deliver, place, and spread the new material in the required amount per station. Manipulate and thoroughly mix new base with existing material to provide a uniform mixture to the specified depth before shaping.

4.2. **Pulverization**. Pulverize or scarify existing material after shaping so that 100% passes a 2-1/2 in. sieve. If the material cannot be uniformly processed to the required depth in a single pass, excavate and windrow the material to expose a secondary grade to achieve processing to plan depth.

4.3. **Application of Lime**. Uniformly apply lime using dry or slurry placement as shown on the plans or as directed. Add lime at the percentage determined in Section 260.2.6., "Mix Design." Apply lime only on an area where mixing can be completed during the same working day.

Start lime application only when the air temperature is at least 35°F and rising or is at least 40°F. The temperature will be taken in the shade and away from artificial heat. Suspend application when the Engineer determines that weather conditions are unsuitable.

Minimize dust and scattering of lime by wind. Do not apply lime when wind conditions, in the opinion of the Engineer, cause blowing lime to become dangerous to traffic or objectionable to adjacent property owners. When pebble grade quicklime is placed dry, mix the material and lime thoroughly at the time of lime application. Use of quicklime can be dangerous. Inform users of the recommended precautions for handling and storage.

4.3.1. **Dry Placement**. Before applying lime, bring the prepared roadway to approximately 2 percentage points above optimum moisture content. When necessary, sprinkle in accordance with Item 204, "Sprinkling." Distribute the required quantity of hydrated lime or pebble grade quicklime with approved equipment. Only hydrated lime may be distributed by bag. Do not use a motor grader to spread hydrated lime.

4.3.2. **Slurry Placement**. Provide slurry free of objectionable materials, at or above the minimum dry solids content, and with a uniform consistency that will allow ease of handling and uniform application. Deliver commercial lime slurry or carbide lime slurry to the jobsite, or use hydrated lime or quicklime to prepare lime slurry at the jobsite or other approved location, as specified. When dry quicklime is applied as slurry, use 80% of the amount shown on the plans.

Distribute slurry uniformly by making successive passes over a measured section of roadway until the specified lime content is reached. Uniformly spread the residue from quicklime slurry over the length of the roadway being processed, unless otherwise directed.

4.4. **Mixing**. Begin mixing within 6 hr. of application of lime. Hydrated lime exposed to the open air for 6 hr. or more between application and mixing, or that experiences excessive loss due to washing or blowing, will not be accepted for payment.

Thoroughly mix the material and lime using approved equipment. When treating subgrade, bring the moisture content above the optimum moisture content to insure adequate chemical reaction of the lime and subgrade materials. Allow the mixture to mellow for 1 to 4 days, as directed. When pebble grade quicklime is used, allow the mixture to mellow for 2 to 4 days, as directed. Sprinkle the treated materials during the mixing and mellowing operation, as directed, to achieve adequate hydration and proper moisture content. When the material to be treated has a sulfate content greater than 3,000 ppm but less than or equal to 7,000 ppm, mellow for a minimum of 7 days. Maintain in a continuously moist condition by sprinkling in accordance with Item 204, "Sprinkling." After mellowing, resume mixing until a homogeneous, friable mixture is obtained. After mixing, the Engineer may sample the mixture at roadway moisture and test in accordance with Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 1.

Table 1
Gradation Requirements (Minimum % Passing)

Sieve Size	Base	Subgrade
1-3/4"	100	100
3/4"	85	85
#4	–	60

4.5. **Compaction**. Compact the mixture using density control, unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved. Bring each layer to the moisture content directed. Sprinkle the treated material in accordance with Item 204, "Sprinkling" or aerate the treated material to adjust the moisture content during compaction so that it is no more than 1.0 percentage points below optimum and 2.0 percentage points above optimum as determined by Tex-121-E. Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same day, unless otherwise shown on the plans or directed.

Begin rolling longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least 1/2 the width of the roller unit. On superelevated curves, begin rolling at the low side and progress toward the high side. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph as directed.

Before final acceptance, the Engineer will select the locations of tests in each unit and measure the treated depth in accordance with Tex-140-E. Correct areas deficient by more than 1/2 in. in thickness or more than 1/2% in target lime content by adding lime as required, reshaping, recompacting, and refinishing at the Contractor's expense.

Rework, recompact, and refinish material that fails to meet or that loses required moisture, density, stability, or finish before the next course is placed or the project is accepted. Continue work until specification

requirements are met. Rework in accordance with Section 260.4.6., "Reworking a Section." Perform the work at no additional expense to the Department.

4.5.1. **Ordinary Compaction**. Roll with approved compaction equipment, as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.

4.5.2. **Density Control**. The Engineer will determine roadway density and moisture content of completed sections in accordance with Tex-115-E. The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

4.5.2.1. **Subgrade**. Compact to at least 95% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans.

4.5.2.2. **Base**. Compact the bottom course to at least 95% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans. Compact subsequent courses treated under this Item to at least 98% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans.

4.6. **Reworking a Section**. When a section is reworked within 72 hr. after completion of compaction, rework the section to provide the required density. When a section is reworked more than 72 hr. after completion of compaction, add additional lime at 25% of the percentage determined in Section 260.2.6., "Mix Design." Reworking includes loosening, adding material or removing unacceptable material if necessary, mixing as directed, compacting, and finishing. When density control is specified, determine a new maximum density of the reworked material in accordance with Tex-121-E, and compact to at least 95% of this density.

4.7. **Finishing**. Immediately after completing compaction of the final course, clip, skin, or tight-blade the surface of the lime-treated material with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove loosened material and dispose of at an approved location. Roll the clipped surface immediately with a pneumatic tire roller until a smooth surface is attained. Add small amounts of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines, and grades shown on the plans or as directed.

Finish grade of constructed subgrade to within 0.1 ft. in the cross-section and 0.1 ft. in 16 ft. measured longitudinally.

Correct grade deviations of constructed base greater than 1/4 in. in 16 ft. measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Remove excess material, reshape, and roll with a pneumatic-tire roller. Correct as directed if material is more than 1/4 in. low. Do not surface patch. The 72-hr. time limit required for completion of placement, compaction, and finishing does not apply to finishing required just before applying the surface course.

4.8. **Curing**. Cure for the minimum number of days shown in Table 2 by sprinkling in accordance with Item 204, "Sprinkling," or by applying an asphalt material at a rate of 0.05 to 0.20 gal. per square yard as directed. Maintain moisture during curing. Upon completion of curing, maintain the moisture content in accordance with Section 132.3.5., "Maintenance of Moisture and Reworking," for subgrade and Section 247.4.5., "Curing" for bases before placing subsequent courses. Do not allow equipment on the finished course during curing except as required for sprinkling, unless otherwise approved. Apply seals or additional courses within 14 calendar days of final compaction.

Table 2
Minimum Curing Requirements before Placing Subsequent Courses[1]

Untreated Material	Curing (Days)
PI ≤ 35	2
PI > 35	5

1. Subject to the approval of the Engineer. Proof rolling may be required as an indicator of adequate curing.

5. MEASUREMENT

5.1. **Lime**. When lime is furnished in trucks, the weight of lime will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."

When lime is furnished in bags, indicate the manufacturer's certified weight. Bags varying more than 5% from that weight may be rejected. The average weight of bags in any shipment, as determined by weighing 10 bags taken at random, must be at least the manufacturer's certified weight.

5.1.1. **Hydrated Lime**.

5.1.1.1. **Dry**. Lime will be measured by the ton (dry weight).

5.1.1.2. **Slurry**. Lime slurry will be measured by the ton (dry weight) of the hydrated lime used to prepare the slurry at the jobsite.

5.1.2. **Commercial Lime Slurry**. Lime slurry will be measured by the ton (dry weight) as calculated from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.

5.1.3. **Quicklime**.

5.1.3.1. **Dry**. Lime will be measured by the ton (dry weight) of the quicklime.

5.1.3.2. **Slurry**. Lime slurry will be measured by the ton (dry weight) of the quicklime used to prepare the slurry multiplied by a conversion factor of 1.28 to give the quantity of equivalent hydrated lime, which will be the basis of payment.

5.1.4. **Carbide Lime Slurry**. Lime slurry will be measured by the ton (dry weight) as calculated from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.

5.2. **Lime Treatment**. Lime treatment will be measured by the square yard of surface area. The dimensions for determining the surface area are established by the widths shown on the plans and the lengths measured at placement.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid in accordance with Section 260.6.1., "Lime," and Section 260.6.2., "Lime Treatment."

Furnishing and delivering new base will be paid for in accordance with Section 247.6.2., "Flexible Base (Roadway Delivery)." Mixing, spreading, blading, shaping, compacting, and finishing new or existing base material will be paid for in accordance with Section 260.6.2., "Lime Treatment." Removal and disposal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.4., "Changes in the Work."

Sprinkling and rolling, except proof rolling, will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans. When proof rolling is shown on the plans or directed by the Engineer, it will be paid for in accordance with Item 216, "Proof Rolling."

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade or existing base will be at the Contractor's expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade or existing base will be paid for in accordance with pertinent Items or Article 4.4., "Changes in the Work."

Where subgrade to be treated under this Contract has sulfates greater than 7,000 ppm, work will be paid for in accordance with Article 4.4., "Changes in the Work."

Asphalt used solely for curing will not be paid for directly but will be subsidiary to this Item. Asphalt placed for curing and priming will be paid for under Item 310, "Prime Coat."

6.1. **Lime**. Lime will be paid for at the unit price bid for "Lime" of one of the following types:

- Hydrated Lime (Dry),
- Hydrated Lime (Slurry),
- Commercial Lime Slurry,
- Quicklime (Dry),
- Quicklime (Slurry), or
- Carbide Lime Slurry.

This price is full compensation for materials, delivery, equipment, labor, tools, and incidentals.

Lime used for reworking a section in accordance with Section 260.4.6., "Reworking a Section," will not be paid for directly but will be subsidiary to this Item.

6.2. **Lime Treatment**. Lime treatment will be paid for at the unit price bid for "Lime Treatment (Existing Material)," "Lime Treatment (New Base)," or "Lime Treatment (Mixing Existing Material and New Base)," for the depth specified. No payment will be made for thickness or width exceeding that shown on the plans. This price is full compensation for shaping existing material, loosening, mixing, pulverizing, spreading, applying lime, compacting, finishing, curing, curing materials, blading, shaping and maintaining shape, replacing mixture, disposing of loosened materials, processing, hauling, preparing secondary subgrade, water, equipment, labor, tools, and incidentals.

Item 263
Lime Treatment (Plant-Mixed)

1. DESCRIPTION

Construct a base course composed of a mixture of flexible base, hydrated lime, and water, mixed in an approved plant.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of proposed sources of materials and of changes to material sources. The Engineer will verify that the requirements of this Item are met before the sources can be used. The Engineer may sample and test project materials at any time before compaction. Use Tex-100-E for material definitions.

2.1. **Lime**. Furnish hydrated lime that meets the requirements of DMS-6350, "Lime and Lime Slurry," and DMS-6330, "Pre-Qualification of Lime Sources."

2.2. **Flexible Base**. Furnish base material that meets the requirements of Item 247, "Flexible Base," for the type and grade shown on the plans, before the addition of lime.

2.3. **Water**. Furnish water free of industrial wastes and other objectionable material.

2.4. **Asphalt**. Furnish asphalt or emulsion when permitted for curing purposes that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," as shown on the plans or as directed.

2.5. **Mix Design**. Using the materials proposed for the project, the Engineer will determine the target lime content and optimum moisture content necessary to produce the required stabilized mixture. The mix will be designed in accordance with Tex-121-E. The Contractor may propose a mix design developed in accordance with Tex-121-E. The Engineer will use Tex-121-E to verify the Contractor's proposed mix design before acceptance. Reimburse the Department for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor. Limit the amount of asphalt concrete pavement to no more than 50% of the mix when treating existing materials unless otherwise shown on the plans or directed.

3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work. Provide rollers in accordance with Item 210, "Rolling." Provide proof rollers in accordance with Item 216, "Proof Rolling," when required.

3.1. **Storage Facility**. Store hydrated lime in closed weatherproof containers.

3.2. **Mixing Plant**. Provide a stationary pugmill that uniformly mixes lime, water, and base material in the specified proportions. Obtain approval before providing weigh-batch or continuous mixers. Equip plants with automatic proportioning and metering devices. Ensure weighing and measuring equipment complies with Item 520, "Weighing and Measuring Equipment." Provide calibration documentation.

3.3. **Spreader Equipment**. Provide equipment that will spread the lime-treated mixture in a uniform layer in one pass when shown on the plans. Equip spreaders with electronic grade controls when shown on the plans.

4. CONSTRUCTION

Construct each layer uniformly, free of loose or segregated areas, and with the required density and moisture content. Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans or as directed. Complete placing, compacting, and finishing within 72 hr. after the lime is added to the base material.

Start lime operations only when the air temperature is at least 35°F and rising or is at least 40°F. The temperature will be taken in the shade and away from artificial heat. Suspend operations when the Engineer determines that weather conditions are unsuitable.

4.1. **Mixing**. Thoroughly mix materials in the proportions designated on the mix design, in a plant that meets the requirements of Section 263.3.2., "Mixing Plant." Mix at optimum moisture content, unless otherwise directed, until a homogeneous mixture is obtained.

4.2. **Placing**. Place lime-treated base on a subgrade or base prepared in accordance with details shown on the plans. Bring the prepared roadway to the moisture content directed. Haul lime-treated base to the roadway in clean trucks and begin placement immediately. Spread and shape in a uniform layer with an approved spreader. Construct individual layers to the thickness shown on the plans, the same day as delivered, unless otherwise approved. Do not place lifts exceeding a compacted depth of 8 in. unless otherwise shown on the plans. Maintain the shape of the course by blading. Correct or replace segregated areas as directed, at no additional expense to the Department.

Construct vertical joints between segmented areas of lime-treated base. The vertical face may be created by using a header or by cutting back the face to approximately vertical. Place successive base courses using the same methods as the first course. Offset construction joints by at least 6 in.

4.3. **Compaction**. Compact the mixture using density control immediately after placing unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved. Bring each layer to the moisture content directed. Sprinkle the treated material when necessary in accordance with Item 204, "Sprinkling." Determine the moisture content of the mixture at the beginning and during compaction in accordance with Tex-103-E.

Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least 1/2 the width of the roller unit. Begin rolling at the low side and progress toward the high side on superelevated curves. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph, as directed.

Rework, recompact, and refinish material that fails to meet or that loses required moisture, density, stability, or finish before the next course is placed or the project is accepted. Continue work until specification requirements are met. Rework in accordance with Section 263.4.4., "Reworking a Section." Perform the work at no additional expense to the Department.

4.3.1. **Ordinary Compaction**. Roll with approved compaction equipment as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.

4.3.2. **Density Control**. Compact the bottom course to at least 95% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans. Compact subsequent courses treated under this Item to at least 98% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans.

The Engineer will determine roadway density and moisture content of completed sections in accordance with Tex-115-E. The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

4.4. **Reworking a Section**. Rework the section, without adding additional lime, to provide the required density when a section is reworked within 72 hr. after completion of compaction. Add additional lime at the rate of 25% of the percentage determined in Section 263.2.5., "Mix Design," when a section is reworked more than 72 hr. after the completion of compaction. Reworking includes loosening, adding material or removing unacceptable material if necessary, road-mixing as directed, compacting, and finishing. Determine the new maximum density of the reworked material in accordance with Tex-121-E when density control is specified, and compact to at least 95% of this density. The Contractor has the option of removing the failing material and replacing it with acceptable lime-treated mix.

4.5. **Finishing**. Clip, skin, or tight-blade the surface of the lime-treated material with a maintainer to a depth of approximately 1/4 in immediately after completing compaction of the final course. Remove loosened material and dispose of it at an approved location. Seal the clipped surface immediately by rolling with a pneumatic-tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines, and grades shown on the plans or as directed.

Correct grade deviations greater than 1/4 in. in 16 ft. measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Remove excess material, reshape, and roll with a pneumatic-tire roller. Correct as directed if material is more than 1/4 in. low. Do not surface patch. The 72-hr. time limit required for completion of placement, compaction, and finishing does not apply to finishing required just before applying the surface course.

4.6. **Curing**. Cure for at least 7 days, unless otherwise approved, by sprinkling in accordance with Item 204, "Sprinkling," or by applying an asphalt material at a rate of 0.05 to 0.20 gal. per square yard as directed. Maintain moisture during curing. Continue curing until placing another course or opening to traffic. Open to traffic as directed. Do not allow equipment on the finished course during curing except as required for sprinkling, unless otherwise approved. Apply seals or additional courses within 14 days of final compaction.

5. MEASUREMENT

Lime-treated base will be measured by the cubic yard, square yard, or ton, as a composite mixture of lime, flexible base, and recycled materials.

Measurement by the cubic yard in final position and by the square yard is plans quantity measurement. The quantity to be paid for is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

Measurement is further defined for payment as follows:

5.1. **Cubic Yard in Vehicles**. Lime-treated base will be measured by the cubic yard in vehicles as delivered on the road.

5.2. **Cubic Yard in Final Position**. Lime-treated base will be measured by the cubic yard in its final position. The volume of each course will be computed in-place between the original subgrade surfaces and the lines, grades, and slopes of the accepted base course as shown on the plans and calculated by the method of average end areas.

5.3. **Square Yard**. Lime-treated base will be measured by the square yard of surface area. The dimensions for determining the surface area are established by the dimensions shown on the plans.

5.4. **Ton**. Lime-treated base will be measured by the ton (dry weight) in vehicles as delivered on the road. The dry weight is determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The Engineer will determine the moisture content in the material in accordance with Tex-103-E, from samples taken at the time of weighing.

When material is measured in trucks, the weight of the material will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Lime Treatment (Plant-Mixed)," of the flexible base type, grade, and thickness (for square yard measurement) specified. For cubic yard measurement, "In Vehicle" or "Final Position" will be specified. This price is full compensation for furnishing and disposing of materials (including lime and base); storing, mixing, hauling, placing, sprinkling, compacting, finishing, curing, and maintaining and reworking of treated base; and equipment, labor, tools, and incidentals.

Sprinkling and rolling, except proof rolling, will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans. When proof rolling is shown on the plans or directed by the Engineer, it will be paid for in accordance with Item 216, "Proof Rolling."

Where subgrade or base courses are constructed under this Contract, correction of soft spots will be at the Contractor's expense. Where subgrade or base is not constructed under this Contract, correction of soft spots will be in accordance with pertinent Items or Article 4.4., "Changes in the Work."

Asphalt used solely for curing will not be paid for directly but will be subsidiary to this Item. Asphalt placed for curing and priming will be paid for under Item 310, "Prime Coat."

Removal and disposal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.4., "Changes in the Work."

6.1. **Thickness Measurement for Cubic Yard In Final Position and Square Yard Payment Adjustment**. Before final acceptance, the Engineer will select the locations of tests within each unit and measure the treated base depths in accordance with Tex-140-E.

6.1.1. **Units for Payment Adjustment**.

6.1.1.1. **Roadways and Shoulders**. Units for applying a payment adjustment for thickness to roadways and shoulders are defined as 1,000 ft. of treated base in each placement width. The last unit in each placement width will be 1,000 ft. plus the fractional part of 1,000 ft. remaining. Placement width is the width between longitudinal construction joints. For widening, the placement width is the average width placed of the widened section that is deficient in thickness.

6.1.1.2. **Ramps and Other Areas**. Units are defined as 2,000 sq. yd. or fraction thereof for establishing an adjusted unit price for ramps, intersections, irregular sections, crossovers, entrances, partially completed units, transitions to ramps, and other areas designated by the Engineer.

6.1.2. **Price Adjustments of Deficient Areas**.

6.1.2.1. **Thickness Deficiency ≤ 1.0 in**. Table 1 will govern the price adjustment for each unit with deficient areas ≤ 1.0 in.

Table 1
Measurements and Price Adjustment for Each Unit

Thickness Deficiency	Minimum Number of Additional Measurements	Average Thickness Deficiency of 3 Measurements	Price Adjustment
≤ 0.5 in.	None	N/A	Full Payment
> 0.5 in.	2	≤ 0.5 in.	Full Payment
		> 0.5 in. and ≤ 0.8 in.	75% Payment
		> 0.8 in. and ≤ 1.0 in.	50% Payment
		> 1.0 in.	In accordance with Section 263.6.1.2.2., "Thickness Deficiency > 1.0 in."

6.1.2.2. **Thickness Deficiency > 1.0 in.** Remove and replace areas of treated base found deficient in thickness by more than 1.0 in., unless otherwise approved. Take exploratory measurements at 50-ft. intervals parallel to the centerline in each direction from the deficient measurement until a measurement is not deficient by more than 1.0 in. If, in the judgment of the Engineer, the area of deficient thickness should not be reworked, there will be no payment for the area left in place. The minimum limit of non-pay will be 100 ft.

6.2. **Excess Thickness and Width**. For cubic yard in final position and square yard measurement, no additional payment will be made for thickness or width exceeding that shown on the plans.

Item 275
Cement Treatment (Road-Mixed)

1. DESCRIPTION

Mix and compact cement, water, and subgrade or base (with or without asphalt concrete pavement) in the roadway.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed material sources and of changes to material sources. The Engineer will verify that the specification requirements are met before the sources can be used. The Engineer may sample and test project materials at any time before compaction. Use Tex-100-E for material definitions.

2.1. **Cement**. Furnish hydraulic cement that meets the requirements of DMS-4600, "Hydraulic Cement," and the Department's *Hydraulic Cement Quality Monitoring Program* (HCQMP). Sources not on the HCQMP will require testing and approval before use.

2.2. **Subgrade**. The Engineer will determine the sulfate content in accordance with Tex-145-E and organic content in accordance with Tex-148-E before cement treatment begins. Suspend operations when material to be treated has a sulfate content greater than 7,000 ppm or an organic content greater than 1.0% and proceed as directed.

2.3. **Flexible Base**. Unless otherwise shown on the plans, furnish base material that meets the requirements of Item 247, "Flexible Base," for the type and grade shown on the plans, before the addition of cement.

2.4. **Water**. Furnish water free of industrial waste and other objectionable material.

2.5. **Asphalt**. When permitted for curing purposes, furnish asphalt or emulsion that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," as shown on the plans or directed.

2.6. **Mix Design**. The Engineer will determine the target cement content and optimum moisture content to produce a stabilized mixture that meets the strength requirements shown on the plans. The mix will be designed in accordance with Tex-120-E or will be based on prior experience with the project materials. The Contractor may propose a mix design developed in accordance with Tex-120-E. Meet strength requirements when shown on the plans. The Engineer will use Tex-120-E to verify the Contractor's proposed mix design before acceptance. Reimburse the Department for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor. Limit the amount of recycled asphalt pavement to no more than 50% of the mix unless otherwise shown on the plans or directed.

3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work. Provide rollers in accordance with Item 210, "Rolling." Provide proof rollers in accordance with Item 216, "Proof Rolling," when required.

3.1. **Cement Storage Facility**. Store cement in closed, weatherproof containers.

3.2. **Cement Slurry Equipment**. Use slurry tanks equipped with agitation devices to slurry cement on the project or other approved location. The Engineer may approve other slurrying methods. Provide a pump for agitating

the slurry when the distributor truck is not equipped with an agitator. Equip the distributor truck with an approved sampling device.

3.3. **Dry Cement Distribution Equipment**. Provide equipment to spread cement evenly across the area to be treated. Provide equipment with a rotary vane feeder when shown on the plans.

3.4. **Pulverization Equipment**. Provide pulverization equipment that:

- cuts and pulverizes material uniformly to the proper depth with cutters that will plane to a uniform surface over the entire width of the cut,
- provides a visible indication of the depth of cut at all times, and
- uniformly mixes the materials.

4. CONSTRUCTION

Construct each layer uniformly, free of loose or segregated areas and with the required density and moisture content. Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans or as directed.

4.1. **Preparation of Subgrade or Existing Base for Treatment**. Before treating, remove existing asphalt concrete pavement in accordance with pertinent Items and the plans or as directed. Shape existing material in accordance with applicable bid items to conform to the typical sections shown on the plans and as directed.

When shown on the plans or directed, proof roll the roadbed in accordance with Item 216, "Proof Rolling," before pulverizing or scarifying existing material. Correct soft spots as directed.

Provide the borrow source location well in advance when material is imported, to allow time for testing and approval to avoid delay to the project. Stockpile as directed. The Engineer will test the borrow source and determine the sulfate and organic contents. When the borrow source has a sulfate content greater than 3,000 ppm or an organic content greater than 1.0%, proceed as directed.

When new base is required to be mixed with existing base, deliver, place, and spread the new material in the required amount per station. Manipulate and thoroughly mix new base with existing material to provide a uniform mixture to the specified depth before shaping.

4.2. **Pulverization**. Pulverize or scarify existing material after shaping so that 100% passes a 2-1/2 in. sieve. If the material cannot be uniformly processed to the required depth in a single pass, excavate and windrow the material to expose a secondary grade to achieve processing to plan depth.

4.3. **Application of Cement**. Uniformly apply cement using dry placement unless otherwise shown on the plans. Add cement at the percentage determined in Section 275.2.6., "Mix Design." Apply cement only on an area where mixing, compacting, and finishing can be completed during the same working day.

Start cement application only when the air temperature is at least 35°F and rising or is at least 40°F. The temperature will be taken in the shade and away from artificial heat. Suspend application when the Engineer determines that weather conditions are unsuitable.

4.3.1. **Dry Placement**. Before applying cement, bring the prepared roadway to approximately optimum moisture content. When necessary, sprinkle in accordance with Item 204, "Sprinkling." Distribute the required quantity of dry cement with approved equipment. Minimize dust and scattering of cement by wind. Do not apply cement when wind conditions, in the opinion of the Engineer, cause blowing cement to become dangerous to traffic or objectionable to adjacent property owners.

4.3.2. **Slurry Placement**. Mix the required quantity of cement with water, as approved. Provide slurry free of objectionable materials and with a uniform consistency that can be easily applied. Agitate the slurry

continuously. Apply slurry within 2 hours of adding water and when the roadway is at a moisture content drier than optimum. Distribute slurry uniformly by making successive passes over a measured section of the roadway until the specified cement content is reached.

4.4. **Mixing**. Thoroughly mix the material and cement using approved equipment. Mix until a homogeneous mixture is obtained. Sprinkle the treated materials during the mixing operation, as directed, to maintain optimum mixing moisture. Spread and shape the completed mixture in a uniform layer.

After mixing, the Engineer may sample the mixture at roadway moisture and test in accordance with Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 1. When strength requirements are shown on the plans, the Engineer may sample the mixture to verify strength in accordance with Tex-120-E and adjust cement content to achieve the target strength for work going forward.

Table 1
Gradation Requirements Minimum % Passing

Sieve Size	Base	Subgrade
1-3/4"	100	100
3/4"	85	85
#4	–	60

4.5. **Compaction**. Compact the mixture in one lift using density control unless otherwise shown on the plans. Complete compaction within 2 hours after the application of water to the mixture of material and cement.

Sprinkle the treated material in accordance with Item 204, "Sprinkling," or aerate the treated material to adjust the moisture content during compaction so that it is within 2.0 percentage points of optimum as determined by Tex-120-E. Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same day to the Engineer, unless otherwise shown on the plans or directed. Adjust operations as required.

Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half the width of the roller unit. On superelevated curves, begin rolling at the low side and progress toward the high side. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph, as directed.

Before final acceptance, the Engineer will select the locations of tests in each unit and measure the treated depth in accordance with Tex-140-E. Correct areas deficient by more than 1/2 in. in thickness or more than 1/2% in target cement content by adding cement as required, reshaping, re-compacting, and refinishing at the Contractor's expense.

Remove or rework areas that lose required stability, compaction, or finish, as directed. When a section is reworked more than 4 hr. after completion of compaction, add additional cement as directed. Provide additional work and material at no additional cost to the Department.

4.5.1. **Ordinary Compaction**. Roll with approved compaction equipment, as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.

4.5.2. **Density Control**. Achieve at least 95% of the maximum density determined in accordance with Tex-120-E when compaction is complete. The Engineer will determine roadway density and moisture content in accordance with Test Method Tex-115-E. The Engineer may verify strength in accordance with Tex-120-E and adjust cement content to achieve the target strength for work going forward. Remove material that does not meet density requirements or rework by adding the target cement content, reshaping, recompacting, and refinishing at the Contractor's expense.

The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

4.6. **Finishing**. Immediately after completing compaction, clip, skin, or tight-blade the surface of the cement treated material with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove loosened material and dispose of it at an approved location. Roll the clipped surface immediately with a pneumatic-tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines and grades shown on the plans or as directed.

Finish grade of constructed subgrade to within 0.1 ft. in the cross-section and 0.1 ft. in 16 ft. measured longitudinally.

Correct grade deviations of constructed base greater than 1/4 in. in 16 ft. measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Remove excess material, reshape, and roll with a pneumatic-tire roller. Correct as directed if material is more than 1/4 in. low. Do not surface patch.

4.7. **Microcracking**. When shown on the plans, maintain moisture content of the finished cement treated base for a period of 24 to 48 hr. During this time, but not sooner than 24 hr., roll the finished course with a vibratory roller to induce microcracking. The vibratory roller must be in accordance with Item 210, "Rolling," with a static weight equal to or more than 12 tons and the vibratory drum must be not less than 20 in. wide. The roller must travel at a speed of 2 mph, vibrating at maximum amplitude, and make 2 to 4 passes with 100% coverage exclusive of the outside 1 ft. of the surface crown, unless otherwise directed by the Engineer. Additional passes may be required to achieve the desired crack pattern as directed. Notify the Engineer 24 hours before the microcracking begins.

4.8. **Curing**. Cure for at least 3 days by sprinkling in accordance with Item 204, "Sprinkling," or by applying an asphalt material at the rate of 0.05 to 0.20 gal. per square yard, as shown on the plans or directed. When a section is microcracked, cure section for an additional 2 days after microcracking. Maintain the moisture content during curing at no lower than 2 percentage points below optimum. Continue curing until placing another course.

5. MEASUREMENT

5.1. **Cement**. Cement will be measured by the ton (dry weight). When cement is furnished in trucks, the weight of cement will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."

When cement is furnished in bags, indicate the manufacturer's certified weight. Bags varying more than 5% from that weight may be rejected. The average weight of bags in any shipment, as determined by weighing 10 bags taken at random, must be at least the manufacturer's certified weight.

Cement slurry will be measured by the ton (dry weight) of the cement used to prepare the slurry at the jobsite or from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.

5.2. **Cement Treatment**. Cement treatment will be measured by the square yard of surface area. The dimensions for determining the surface areas are established by the widths shown on the plans and lengths measured at placement.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid in accordance with Section 275.5.1., "Cement," and Section 275.5.2., "Cement Treatment."

Furnishing and delivering new base will be paid for in accordance with Section 247.6.2., "Flexible Base (Roadway Delivery)." Mixing, spreading, blading, shaping, compacting, and finishing new or existing base material will be paid for under Section 275.6.2., "Cement Treatment." Removal and disposal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.4., "Changes in the Work."

Sprinkling and rolling, except proof-rolling, will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans. When proof-rolling is shown on the plans or directed by the Engineer, it will be paid for in accordance with Item 216, "Proof Rolling."

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade or existing base will be at the Contractor's expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade or existing base will be in accordance with pertinent Items or Article 4.4., "Changes in the Work."

Where subgrade to be treated under this Contract has sulfates greater than 7,000 ppm, work will be paid for in accordance with Article 4.4., "Changes in the Work."

Asphalt used solely for curing will not be paid for directly but will be subsidiary to this Item. Asphalt placed for the purpose of curing and priming will be paid for under Item 310, "Prime Coat."

6.1. **Cement**. Cement will be paid for at the unit price bid for "Cement." This price is full compensation for materials, delivery, equipment, labor, tools, and incidentals.

6.2. **Cement Treatment**. Cement treatment will be paid for at the unit price bid for "Cement Treatment (Existing Material)," "Cement Treatment (New Base)," or "Cement Treatment (Mixing Existing Material and New Base)," for the depth specified. No payment will be made for thickness or width exceeding that shown on the plans. This price is full compensation for shaping existing material, loosening, mixing, pulverizing, spreading, applying cement, compacting, microcracking, finishing, curing, curing materials, blading, shaping and maintaining shape, replacing mixture, disposing of loosened materials, processing, hauling, preparing secondary subgrade, water, equipment, labor, tools, and incidentals.

Item 276
Cement Treatment (Plant-Mixed)

1. DESCRIPTION

Construct a base course composed of flexible base, hydraulic cement, and water, mixed in an approved plant.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of proposed sources of materials and of changes in material sources. The Engineer will verify that the specification requirements are met before the sources can be used. The Engineer may sample and test project materials at any time before compaction. Use Tex-100-E for material definitions.

2.1. **Cement**. Furnish hydraulic cement that meets the requirements of DMS-4600, "Hydraulic Cement," and the Department's *Hydraulic Cement Quality Monitoring Program* (HCQMP). Sources not on the HCQMP will require testing and approval before use.

2.2. **Flexible Base**. Furnish base material that meets the requirements of Item 247, "Flexible Base," for the type and grade shown on the plans, before the addition of cement.

2.3. **Water**. Furnish water that is free of industrial waste and other objectionable material.

2.4. **Asphalt**. Furnish asphalt or emulsion that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," when permitted for curing purposes as shown on the plans or as directed.

2.5. **Mix Design**. Using the materials proposed for the project, the Engineer will determine the target cement content and optimum moisture content necessary to produce a stabilized mixture meeting the strength requirements shown in Table 1 for the class specified on the plans. The mix will be designed in accordance with Tex-120-E. The Contractor may propose a mix design developed in accordance with Tex-120-E. The Engineer will use Tex-120-E to verify the Contractor's proposed mix design before acceptance. The Engineer may use project materials sampled from the plant or the quarry, and sampled by the Engineer or the Contractor, as determined by the Engineer. Limit the amount of asphalt concrete pavement to no more than 50% of the mix unless otherwise shown on the plans or directed.

Table 1
Strength Requirements

Class	7-Day Unconfined Compressive Strength, Min psi
L	500
M	300
N	As shown on the plans

3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work. Provide rollers in accordance with Item 210, "Rolling." Provide proof rollers in accordance with Item 216, "Proof Rolling," when required.

3.1. **Cement Storage Facility**. Store cement in closed, weatherproof containers.

3.2. **Mixing Plant**. Provide a stationary pugmill, weigh-batch, or continuous mixing plant as approved. Equip plants with automatic proportioning and metering devices that produce a uniform mixture of base material, cement, and water in the specified proportions.

3.3. **Spreader Equipment**. Provide equipment that will spread the cement-treated mixture in a uniform layer in 1 pass when shown on the plans. Equip spreaders with electronic grade controls when shown on the plans.

4. CONSTRUCTION

Construct each layer uniformly, free of loose or segregated areas and with the required density and moisture content. Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans or established by the Engineer. Start placement operations only when the air temperature is at least 35°F and rising or is at least 40°F. The temperature will be taken in the shade and away from artificial heat. Suspend operations when the Engineer determines that weather conditions are unsuitable.

4.1. **Mixing**. Thoroughly mix materials in the proportions designated on the mix design, in a mixing plant that meets the requirements of Section 276.3.2., "Mixing Plant." Mix at optimum moisture content, unless otherwise directed, until a homogeneous mixture is obtained. Do not add water to the mixture after mixing is completed unless directed. The Engineer may sample the mixture to verify strength in accordance with Tex-120-E and adjust cement content to achieve the target strength for work going forward.

4.2. **Placing**. Place the cement-treated base on a subgrade or base prepared in accordance with details shown on the plans. Bring the prepared roadway to the moisture content directed. Haul cement-treated base to the roadway in clean trucks and begin placement immediately. Place cement-treated base only on an area where compacting and finishing can be completed during the same working day. Spread and shape in a uniform layer with an approved spreader. Construct individual layers to the thickness shown on the plans. Maintain the shape of the course by blading. Correct or replace segregated areas as directed, at no additional expense to the Department.

Construct vertical joints between new cement-treated base and cement-treated base that has been in place 4 hr. or longer. The vertical face may be created by using a header or by cutting back the face to approximately vertical. Place successive base courses using the same methods as the first course. Offset construction joints by at least 6 in.

4.3. **Compaction**. Compact each layer immediately after placing. Complete compaction within 2 hr. after plant-mixing water with dry material. Complete compaction of the final lift within 5 hr. after adding water to the treated base used in the first lift when multiple lifts are permitted.

Moisture content in the mixture at the plant may be adjusted so that during compaction it is within 2.0 percentage points of optimum as determined by Tex-120-E. Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same, unless otherwise shown on the plans or directed. Maintain uniform moisture content by sprinkling the treated material in accordance with Item 204, "Sprinkling."

Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least 1/2 the width of the roller unit. Begin rolling at the low side and progress toward the high side on superelevated curves. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph, as directed.

Achieve at least 95% of maximum density determined in accordance with Tex-120-E when compaction is complete. The Engineer will determine roadway density and moisture content in accordance with Tex-115-E. Remove material that does not meet density requirements. Remove areas that lose required stability, compaction, or finish. Replace with cement-treated mixture, compact, and test in accordance with density control methods.

The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

4.4. **Finishing**. Clip, skin, or tight blade the surface of the cement-treated material with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. immediately after completing compaction. Remove loosened material and dispose of at an approved location. Roll the clipped surface immediately with a pneumatic tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines, and grades shown on the plans or as directed.

Trim grade deviations greater than 1/4 in. in 16 ft. measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Remove excess material, reshape, and then roll with a pneumatic tire roller. Correct as directed if material is more than 1/4 in. low. Do not surface patch.

4.5. **Microcracking**. Maintain moisture content of the finished cement-treated base for a period of 24 to 48 hr. when shown on the plans. Roll the finished course with a vibratory roller to induce microcracking during this time, but not sooner than 24 hours. The vibratory roller must be in accordance with Item 210, "Rolling," with a static weight equal to or more than 12 tons and the vibratory drum must be not less than 20 in. wide. The roller must travel at a speed of 2 mph, vibrating at maximum amplitude, and make 2 to 4 passes with 100% coverage exclusive of the outside 1 ft. of the surface crown, unless otherwise directed by the Engineer. Additional passes may be required to achieve the desired crack pattern as directed. Notify the Engineer 24 hr. before the microcracking begins.

4.6. **Curing**. Cure for at least 3 days by sprinkling in accordance with Item 204, "Sprinkling," or by applying an asphalt material at the rate of 0.05 to 0.20 gal. per square yard, as shown on the plans or directed. When a section is microcracked, cure section for an additional 2 days after microcracking. Maintain the moisture content during curing at no lower than 2 percentage points below optimum. Continue curing until placing another course.

5. MEASUREMENT

Cement-treated base will be measured by the ton, cubic yard, or square yard as a composite mixture of cement, flexible base, and recycled materials.

Measurement by the cubic yard in final position and square yard is a plans quantity measurement. The quantity to be paid for is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

Measurement is further defined for payment as follows:

5.1. **Cubic Yard in Vehicles**. Cement-treated base will be measured by the cubic yard in vehicles as delivered on the road.

5.2. **Cubic Yard in Final Position**. Cement-treated base will be measured by the cubic yard in its completed and accepted final position. The volume of each course will be computed in-place between the original subgrade surfaces and the lines, grades, and slopes of the accepted base course as shown on the plans, and calculated by the method of average end areas.

5.3. **Square Yard**. Cement-treated base will be measured by the square yard of surface area. The dimensions for determining the surface area are established by the dimensions shown on the plans.

5.4. **Ton**. Cement-treated base will be measured by the ton (dry weight) in vehicles as delivered on the road. The dry weight is determined by deducting the weight of the moisture in the material at the time of weighing from

the gross weight of the material. The Engineer will determine the moisture content in the material in accordance with Tex-103-E from samples taken at the time of weighing.

When material is measured in trucks, the weight of the material will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at an approved location. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Cement Treatment (Plant-Mix)" of the class (strength), flexible base type, grade, and thickness (for square yard measurement) specified. For cubic yard measurement, "In Vehicle" or "In Final Position" will be specified. This price is full compensation for furnishing and disposing of materials (including cement and base); storing, mixing, hauling, placing, sprinkling, compacting, microcracking, finishing, curing, and maintaining and reworking treated base; and equipment, labor, tools, and incidentals.

Sprinkling and rolling, except proof rolling, will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans. When proof rolling is shown on the plans or directed by the Engineer, it will be paid for in accordance with Item 216, "Proof Rolling."

Where subgrade or base courses are constructed under this Contract, correction of soft spots will be at the Contractor's expense. Where subgrade or base is not constructed under this Contract, correction of soft spots will be paid for in accordance with pertinent Items and Article 4.4., "Changes in the Work."

Asphalt used solely for curing will not be paid for directly but will be subsidiary to this Item. Asphalt placed for curing and priming will be paid for under Item 310, "Prime Coat."

Removal and disposal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.4., "Changes in the Work."

6.1. **Thickness Measurement for Cubic Yard In Final Position and Square Yard Payment Adjustment**. Before final acceptance, the Engineer will select the locations of tests within each unit and measure the treated base depths in accordance with Tex-140-E.

6.1.1. **Units for Payment Adjustment**.

6.1.1.1. **Roadways and Shoulders**. Units for applying a payment adjustment for thickness to roadways and shoulders are defined as 1,000 ft. of treated base in each placement width. The last unit in each placement width will be 1,000 ft. plus the fractional part of 1,000 ft. remaining. Placement width is the width between longitudinal construction joints. For widening, the placement width is the average width placed of the widened section that is deficient in thickness.

6.1.1.2. **Ramps and Other Areas**. Units are defined as 2,000 sq. yd. or fraction thereof for establishing an adjusted unit price for ramps, intersections, irregular sections, crossovers, entrances, partially completed units, transitions to ramps, and other areas designated by the Engineer.

6.1.2. **Price Adjustments of Deficient Areas**.

6.1.2.1. **Thickness Deficiency ≤ 1.0 in.** Table 2 will govern the price adjustment for each unit with deficient areas ≤ 1.0 in.

Table 2
Measurements and Price Adjustment for Each Unit

Thickness Deficiency	Additional Measurements	Average Thickness Deficiency of 3 Measurements		Price Adjustment
≤ 0.5 in.	None	N/A		Full Payment
> 0.5 in.	2	≤ 0.5 in.		Full Payment
		> 0.5 in.	≤ 0.8 in.	75% Payment
		> 0.8 in.	≤ 1.0 in.	50% Payment
		> 1.0 in.		In accordance with Section 276.6.1.2.2., "Thickness Deficiency ≥ 1.0 in."

6.1.2.2. **Thickness Deficiency ≥ 1.0 in.** Remove and replace areas of treated base found deficient in thickness by more than 1.0 in., unless otherwise approved. Take exploratory measurements at 50-ft. intervals parallel to the centerline in each direction from the deficient measurement until a measurement is not deficient by more than 1.0 in. The minimum limit of non-pay will be 100 ft.

6.2. **Excess Thickness and Width**. For cubic yard in final position and square yard measurement, no additional payment will be made for thickness or width exceeding that shown on the plans.

Item 292
Asphalt Treatment (Plant-Mixed)

1. DESCRIPTION

Construct a base or foundation course composed of a compacted mixture of aggregate and asphalt binder mixed hot in a mixing plant.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed material sources and of changes to material sources. When a source change occurs, the Engineer will verify that the specification requirements are met and may require a new laboratory mixture design. Use Tex-100-E for material definitions.

2.1. **Aggregate**. Furnish aggregates that conform to the requirements shown in Table 1 and specified in this Section unless otherwise shown on the plans. Each source must meet the requirements of Table 1. Stockpile aggregates for each source and type separately. Do not add material to an approved stockpile unless approved by the Engineer. The Engineer may allow testing of the proposed combined aggregates, rather than each source, to meet Table 1 requirements.

Table 1
Aggregate Quality Requirements

Property	Test Method	Specification Requirement
Wet ball mill, % Max	Tex-116-E	50
Max increase, % passing #40		20
Los Angeles abrasion,[1] % Max	Tex-410-A	50
Liquid limit, Max	Tex-104-E	40
Plasticity index, Max	Tex-106-E	10
Sand equivalent, % Min	Tex-203-F	40
Decantation,[2] % Max	Tex-406-A	5.0
Crushed faces, % Min	Tex-460-A	60

1. Use only when shown on the plans, instead of wet ball mill test.
2. Required only for reclaimed asphalt pavement (RAP) stockpiles and recycled aggregates when more than 30% RAP is allowed.

2.2. **Recycled Materials**. Use of RAP and RAS is permitted unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 2. Determine asphalt content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F. The Engineer may verify the asphalt content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. When RAP or RAS is used, calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 2 during mixture design and production. During production, use a separate cold feed bin for each stockpile of RAP and RAS.

2.2.1. **RAP**. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Crush or break RAP so that 100% of the particles pass the 2 in. sieve.

Use of Contractor-owned RAP including HMA plant waste is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP.

Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

Fractionated RAP is defined as having 2 or more RAP stockpiles, divided into coarse and fine fractions. The coarse RAP stockpile will contain only material retained by processing over a 3/8 in. screen or 1/2 in. screen unless otherwise approved. The fine RAP stockpile will contain only material passing the 3/8 in. screen or 1/2 in. screen unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8 in. screen or 1/2 in. screen to fractionate the RAP. The maximum percentages of fractionated RAP may be comprised of coarse or fine fractionated RAP or the combination of both coarse and fine fractionated RAP.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than 8. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

2.2.2. **RAS**. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is permitted unless otherwise shown on the plans. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt.

Add sand meeting the requirements of Table 3 and having a maximum linear shrinkage of 3.0% when tested in accordance with Tex-107-E, or fine RAP, to RAS stockpiles if needed to keep the processed material workable. For any stockpile that contains RAS, the entire stockpile will be considered a RAS stockpile and be limited to no more than 3.0% of the mixture in accordance with Table 2.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials (NRM) Guidelines." If the RAS has not come into contact with any hazardous materials, treat it as an established NRM. Use RAS from shingle sources on the Department's MPL. Before use, remove substantially all materials that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless otherwise approved. Submit a sample for approval to the Engineer before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

Table 2
Maximum Allowable Amounts of Recycled Binder, RAP, and RAS

Mixture Description & Location	Maximum Ratio of Recycled Binder to Total Binder[1] (%)	Maximum Allowable Recycled Material (%)		
		Unfractionated RAP[2]	Fractionated RAP[3]	RAS[4]
Non-Surface	40.0	20.0	30.0	3.0

1. Combined recycled binder from fractionated RAP and RAS.
2. Do not use in combination with RAS or Fractionated RAP.
3. May replace up to 3.0% fractionated RAP with RAS.
4. May be used separately or as a replacement for no more than 3.0% of the allowable fractionated RAP.

Table 3
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.3. **Asphalt Material**. Furnish PG64-22 asphalt binder that meets requirements of Item 300, "Asphalts, Oils and Emulsions." When more than 30% RAP is allowed and used, ensure that the new binder and recovered binder from the RAP, when blended proportionally, meet the PG64-22 requirements.

2.4. **Tack Coat**. Unless otherwise shown on the plans or as approved, furnish CSS-1H, SS-1H, or a PG binder with a minimum high temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions."

Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use. If required, verify that emulsified asphalt proposed for use meets the minimum residual asphalt percentage specified in Item 300, "Asphalts, Oils, and Emulsions."

The Engineer will obtain at least one sample of the tack coat binder per project and test to verify compliance with Item 300, "Asphalts, Oils, and Emulsions." The Engineer will obtain the sample from the asphalt distributor immediately before use.

2.5. **Additives**. When shown on the plans, use the type and rate of additive specified. Other additives that facilitate mixing or improve the quality of the mix may be allowed when approved.

If lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the fines back into the drum.

3. EQUIPMENT

Provide machinery, tools, and equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Produce, haul, place, and compact the specified mixture in accordance with the requirements of this Item.

4.1. **Mixture Design**. Using Tex-126-E and the materials proposed for the project, the Engineer will determine the target asphalt content required to produce a mixture meeting the requirements in Table 4 for the grade shown on the plans. The gradation of the combined aggregates will be determined in accordance with Tex-200-F, Part I. Reimburse the Department for subsequent mixture designs or partial designs necessitated by changes in the material or requests by the Contractor. The Engineer may accept a design from the

Contractor that is performed in accordance with Tex-126-E and is submitted on the Department-provided Excel template. Obtain mixture design verification and approval before beginning production.

Table 4
Mix Requirements

Master Gradation Bands Tex-200-F, Part I, % Passing by Weight				
Sieve Size	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**
1-3/4"		100	100	As shown on the plans
1-1/2"	100	90–100		
1"	90–100			
3/8"	45–70			
#4	30–55	25–55		
#40	15–30	15–40	15–40	
Asphalt Content, Min(Tex-236-F)				
	4.0%	4.0%	4.0%	4.0%
Strength Requirements (Tex-226-F)				
Indirect tensile strength,(dry) psi[1]	85–200	85–200	85–200	85–200

1. At optimum asphalt content.

The Engineer will evaluate the mixture for moisture susceptibility in accordance with Tex-530-C unless otherwise shown on the plans. A maximum of 10% stripping is allowed unless otherwise shown on the plans. The test sample will be retained and used to establish a baseline for comparison to production results. The Engineer may waive this test if a similar design using the same materials has proven satisfactory.

Produce a trial batch using the proposed project equipment and materials in a large enough quantity to ensure that the mixture is representative of the mixture design. Within one full working day, the Engineer will sample and test the trial batch to ensure that the gradation, asphalt content and strength requirements in Table 4 are met. The Engineer may waive trial mixtures if similar designs have proven satisfactory.

4.2. **Production Operations**. Produce a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for non-compliance to the specification.

4.2.1. **Storage and Heating of Materials**. Do not heat the asphalt binder above the temperature specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. On a daily basis, provide the Engineer with the records of asphalt binder and hot-mix asphalt discharge temperatures in accordance with Item 320, "Equipment for Asphalt Concrete Pavement." Unless otherwise approved, do not store hot-mix for more than 12 hr. or for a time period less than 12 hr. that affects the quality of the mixture.

4.2.2. **Mixing and Discharge of Materials**. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. When ordinary compaction is used, the Engineer will select a target discharge temperature between 225°F and 350°F. Produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed 350°F. The Department will not pay for or allow placement of any mixture produced at more than 350°F.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. The Engineer may perform Tex-212-F, Part II, to verify that the mixture contains no more than 0.2% moisture by weight. The sample will be taken immediately after the mixture is discharged into the truck and tested promptly.

4.3. **Hauling Operations**. Before use, clean all truck beds to ensure that the mixture will not become contaminated. When a release agent is necessary, use a release agent on the Department's MPL to coat the truck bed.

4.4. **Placement Operations**. Prepare the surface by removing objectionable material such as moisture, dirt, sand, leaves and other loose impediments before placing the mixture. Coordinate mixture delivery and paver speed to ensure a continuous placement operation. Suspend placement operations when, in the opinion of

the Engineer, a continuous paving operation is not maintained. Place the mixture to produce a smooth, finished surface with a uniform appearance and texture that meet typical section requirements. Offset longitudinal joints of successive courses of stabilized base by at least 6 in. Place the mix adjacent to gutters and structures so that the pavement will drain properly.

4.4.1. **Weather Conditions**. Tack coat and mixture may be placed only when the roadway surface temperature is 60°F or higher unless otherwise approved. Measure the roadway surface temperature with a handheld infrared thermometer. Place tack coat or mixtures only when the Engineer determines that general weather conditions and moisture conditions of the roadway surface are suitable. The Engineer may waive placement temperature requirements.

4.4.2. **Tack Coat**. Clean the surface before placing the tack coat. Unless otherwise approved, apply tack coat uniformly at a rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and joints. Prevent splattering of tack coat when placed adjacent to curbs, gutters, and structures. Roll the tack coat with a pneumatic tire roller unless otherwise directed. The Engineer may use Tex-243-F to verify that the tack coat has adequate adhesive properties. The Engineer may suspend paving operations until there is adequate adhesion. The Engineer may waive the requirement to place tack coat.

4.4.3. **Lay-Down Operations**. Dump and spread the asphalt mixture on the approved prepared surface with a spreading and finishing machine. Place the material without tearing, shoving, gouging, or segregating the mixture.

Do not jar or bounce the finishing machine when loading it. Obtain the required lines and grades without hand finishing. The Engineer may authorize hand finishing when the mixture is:

- placed in a narrow strip along the edge of existing pavement,
- used to level small areas, or
- placed in small irregular areas where the use of a finishing machine is not practical.

Leveling courses and other areas may be spread with a motor grader when shown on the plans or approved.

When hot-mix is placed in windrows, operate windrow pick-up equipment so that substantially all the mixture deposited on the roadbed is picked up and loaded into the spreading and finishing machine.

Adjust the hopper flow gates of the spreading and finishing machine to provide an adequate and consistent flow of material. Operate the augers at least 85% of the time. Keep the augers one-half to three-quarters full of mixture. Maintain an adequate flow of material to the center of the paver for the full width of the mat.

Immediately take appropriate corrective action if surface irregularities including but not limited to segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, or streaks are detected. Continue placement for no more than one day of production while appropriate action is taken. If no appropriate corrective action is taken or if the problem still exists after one day, suspend paving until the Engineer approves further production.

4.5. **Compaction**. Uniformly compact the pavement to the density requirements of this Item. Use the procedure described in Tex-207-F, Part IV, to establish the rolling pattern. Do not use pneumatic tire rollers if excessive pickup of fines by roller tires occurs.

When using three-wheel, tandem, or vibratory rollers, first roll the joint with the adjacent pavement. Continue rolling longitudinally at the sides, proceeding toward the center of the pavement, and overlap successive trips by at least one foot unless otherwise directed. Make alternate trips of the roller slightly different in length. Begin rolling of superelevated curves at the low side and proceed toward the high side unless otherwise directed.

When operating vibratory rollers:

- do not operate in vibrating mode when stationary;

- do not operate in vibrating mode when changing directions;
- do not operate in vibrating mode on mats with a plan depth of less than 1-1/2 in.;
- do not allow the roller to stand on pavement that has not been fully compacted;
- do not operate when in contact with the compacted, finished pavement structure layer;
- in case of over-vibration resulting in disruption of the compacted material, rework and recompact or replace the damaged material at the Contractor's expense;
- roll at a speed producing at least 10 blows per foot unless otherwise directed;
- keep the drums moist with water without using excess water; and
- do not drop diesel, gasoline, oil, grease, or other foreign matter on the pavement.

Where specific air void requirements are waived, furnish and operate compaction equipment as approved. Use lightly oiled tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not permit thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

In-place compaction control is required for all mixtures. Complete all rolling for compaction before the mixture temperature drops below 175°F. Unless otherwise shown on the plans, use density control.

4.5.1. **Density Control**. Determine the number and type of rollers needed to obtain the required density. Operate the rollers in accordance with the requirements of this specification and as approved.

Place and compact material to a minimum of 97.0% density as determined by Tex-126-E or as shown on the plans. The Engineer will determine laboratory-molded density in accordance with Tex-126-E from material sampled at the plant. Actual in-place density will be determined in accordance with Tex-126-E unless otherwise directed. Unless otherwise shown on the plans, obtain required roadway specimens as directed. The Engineer will measure air voids in accordance with Tex-207-F. When a satisfactory correlation to results obtained in accordance with Tex-126-E is shown, other methods of determining in-place compaction may be used.

If in-place density is more than 1.0% below minimum density, cease production immediately. If in-place density is between 0.1% and 1.0% below minimum density, investigate the causes and make the necessary corrections. If minimum density is not obtained within one full day of operation, cease production.

Resume production after placing a test section of one lane width and a maximum 0.2 miles long that demonstrates that minimum density can be obtained. Repeat this procedure until producing a test section that meets minimum density requirements. Place no more than 2 test sections per day. Increasing the asphalt content of the mixture to increase in-place density is allowed by approval only.

4.5.2. **Ordinary Compaction**. Furnish the type, size and number of rollers required for compaction, as approved or directed. Use at least one pneumatic tire roller. Pneumatic tire rollers will provide a minimum of 80 psi ground contact pressure when used for compaction and a minimum of 55 psi ground contact pressure when used for kneading and sealing the surface.

Establish rolling patterns in accordance with Tex-207-F, Part IV, unless otherwise directed. Follow the selected rolling pattern unless changes in mixture or placement conditions that affect compaction occur. When changes occur, establish a new rolling pattern.

4.6. **Sampling and Testing**.

4.6.1. **Production Sampling**.

4.6.1.1. **Mixture Sampling**. The Engineer will obtain mixture samples in accordance with Tex-222-F.

4.6.1.2. **Asphalt Binder Sampling**. The Engineer will obtain at least one 1-quart sample of the asphalt binder used during the project, labeled with date and time, sampled from a port located immediately upstream from the mixing drum or pug mill. The sample will be taken in accordance with Tex-500-C, Part II.

4.6.2. **Production Testing**. The Engineer will perform production tests.

4.6.2.1. **Operational Tolerances**. The Engineer will determine compliance with operational tolerances. The gradation of the aggregate must be within the master grading limits for the specified grade except that a tolerance of 2% is allowed on the sieve size for each mixture grade that shows 100% passing in Table 2.

Ensure that the asphalt content does not vary by more than 0.5% from the design target.

4.6.2.2. **Individual Loads of Asphalt-Stabilized Base**. The Engineer retains the right to reject individual truckloads of asphalt-stabilized base when it is evident that the material quality is unacceptable. When a load is rejected for reasons other than temperature, the Contractor may request that the rejected load be tested. Make this request within 4 hours of rejection. If Department test results are within the operational tolerances listed in Section 292.4.6.2.1., "Operational Tolerances," payment will be made for the load. If Department test results are not within operational tolerances, no payment will be made for the load.

4.6.3. **Placement Sampling and Testing**. Obtain two 6-in. diameter cores side by side at locations selected by the Engineer. Provide the Engineer an opportunity to witness the coring operation and measure the core thickness. Mark the cores for identification. Immediately after obtaining the cores, dry the core holes and tack the sides and bottom. Fill the hole with the same type of mixture and properly compact the mixture. Other methods of repairing the core holes are allowed when approved.

Trim the cores, if necessary, and deliver them to the Engineer within one working day following placement operations unless otherwise approved.

4.6.3.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F to verify that in-place density requirements of Section 292.4.5.1., "Density Control," are met.

4.6.3.2. **Irregularities**. Remove and replace, at the expense of the Contractor and to the satisfaction of the Engineer, any mixture that does not bond to the existing pavement or has other surface irregularities identified by the Engineer.

4.6.3.3. **Production Binder Properties**. The Engineer may take cores or other production samples at random from the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Construction Division. The aging ratio, as determined in accordance with AASHTO T 315, is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. The binder from RAP will be included proportionally as part of the original unaged binder. The Engineer may require the defective material be removed and replaced at the Contractor's expense. The asphalt binder will be recovered for testing from cores in accordance with Tex-211-F.

4.7. **Surface Finish**. Use Surface Test Type A in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

4.8. **Opening to Traffic**. Open the completed course to traffic when permitted or directed. If the surface ravels, flushes, ruts, or deteriorates in any manner before final acceptance, correct it at the Contractor's expense and to the satisfaction of the Engineer.

5. MEASUREMENT

Asphalt-treated base will be measured by the ton as a composite mixture of asphalt, aggregate, RAP, and additives noted on the plans and approved. Measurement will be made using scales meeting the requirements of Item 520, "Weighing and Measuring Equipment."

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Asphalt Stabilized Base" of the grade and binder type specified. This price is full compensation for furnishing and disposing of materials, producing trial batches, loading, hauling, placing, compacting, sampling, testing, replacing defective material, furnishing scales and labor for weighing and measuring, and equipment, labor, tools, and incidentals. State-owned RAP from sources designated on the plans shown to be available will be provided to the Contractor at no cost.

Item 300
Asphalts, Oils, and Emulsions

1. DESCRIPTION

Provide asphalt cements, cutback and emulsified asphalts, performance-graded asphalt binders, and other miscellaneous asphalt materials as specified on the plans.

2. MATERIALS

Provide asphalt materials that meet the stated requirements when tested in accordance with the referenced Department, AASHTO, and ASTM test methods. Provide asphalt materials that have been preapproved for use by the Construction Division in accordance with Tex-545-C, "Asphalt Binder Quality Program," unless otherwise shown on the plans.

Acronyms used in this Item are defined in Table 1.

Table 1
Acronyms

Acronym	Definition
Test Procedure Designations	
Tex	Department
T or R	AASHTO
D	ASTM
Polymer Modifier Designations	
P	polymer-modified
SBR or L	styrene-butadiene rubber (latex)
SBS	styrene-butadiene-styrene block co-polymer
TR	tire rubber (from ambient temperature grinding of truck and passenger tires)
AC	asphalt cement
AE	asphalt emulsion
AE-P	asphalt emulsion prime
A-R	asphalt-rubber
C	cationic
EAP&T	emulsified asphalt prime and tack
H-suffix	harder residue (lower penetration)
HF	high float
MC	medium-curing
MS	medium-setting
PCE	prime, cure, and erosion control
PG	performance grade
RC	rapid-curing
RS	rapid-setting
S-suffix	stockpile usage
SCM	special cutback material
SS	slow-setting

2.1. **Asphalt Cement**. Provide asphalt cement that is homogeneous, water-free, and nonfoaming when heated to 347°F, and meets the requirements in Table 2.

Table 2
Asphalt Cement

Property	Test Procedure	Viscosity Grade									
		AC-0.6		AC-1.5		AC-3		AC-5		AC-10	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity	T 202										
140°F, poise		40	80	100	200	250	350	400	600	800	1,200
275°F, poise		0.4	–	0.7	–	1.1	–	1.4	–	1.9	–
Penetration, 77°F, 100g, 5 sec.	T 49	350	–	250	–	210	–	135	–	85	–
Flash point, C.O.C., °F	T 48	425	–	425	–	425	–	425	–	450	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.		Neg.		Neg.	
Tests on residue from Thin-Film Oven Test:	T 179										
Viscosity, 140°F, poise	T 202	–	180	–	450	–	900	–	1,500	–	3,000
Ductility,[1] 77°F 5 cm/min., cm	T 51	100	–	100	–	100	–	100	–	100	–

1. If AC-0.6 or AC-1.5 ductility at 77°F is less than 100 cm, material is acceptable if ductility at 60°F is more than 100 cm.

2.2. **Polymer-Modified Asphalt Cement**. Provide polymer-modified asphalt cement that is smooth, homogeneous, and meets the requirements of Table 3. Supply samples of the base asphalt cement and polymer additives if requested.

Table 3
Polymer-Modified Asphalt Cement

Property	Test Procedure	Polymer-Modified Viscosity Grade											
		AC-5 w/2% SBR		AC-10 w/2% SBR		AC-15P		AC-20XP		AC-10-2TR		AC-20-5TR	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Polymer		SBR		SBR		SBS		SBS		TR		TR	
Polymer content, % (solids basis)	Tex-533-C	2.0	–	2.0	–	3.0	–	–	–	2.0	–	5.0	–
Dynamic shear, G*/sin δ, 64°C, 10 rad/s, kPa	T 315	–	–	–	–	–	–	1.0	–	–	–	1.0	–
Dynamic shear, G*/sin δ, 58°C, 10 rad/s, kPa	T 315	–	–	–	–	–	–	–	–	1.0	–	–	–
Viscosity													
140°F, poise	T 202	700	–	1,300	–	1,500	–	2,000	–	1,000	–	2,000	–
275°F, poise	T 202	–	7.0	–	8.0	–	8.0	–	–	–	8.0	–	10.0
Penetration, 77°F, 100 g, 5 sec.	T 49	120	–	80	–	100	150	75	115	95	130	75	115
Ductility, 5cm/min., 39.2°F, cm	T 51	70	–	60	–	–	–	–	–	–	–	–	–
Elastic recovery, 50°F, %	Tex-539-C	–	–	–	–	55	–	55	–	30	–	55	–
Softening point, °F	T 53	–	–	–	–	–	–	120	–	110	–	120	–
Polymer separation, 48 hr.	Tex-540-C	None		None		None		None		None		None	
Flash point, C.O.C., °F	T 48	425	–	425	–	425	–	425	–	425	–	425	–
Tests on residue from RTFOT aging and pressure aging:	Tex-541-C and R 28 T 313												
Creep stiffness													
S, -18°C, MPa		–	–	–	–	–	300	–	300	–	300	–	300
m-value, -18°C		–	–	–	–	0.300	–	0.300	–	0.300	–	0.300	–

2.3. **Cutback Asphalt**. Provide cutback asphalt that meets the requirements of Tables 4, 5, and 6 for the specified type and grade. Supply samples of the base asphalt cement and polymer additives if requested.

Table 4
Rapid-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade					
		RC-250		RC-800		RC-3000	
		Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	250	400	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	80	–	80	–	80	–
Distillation test:	T 78						
Distillate, percentage by volume of total distillate to 680°F							
to 437°F		40	75	35	70	20	55
to 500°F		65	90	55	85	45	75
to 600°F		85	–	80	–	70	–
Residue from distillation, volume %		70	–	75	–	82	–
Tests on distillation residue:							
Viscosity, 140°F, poise	T 202	60	240	60	240	60	240
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.	

Table 5
Medium-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade							
		MC-30		MC-250		MC-800		MC-3000	
		Min	Max	Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	30	60	250	500	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	95	–	122	–	140	–	149	–
Distillation test:	T 78								
Distillate, percentage by volume of total distillate to 680°F									
to 437°F		–	35	–	20	–	–	–	–
to 500°F		30	75	5	55	–	40	–	15
to 600°F		75	95	60	90	45	85	15	75
Residue from distillation, volume %		50	–	67	–	75	–	80	–
Tests on distillation residue:									
Viscosity, 140°F, poise	T 202	30	120	30	120	30	120	30	120
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.		Neg.	

Table 6
Special-Use Cutback Asphalt

Property	Test Procedure	Type–Grade					
		MC-2400L		SCM I		SCM II	
		Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	2,400	4,800	500	1,000	1,000	2,000
Water, %	D95	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	150	–	175	–	175	–
Distillation test:	T 78						
Distillate, percentage by volume of total distillate to 680°F							
to 437°F		–	–	–	–	–	–
to 500°F		–	35	–	0.5	–	0.5
to 600°F		35	80	20	60	15	50
Residue from distillation, volume %		78	–	76	–	82	–
Tests on distillation residue:							
Polymer		SBR		–		–	
Polymer content, % (solids basis)	Tex-533-C	2.0	–	–	–	–	–
Penetration, 100 g, 5 sec., 77°F	T 49	150	300	180	–	180	–
Ductility, 5 cm/min., 39.2°F, cm	T 51	50	–	–	–	–	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–

2.4. **Emulsified Asphalt**. Provide emulsified asphalt that is homogeneous, does not separate after thorough mixing, and meets the requirements for the specified type and grade in Tables 7, 8, 9, and 10.

Table 7
Emulsified Asphalt

Property	Test Procedure	Type–Grade									
		Rapid-Setting		Medium-Setting				Slow-Setting			
		HFRS-2		MS-2		AES-300		SS-1		SS-1H	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72										
77°F, sec.		–	–	–	–	75	400	20	100	20	100
122°F, sec.		150	400	100	300	–	–	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Miscibility	T 59	–		–		–		Pass		Pass	
Cement mixing, %	T 59	–	–	–	–	–	–	–	2.0	–	2.0
Coating ability and water resistance:	T 59										
Dry aggregate/after spray		–		–		Good/Fair		–		–	
Wet aggregate/after spray		–		–		Fair/Fair		–		–	
Demulsibility, 35 ml of 0.02 N $CaCl_2$, %	T 59	50	–	–	30	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1
Freezing test, 3 cycles[1]	T 59	–		Pass		–		Pass		Pass	
Distillation test:	T 59										
Residue by distillation, % by wt.		65	–	65	–	65	–	60	–	60	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	5	–	0.5	–	0.5
Tests on residue from distillation:											
Penetration, 77°F, 100 g, 5 sec.	T 49	100	140	120	160	300	–	120	160	70	100
Solubility in trichloroethylene, %	T 44	97.5	–	97.5		97.5	–	97.5	–	97.5	–
Ductility, 77°F, 5 cm/min., cm	T 51	100	–	100		–	–	100	–	80	–
Float test, 140°F, sec.	T 50	1,200	–	–		1,200	–	–	–	–	–

1. Applies only when the Engineer designates material for winter use.

Table 8
Cationic Emulsified Asphalt

Property	Test Procedure	Type–Grade											
		Rapid-Setting				Medium-Setting				Slow-Setting			
		CRS-2		CRS-2H		CMS-2		CMS-2S		CSS-1		CSS-1H	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol													
77°F, sec.	T 72	–	–	–	–	–	–	–	–	20	100	20	100
122°F, sec.		150	400	150	400	100	300	100	300	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Cement mixing, %	T 59	–	–	–	–	–	–	–	–	–	2.0	–	2.0
Coating ability and water resistance:													
Dry aggregate/after spray	T 59	–		–		Good/Fair		Good/Fair		–		–	
Wet aggregate/after spray		–		–		Fair/Fair		Fair/Fair		–		–	
Demulsibility, 35 ml of 0.8% Sodium dioctyl sulfosuccinate, %	T 59	70	–	70	–	–	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1	–	1
Particle charge	T 59	Positive		Positive		Positive		Positive		Positive		Positive	
Distillation test:													
Residue by distillation, % by wt.	T 59	65	–	65	–	65	–	65	–	60	–	60	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	7	–	5	–	0.5	–	0.5
Tests on residue from distillation:													
Penetration, 77°F, 100 g, 5 sec.	T 49	120	160	70	110	120	200	300	–	120	160	70	110
Solubility in trichloroethylene, %	T 44	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–
Ductility, 77°F, 5 cm/min., cm	T 51	100	–	80	–	100	–	–	–	100	–	80	–

Table 9
Polymer-Modified Emulsified Asphalt

Property	Test Procedure	Type–Grade											
		Rapid-Setting				Medium-Setting				Slow-Setting			
		RS-1P		HFRS-2P		AES-150P		AES-300P		AES-300S		SS-1P	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72												
77°F, sec.		–	–	–	–	75	400	75	400	75	400	30	100
122°F, sec.		50	200	150	400	–	–	–	–	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Miscibility	T 59	–		–		–		–		–		Pass	
Coating ability and water resistance:	T 59												
Dry aggregate/after spray		–		–		Good/Fair		Good/Fair		Good/Fair		–	
Wet aggregate/after spray		–		–		Fair/Fair		Fair/Fair		Fair/Fair		–	
Demulsibility, 35 ml of 0.02 N $CaCl_2$, %	T 59	60	–	50	–	–	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1	–	1
Breaking index, g	Tex-542-C	–	80	–	–	–	–	–	–	–	–	–	–
Distillation test:[1]	T 59												
Residue by distillation, % by wt.		65	–	65	–	65	–	65	–	65	–	60	–
Oil distillate, % by volume of emulsion		–	3	–	0.5	–	3	–	5	–	7	–	0.5
Tests on residue from distillation:													
Polymer content, wt. % (solids basis)	Tex-533-C	–	–	3.0	–	–	–	–	–	–	–	3.0	–
Penetration, 77°F, 100 g, 5 sec.	T 49	225	300	90	140	150	300	300	–	300	–	100	140
Solubility in trichloroethylene, %	T 44	97.0	–	97.0	–	97.0	–	97.0	–	97.0	–	97.0	–
Viscosity, 140°F, poise	T 202	–	–	1,500	–	–	–	–	–	–	–	1,300	–
Float test, 140°F, sec.	T 50	–	–	1,200	–	1,200	–	1,200	–	1,200	–	–	–
Ductility,[2] 39.2°F, 5 cm/min., cm	T 51	–	–	50	–	–	–	–	–	–	–	50	–
Elastic recovery,[2] 50°F, %	Tex-539-C	55	–	55	–	–	–	–	–	–	–	–	–
Tests on RTFO curing of distillation residue	Tex-541-C												
Elastic recovery, 50°F, %	Tex-539-C	–	–	–	–	50	–	50	–	30	–	–	–

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F ±10°F. Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. HFRS-2P must meet one of either the ductility or elastic recovery requirements.

Table 10
Polymer-Modified Cationic Emulsified Asphalt

Property	Test Procedure	Type-Grade											
		Rapid-Setting						Medium-Setting				Slow-Setting	
		CRS-1P		CRS-2P		CHFRS-2P		CMS-1P[3]		CMS-2P[3]		CSS-1P	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72												
77°F, sec.		–	–	–	–	–	–	20	100	–	–	20	100
122°F, sec.		50	150	150	400	100	400	–	–	50	400	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Demulsibility, 35 ml of 0.8% Sodium dioctyl sulfosuccinate, %	T 59	60	–	70	–	60	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	–	–	–	–	1
Breaking index, g	Tex-542-C	–	80	–	–	–	–	–	–	–	–	–	–
Particle charge	T 59	Positive		Positive		Positive		Positive		Positive		Positive	
Distillation test:[1]	T 59												
Residue by distillation, % by weight		65	–	65	–	65	–	65	–	65	–	62	–
Oil distillate, % by volume of emulsion		–	3	–	0.5	–	0.5	–	0.5	–	0.5	–	0.5
Tests on residue from distillation:													
Polymer content, wt. % (solids basis)	Tex-533-C	–	–	3.0	–	3.0	–	–	–	–	–	3.0	–
Penetration, 77°F, 100 g, 5 sec.	T 49	225	300	90	150	80	130	40	–	40	–	55	90
Viscosity, 140°F, poise	T 202	–	–	1,300	–	1,300	–	–	5,000	–	5,000	–	–
Solubility in trichloroethylene, %	T 44	97.0	–	97.0	–	95.0	–	–	–	–	–	97.0	–
Softening point, °F	T 53	–	–	–	–	130	–	–	–	–	–	135	–
Ductility, 77°F, 5 cm/min., cm	T 51	–	–	–	–	–	–	–	–	–	–	70	–
Float test, 140°F, sec.	T 50	–	–	–	–	1,800	–	–	–	–	–		
Ductility,[2] 39.2°F, 5 cm/min., cm	T 51	–	–	50	–	–	–	–	–	–	–	–	–
Elastic recovery,[2] 50°F, %	Tex-539-C	45	–	55	–	55	–	45	–	45	–	–	–
Tests on rejuvenating agent:													
Viscosity, 140°F, cSt	T 201	–	–	–	–	–	–	50	175	50	175	–	–
Flash point, C.O.C., °F	T 48	–	–	–	–	–	–	380	–	380	–	–	–
Saturates, % by weight	D2007	–	–	–	–	–	–	–	30	–	30	–	–
Solubility in n-pentane, % by weight	D2007	–	–	–	–	–	–	99	–	99	–	–	–
Tests on rejuvenating agent after TFO or RTFO:	T 240 or T 179												
Weight Change, %		–	–	–	–	–	–	–	6.5	–	6.5	–	–
Viscosity Ratio		–	–	–	–	–	–	–	3.0	–	3.0	–	–
Tests on latex:[4]													
Tensile strength, die C dumbbell, psi	D412[5]	–	–	–	–	–	–	500	–	500	–	–	–
Change in mass after immersion in rejuvenating agent, %	D471	–	–	–	–	–	–	–	40[6]	–	40[6]	–	–

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F (±0°F). Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. CRS-2P must meet one of either the ductility or elastic recovery requirements.
3. With all precertification samples of CMS-1P or CMS-2P, submit certified test reports showing that the rejuvenating agent and latex meet the stated requirements. Submit samples of these raw materials if requested by the Engineer.
4. Preparation of latex films: Use any substrate which produces a film of uniform cross-section. Apply latex using a drawdown tool that will deliver enough material to achieve desired residual thickness. Cure films for 14 days at 75°F and 50% relative humidity.
5. Cut samples for tensile strength determination using a crosshead speed of 20 in./min.
6. Specimen must remain intact after exposure and removal of excess rejuvenating agent.

2.5. **Specialty Emulsions**. Provide specialty emulsion that is either asphalt-based or resin-based and meets the requirements of Table 11.

Table 11
Specialty Emulsions

Property	Test Procedure	Type–Grade					
		Medium-Setting				Slow-Setting	
		AE–P		EAP&T		PCE[1]	
		Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72						
77°F, sec.		–	–	–	–	10	100
122°F, sec.		15	150	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1
Miscibility[2]	T 59	–		Pass		Pass	
Demulsibility, 35 ml of 0.10 N $CaCl_2$, %	T 59	–	70	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	–
Particle size,[5] % by volume < 2.5 µm	Tex-238-F[3]	–	–	90	–	90	–
Asphalt emulsion distillation to 500°F followed by Cutback asphalt distillation of residue to 680°F:	T 59 & T 78						
Residue after both distillations, % by wt.		40	–	–	–	–	–
Total oil distillate from both distillations, % by volume of emulsion		25	40	–	–	–	–
Residue by distillation, % by wt.	T 59	–	–	60	–	–	–
Residue by evaporation,[4] % by wt.	T 59	–	–	–	–	60	–
Tests on residue after all distillation(s):							
Viscosity, 140°F, poise	T 202	–	–	800	–	–	–
Kinematic viscosity,[5] 140°F, cSt	T 201	–	–	–	–	100	350
Flash point C.O.C., °F	T 48	–	–	–	–	400	–
Solubility in trichloroethylene, %	T 44	97.5	–	–	–	–	–
Float test, 122°F, sec.	T 50	50	200	–	–	–	–

Supply with each shipment of PCE:
a copy of a lab report from an approved analytical lab, signed by a lab official, indicating the PCE formulation does not meet any characteristics of a Resource Conservation Recovery Act (RCRA) hazardous waste;
a certification from the producer that the formulation supplied does not differ from the one tested and that no listed RCRA hazardous wastes or Polychlorinated Biphenyls (PCBs) have been mixed with the product; and
a Material Safety Data Sheet.
Exception to T 59: In dilution, use 350 ml of distilled or deionized water and a 1,000-ml beaker.
Use Tex-238-F, beginning at "Particle Size Analysis by Laser Diffraction," with distilled or deionized water as a medium and no dispersant, or use another approved method.
Exception to T 59: Leave sample in the oven until foaming ceases, then cool and weigh.
PCE must meet either the kinematic viscosity requirement or the particle size requirement.

2.6. **Recycling Agent**. Recycling agent and emulsified recycling agent must meet the requirements in Table 12. Additionally, recycling agent and residue from emulsified recycling agent, when added in the specified proportions to the recycled asphalt, must meet the properties specified on the plans.

Table 12
Recycling Agent and Emulsified Recycling Agent

Property	Test Procedure	Recycling Agent		Emulsified Recycling Agent	
		Min	Max	Min	Max
Viscosity, Saybolt Furol, 77°F, sec.	T 72	–	–	15	100
Sieve test, %	T 59	–	–	–	0.1
Miscibility[1]	T 59	–		No coagulation	
Residue by evaporation,[2] % by wt.	T 59	–	–	60	–
Tests on recycling agent or residue from evaporation:					
Flash point, C.O.C., °F	T 48	400	–	400	–
Kinematic viscosity,	T 201				
140°F, cSt		75	200	75	200
275°F, cSt		–	10.0	–	10.0

1. Exception to T 59: Use 0.02 N CaCl2 solution in place of water.
2. Exception to T 59: Maintain sample at 300°F until foaming ceases, then cool and weigh.

2.7. **Crumb Rubber Modifier**. Crumb rubber modifier (CRM) consists of automobile and truck tires processed by ambient temperature grinding.

CRM must be:

- free from contaminants including fabric, metal, and mineral and other nonrubber substances;
- free-flowing; and
- nonfoaming when added to hot asphalt binder.

Ensure rubber gradation meets the requirements of the grades in Table 13 when tested in accordance with Tex-200-F, Part I, using a 50-g sample.

Table 13
CRM Gradations

Sieve Size (% Passing)	Grade A		Grade B		Grade C		Grade D	Grade E
	Min	Max	Min	Max	Min	Max		
#8	100	–	–	–	–	–	As shown on the plans	As approved
#10	95	100	100	–	–	–		
#16	–	–	70	100	100	–		
#30	–	–	25	60	90	100		
#40	–	–	–	–	45	100		
#50	0	10	–	–	–	–		
#200	–	–	0	5	–	–		

2.8. **Crack Sealer**. Provide polymer-modified asphalt-emulsion crack sealer meeting the requirements of Table 14. Provide rubber-asphalt crack sealer meeting the requirements of Table 15.

Table 14
Polymer-Modified Asphalt-Emulsion Crack Sealer

Property	Test Procedure	Min	Max
Rotational viscosity, 77°F, cP	D2196, Method A	10,000	25,000
Sieve test, %	T 59	–	0.1
Storage stability, 1 day, %	T 59	–	1
Evaporation Residue by evaporation, % by wt.	Tex-543-C	65	–
Tests on residue from evaporation: Penetration, 77°F, 100 g, 5 sec. Softening point, °F Ductility, 39.2°F, 5 cm/min., cm	 T 49 T 53 T 51	 35 140 100	 75 – –

Table 15
Rubber-Asphalt Crack Sealer

Property	Test Procedure	Class A		Class B	
		Min	Max	Min	Max
CRM content, Grade A or B, % by wt.	Tex-544-C	22	26	–	–
CRM content, Grade B, % by wt.	Tex-544-C	–	–	13	17
Virgin rubber content,[1] % by wt.		–	–	2	–
Flash point,[2] C.O.C., °F	T 48	400	–	400	–
Penetration,[3] 77°F, 150 g, 5 sec.	T 49	30	50	30	50
Penetration,[3] 32°F, 200 g, 60 sec.	T 49	12	–	12	–
Softening point, °F	T 53	–	–	170	–
Bond Test, non-immersed, 0.5 in specimen, 50% extension, 20°F[4]	D5329	–		Pass	

1. Provide certification that the Min % virgin rubber was added.
2. Agitate the sealing compound with a 3/8- to 1/2-in. (9.5- to 12.7-mm) wide, square-end metal spatula to bring the material on the bottom of the cup to the surface (i.e., turn the material over) before passing the test flame over the cup. Start at one side of the thermometer, move around to the other, and then return to the starting point using 8 to 10 rapid circular strokes. Accomplish agitation in 3 to 4 sec. Pass the test flame over the cup immediately after stirring is completed.
3. Exception to T 49: Substitute the cone specified in D217 for the penetration needle.
4. Allow no crack in the crack sealing materials or break in the bond between the sealer and the mortar blocks over 1/4 in. deep for any specimen after completion of the test.

2.9. **Asphalt-Rubber Binders**. Provide asphalt-rubber (A-R) binders that are mixtures of asphalt binder and CRM, which have been reacted at elevated temperatures. Provide A-R binders meeting D6114 and containing a minimum of 15% CRM by weight. Provide Types I or II, containing CRM Grade C, for use in hot-

mixed aggregate mixtures. Provide Types II or III, containing CRM Grade B, for use in surface treatment binder. Ensure binder properties meet the requirements of Table 16.

Table 16
A-R Binders

Property	Test Procedure	Binder Type					
		Type I		Type II		Type III	
		Min	Max	Min	Max	Min	Max
Apparent viscosity, 347°F, cP	D2196, Method A	1,500	5,000	1,500	5,000	1,500	5,000
Penetration, 77°F, 100 g, 5 sec.	T 49	25	75	25	75	50	100
Penetration, 39.2°F, 200 g, 60 sec.	T 49	10	–	15	–	25	–
Softening point, °F	T 53	135	–	130	–	125	–
Resilience, 77°F, %	D5329	25	–	20	–	10	–
Flash point, C.O.C., °F	T 48	450	–	450	–	450	–
Tests on residue from Thin-Film Oven Test:	T 179						
Retained penetration ratio, 39.2°F, 200 g, 60 sec., % of original	T 49	75	–	75	–	75	–

2.10. **Performance-Graded Binders**. Provide PG binders that are smooth and homogeneous, show no separation when tested in accordance with Tex-540-C, and meet the requirements of Table 17.

Separation testing is not required if:

- a modifier is introduced separately at the mix plant either by injection in the asphalt line or mixer,
- the binder is blended on site in continuously agitated tanks, or
- binder acceptance is based on field samples taken from an in-line sampling port at the hot-mix plant after the addition of modifiers.

Table 17
Performance-Graded Binders

Property and Test Method	Performance Grade																		
	PG 58			PG 64				PG 70				PG 76				PG 82			
	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	
Average 7-day max pavement design temperature, °C[1]	< 58			< 64				< 70				< 76				< 82			
Min pavement design temperature, °C[1]	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28	
Original Binder																			
Flash point, T 48, Min, °C	230																		
Viscosity, T 316:[2,3] Max, 3.0 Pa·s, test temperature, °C	135																		
Dynamic shear, T 315:[4] G*/sin(δ), Min, 1.00 kPa, Max, 2.00 kPa,[7] Test temperature @ 10 rad/sec., °C	58			64				70				76				82			
Elastic recovery, D6084, 50°F, % Min	–	–	30	–	–	30	50	–	30	50	60	30	50	60	70	50	60	70	
Rolling Thin-Film Oven (Tex-541-C)																			
Mass loss, Tex-541-C, Max, %	1.0																		
Dynamic shear, T 315: G*/sin(δ), Min, 2.20 kPa, Max, 5.00 kPa,[7] Test temperature @ 10 rad/sec., °C	58			64				70				76				82			
Pressure Aging Vessel (PAV) Residue (R 28)																			
PAV aging temperature, °C	100																		
Dynamic shear, T 315: G*/sin(δ), Max, 5,000 kPa Test temperature @ 10 rad/sec., °C	25	22	19	28	25	22	19	28	25	22	19	28	25	22	19	28	25	22	
Creep stiffness, T 313:[5,6] S, max, 300 MPa, *m*-value, Min, 0.300 Test temperature @ 60 sec., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	
Direct tension, T 314:[6] Failure strain, Min, 1.0% Test temperature @ 1.0 mm/min., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	

1. Pavement temperatures are estimated from air temperatures using an algorithm contained in a Department-supplied computer program, may be provided by the Department, or by following the procedures outlined in AASHTO MP 2 and PP 28.
2. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. At test temperatures where the binder is a Newtonian fluid, any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
3. Viscosity at 135°C is an indicator of mixing and compaction temperatures that can be expected in the lab and field. High values may indicate high mixing and compaction temperatures. Additionally, significant variation can occur from batch to batch. Contractors should be aware that variation could significantly impact their mixing and compaction operations. Contractors are therefore responsible for addressing any constructability issues that may arise.
4. For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be substituted for dynamic shear measurements of G*/sin(δ) at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
5. Silicone beam molds, as described in AASHTO TP 1-93, are acceptable for use.
6. If creep stiffness is below 300 MPa, direct tension test is not required. If creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.
7. Maximum values for unaged and RTFO aged dynamic shear apply only to materials used as substitute binders, as described in specification items, 340, 341, and 344.

3. EQUIPMENT

Provide all equipment necessary to transport, store, sample, heat, apply, and incorporate asphalts, oils, and emulsions.

4. CONSTRUCTION

Typical Material Use. Use materials shown in Table 18, unless otherwise determined by the Engineer.

Table 18
Typical Material Use

Material Application	Typically Used Materials
Hot-mixed, hot-laid asphalt mixtures	PG binders, A-R binders Types I and II
Surface treatment	AC-5, AC-10, AC-5 w/2% SBR, AC-10 w/2% SBR, AC-15P, AC-20XP, AC-10-2TR, AC-20-5TR, HFRS-2, MS-2, CRS-2, CRS-2H, HFRS-2P,CRS-2P, CHFRS-2P, A-R binders Types II and III
Surface treatment (cool weather)	RS-1P, CRS-1P, RC-250, RC-800, RC-3000, MC-250, MC-800, MC-3000, MC-2400L
Precoating	AC-5, AC-10, PG 64-22, SS-1, SS-1H, CSS-1, CSS-1H
Tack coat	PG Binders, SS-1H, CSS-1H, EAP&T
Fog seal	SS-1, SS-1H, CSS-1, CSS-1H
Hot-mixed, cold-laid asphalt mixtures	AC-0.6, AC-1.5, AC-3, AES-300, AES-300P, CMS-2, CMS-2S
Patching mix	MC-800, SCM I, SCM II, AES-300S
Recycling	AC-0.6, AC-1.5, AC-3, AES-150P, AES-300P, recycling agent, emulsified recycling agent
Crack sealing	SS-1P, polymer mod AE crack sealant, rubber asphalt crack sealers (Class A, Class B)
Microsurfacing	CSS-1P
Prime	MC-30, AE-P, EAP&T, PCE
Curing membrane	SS-1, SS-1H, CSS-1, CSS-1H, PCE
Erosion control	SS-1, SS-1H, CSS-1, CSS-1H, PCE

4.1. **Storage and Application Temperatures**. Use storage and application temperatures in accordance with Table 19. Store and apply materials at the lowest temperature yielding satisfactory results. Follow the manufacturer's instructions for any agitation requirements in storage. Manufacturer's instructions regarding recommended application and storage temperatures supersede those of Table 19.

Table 19
Storage and Application Temperatures

Type–Grade	Application		Storage Maximum (°F)
	Recommended Range (°F)	Maximum Allowable (°F)	
AC-0.6, AC-1.5, AC-3	200–300	350	350
AC-5, AC-10	275–350	350	350
AC-5 w/2% SBR, AC-10 w/2% SBR, AC-15P, AC-20-5TR	300–375	375	360
RC-250	125–180	200	200
RC-800	170–230	260	260
RC-3000	215–275	285	285
MC-30, AE-P	70–150	175	175
MC-250	125–210	240	240
MC-800, SCM I, SCM II	175–260	275	275
MC-3000, MC-2400L	225–275	290	290
HFRS-2, MS-2, CRS-2, CRS-2H, HFRS-2P, CRS-2P, CMS-2, CMS-2S, AES-300, AES-300S, AES-150P, AES-300P	120–160	180	180
SS-1, SS-1H, CSS-1, CSS-1H, PCE, EAP&T, SS-1P, RS-1P, CRS-1P, CSS-1P, recycling agent, emulsified recycling agent, polymer mod AE crack sealant	50–130	140	140
PG binders	275–350	350	350
Rubber asphalt crack sealers (Class A, Class B)	350–375	400	–
A-R binders Types I, II, and III	325–425	425	425

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but is subsidiary or is included in payment for other pertinent Items.

Item 301
Asphalt Antistripping Agents

1. DESCRIPTION

Furnish and incorporate all required asphalt antistripping agents in asphalt concrete paving mixtures and asphalt-stabilized base mixtures to meet moisture resistance testing requirements.

2. MATERIALS

2.1. **Lime**. Provide hydrated lime or commercial lime slurry in accordance with DMS-6350, "Lime and Lime Slurry."

2.2. **Liquid Antistripping Agent**. Provide a liquid antistripping agent that is uniform and shows no evidence of crystallization, settling, or separation.

Ensure all liquid antistripping agents arrive in:

- properly labeled and unopened containers, as shipped from the manufacturer, or
- sealed tank trucks with an invoice to show contents and quantities.

Provide product information to the Engineer including:

- material safety data sheet,
- specific gravity of the agent at the manufacturer's recommended addition temperature,
- manufacturer's recommended dosage range, and
- handling and storage instructions.

3. EQUIPMENT

Provide all equipment to store, handle, dispense, meter, and mix asphalt antistripping agents.

4. CONSTRUCTION

4.1. **Laboratory Design Evaluation and Production Mixture Verification**. Provide a laboratory mixture design and production mixture that meet moisture resistance requirements. Evaluate proposed asphalt pavement or base mixtures during design and production according to the moisture resistance requirements in the asphalt mixture specification.

Governing specifications require the Contractor or Engineer to design the mixture, and the party performing the design is responsible for the moisture susceptibility evaluation. If the Contractor designs the mixture, the Engineer verifies compliance.

Determine the dosage needed to achieve the moisture resistance requirements during design if an antistripping agent is required. Use this addition rate in the production mixture.

Add between 0.5% and 2.0% of hydrated lime or commercial lime slurry solids by weight of the individual aggregate treated when using lime.

Add liquid antistripping agent, when used, to the binder, in accordance with the manufacturer's instructions. Do not exceed the manufacturer's maximum recommended dosage rate.

Stop production if the production mixture does not meet moisture resistance requirements and correct the problem.

4.2. **Addition of Antistripping Agents at the Mix Plant**. Connect the measuring device for the addition of the asphalt antistripping agent into the automatic plant controls to automatically adjust the supply to plant production and provide a consistent percentage in the mixture. Set automatic plant controls so that an interruption of asphalt antistripping agent's flow causes plant shutdown.

4.2.1. **Lime**. Incorporate lime in a manner that thoroughly and uniformly distributes lime onto the aggregate surface or into the mixture. Use metering equipment, as approved, to ensure the required quantity of lime is used.

4.2.1.1. **Hydrated Lime**. Add hydrated lime to the aggregate by one of the following methods, unless otherwise shown on the plans:

- Mix in an approved pug mill mixer with damp aggregate containing water at least 2% above saturated surface dry conditions.
- Add into the drum-mix plant immediately before asphalt binder addition or in the pug mill of the weigh-batch plant before asphalt binder addition. Dry mix aggregates and lime before adding asphalt binder when a weigh batch plant is used.

4.2.1.2. **Commercial Lime Slurry**. Add commercial lime slurry to the aggregate by one of the following methods unless otherwise shown on the plans:

- Mix in a suitable pug mill mixer with the aggregate.
- Mix with aggregate between the plant cold feeds and the dryer or mixing drum during mixture production.

4.2.2. **Liquid Antistripping Agent**. Incorporate liquid antistripping agent into the binder as follows:

- Handle in accordance with the manufacturer's recommendations.
- Add at the manufacturer's recommended addition temperature.
- Add into the asphalt line by means of an in-line-metering device, in accordance with Item 520, "Weighing and Measuring Equipment," and a blending device to disperse the agent.
- Place the metering and blending devices in an approved location.

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but is subsidiary or is included in payment quantity for other pertinent Items.

Item 302
Aggregates for Surface Treatments

1. DESCRIPTION

Furnish aggregate for surface treatments in conformance to the type, grade, and Surface Aggregate Classification (SAC) shown on the plans.

2. MATERIALS

Furnish uncontaminated materials of uniform quality throughout that meet the requirements of the plans and specifications. Notify the Engineer of all proposed material sources and of changes to material sources. The Engineer will designate the sampling location.

2.1. **Aggregate**. Stockpile aggregates for each source and type separately. Do not add materials to approved stockpiles without the approval of the Engineer.

Furnish aggregate of the type shown on the plans and listed in Table 1. Use Tex-100-E material definitions.

Table 1
Aggregate Types

Type	Material
A	Gravel, crushed slag, crushed stone, or limestone rock asphalt (LRA)
B	Crushed gravel, crushed slag, crushed stone, or LRA
C	Gravel, crushed slag, or crushed stone
D	Crushed gravel, crushed slag, or crushed stone
E	Aggregate as shown on the plans
L	Lightweight Aggregate
PA	Precoated gravel, crushed slag, crushed stone, or LRA
PB	Precoated crushed gravel, crushed slag, crushed stone, or LRA
PC	Precoated gravel, crushed slag, or crushed stone
PD	Precoated crushed gravel, crushed slag, crushed stone
PE	Precoated aggregate as shown on the plans
PL	Precoated lightweight aggregate

Ensure the aggregate gradation meets the requirements in Table 2 for the specified grade when tested in accordance with Tex-200-F, Part I.

Furnish aggregates that meet the quality requirements shown in Table 3, unless otherwise shown on the plans. Furnish LRA in accordance with DMS-9210, "Limestone Rock Asphalt (LRA)," when used. Provide aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC). Use material not listed or not meeting the requirements of the BRSQC only when tested by the Engineer and approved before use. Allow 30 calendar days for testing of material from such sources.

Provide aggregates for final surfaces that meet the SAC shown on the plans. Do not blend to meet the SAC. The SAC requirement will apply only to the aggregate used on the travel lanes unless otherwise shown on the plans. The BRSQC lists the SAC for sources on the *Aggregate Quality Monitoring Program* (AQMP).

Table 2
Aggregate Gradation Requirements (Cumulative % Retained[1])

Sieve	Grade								
	1	2	3S[2]	3		4S[2]	4	5S[2]	5
				Non-Lightweight	Lightweight				
1"	-	-	-	-	-	-	-	-	-
7/8"	0–2	0	-	-	-	-	-	-	-
3/4"	20–35	0–2	0	0	0	-	-	-	-
5/8"	85–100	20–40	0–5	0–5	0–2	0	0	-	-
1/2"	-	80–100	55–85	20–40	10–25	0–5	0–5	0	0
3/8"	95–100	95–100	95–100	80–100	60–80	60–85	20–40	0–5	0–5
1/4"	-	-	-	95–100	95–100	-	-	65–85	-
#4	-	-	-	-	-	95–100	95–100	95–100	50–80
#8	99–100	99–100	99–100	99–100	98–100	98–100	98–100	98–100	98–100

1. Round test results to the nearest whole number.
2. Single-size gradation.

Table 3
Aggregate Quality Requirements

Property	Test Method	Requirement	Remarks
SAC	AQMP	As shown on the plans	
Deleterious Material, %, Max	Tex-217-F, Part I	2.0	Not required for lightweight aggregate.
Decantation, %, Max	Tex-406-A	1.5	
Flakiness Index, Max	Tex-224-F	17	Unless otherwise shown on the plans.
Los Angeles Abrasion, %, Max	Tex-410-A	35	
Magnesium Sulfate Soundness, 5 Cycle, %, Max	Tex-411-A	25	
Micro-Deval Abrasion, %, Max	Tex-461-A	–	Not used for acceptance purposes. Used by the Engineer as an indicator for further investigation.
Coarse Aggregate Angularity, 2 Crushed Faces, %, Min	Tex-460-A, Part I	85	Unless otherwise shown on the plans. Only required for crushed gravel
Additional Requirements for Lightweight Aggregate			
Dry Loose Unit Wt., lb./cu. ft.	Tex-404-A	35–60	
Pressure Slaking, %, Max	Tex-431-A	6.0	
Freeze-Thaw Loss, %, Max	Tex-432-A	10.0	
Water Absorption, 24°hr., %, Max	Tex-433-A	12.0	Unless otherwise shown on the plans.

2.2. **Precoating**. Precoat aggregate uniformly and adequately with asphalt material to the satisfaction of the Engineer when shown on the plans. Specific aggregates may be prohibited from being precoated when shown on the plans. Meet Table 2 and Table 3 requirements before precoating. Furnish precoated aggregate that spreads uniformly using approved mechanical spreading equipment.

The Engineer retains the right to select a target value for the desired percent by weight of residual bitumen coating on the aggregate. Furnish precoated aggregate that is within ±0.3% of the target value when tested in accordance with Tex-236-F. The Engineer may require trial batches to assist in selecting the target value.

The Engineer retains the right to remove precoat material from aggregate samples in accordance with Tex-236-F and test the aggregate to verify compliance with Table 2 and Table 3 requirements. Gradation testing may be performed with precoat intact.

2.2.1. **Asphalt Material**. Precoat the aggregates with asphalt material that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions." Use any asphalt material that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," unless a specific precoat material is specified on the plans.

2.2.2. **Additives**. Use the type and rate of additive specified when shown on the plans. Add in accordance with Item 301, "Asphalt Antistripping Agents." Use Tex-530-C for verification during production testing unless otherwise directed.

3. EQUIPMENT

Manufacture precoated aggregate in a mixing plant that produces uniformly coated aggregate.

4. CONSTRUCTION

Deliver aggregate to the locations shown on the plans. Prevent segregation, mixing of the various materials or sizes, and contamination with foreign materials when aggregates are stockpiled. The Engineer will reject contaminated stockpiles.

Provide adequate initial cooling of precoated aggregate to prevent asphalt or aggregate damage due to excessive heat buildup in stockpiles. Limit stockpile height to 3 ft. immediately after production when asphalt cement is the precoating material. Consolidate stockpiles after adequate cooling, as approved. The Engineer will reject stockpiles showing evidence of damage due to excessive heat buildup.

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, tools, and incidentals will not be measured or paid for directly but is subsidiary to or included under "Payment" in other pertinent Items.

Item 310
Prime Coat

1. DESCRIPTION

Prepare and treat existing or newly constructed surface with an asphalt binder or other specialty prime coat binder material. Apply blotter material as required.

2. MATERIALS

2.1. **Binder**. Use material of the type and grade shown on the plans in accordance with Item 300, "Asphalts, Oils, and Emulsions," or as listed in the Department's MPL for prime coat binders.

2.2. **Blotter**. Use either base course sweepings obtained from cleaning the base or native sand as blotter materials unless otherwise shown on the plans or approved.

3. EQUIPMENT

Provide applicable equipment in accordance with Article 316.3., "Equipment."

4. CONSTRUCTION

4.1. **General**. Apply the mixture when the air temperature is at or above 60°F, or above 50°F and rising. Measure the air temperature in the shade away from artificial heat. The Engineer will determine when weather conditions are suitable for application.

Do not permit traffic, hauling, or placement of subsequent courses over freshly constructed prime coats. Maintain the primed surface until placement of subsequent courses or acceptance of the work.

4.2. **Surface Preparation**. Prepare the surface by sweeping or other approved methods. Lightly sprinkle the surface with water before applying bituminous material, when directed, to control dust and ensure absorption.

4.3. **Application**.

4.3.1. **Binder**. The Engineer will select the application temperature within the limits recommended in Item 300, "Asphalts, Oils, and Emulsions," or by the material manufacturer. Apply material within 15°F of the selected temperature but do not exceed the maximum allowable temperature.

Distribute the material smoothly and evenly at the rate selected by the Engineer. Roll the freshly applied prime coat with a pneumatic-tire roller to ensure penetration when directed.

4.3.2. **Blotter**. Spread blotter material before allowing traffic to use a primed surface. Apply blotter material to primed surface at the specified rate when "Prime Coat and Blotter" is shown on the plans as a bid item or as directed. Apply blotter to spot locations when "Prime Coat" is shown on the plans as a bid item or as directed to accommodate traffic movement through the work area. Remove blotter material before placing the surface. Dispose of blotter material according to applicable state and federal requirements.

5. MEASUREMENT

This Item will be measured by the gallon of binder placed and accepted.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Prime Coat" or "Prime Coat and Blotter" of the type and grade of binder specified. This price is full compensation for cleaning and sprinkling the area to be primed; materials, including blotter material; and rolling, equipment, labor, tools, and incidentals.

Item 316
Seal Coat

1. DESCRIPTION

Construct a surface treatment consisting of one or more applications of a single layer of asphalt material covered with a single layer of aggregate.

2. MATERIALS

Furnish materials of the type and grade shown on the plans in accordance with the following:

2.1. **Asphalt**. Furnish asphalt materials meeting the requirements of Item 300, "Asphalts, Oils, and Emulsions."

Furnish Type II or Type III A-R binder in accordance with Section 300.2.9., "Asphalt-Rubber Binders," as shown on the plans. Furnish a blend design for approval. Include in the design, at a minimum, the following:

- manufacturer and grade of asphalt cement;
- manufacturer and grade of crumb rubber;
- manufacturer, type, and percentage of extender oil, if used;
- test report on crumb rubber gradation in accordance with Tex-200-F, Part I;
- design percentage of crumb rubber versus asphalt content;
- blending temperature; and
- test results on the properties at reaction times of 60, 90, 240, 360, and 1,440 min. in accordance with Section 300.2.9., "Asphalt-Rubber Binders."

Furnish a new asphalt-rubber blend design if the grade or source for any of the components changes.

If a tack coat is specified when using asphalt-rubber, unless otherwise shown on the plans or approved, furnish CSS-1H, SS-1H, or a performance grade (PG) binder with a minimum high temperature grade of PG 58 for tack coat binder. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use. If required, verify that emulsified asphalt proposed for use meets the minimum residual asphalt percentage specified in Item 300, "Asphalts, Oils, and Emulsions."

2.2. **Aggregate**. Furnish aggregate meeting Item 302, "Aggregates for Surface Treatments," of the type and grade shown on the plans. Unless otherwise shown on the plans, furnish aggregate with a minimum B Surface Aggregate Classification.

2.3. **Materials Selections**. Furnish asphalt and aggregate shown on the plans.

3. EQUIPMENT

3.1. **Distributor**. Furnish a distributor that will apply the asphalt material uniformly at the specified rate or as directed.

3.1.1. **Transverse Variable Rate**. When a transverse variable rate is shown on the plans, ensure that the nozzles outside the wheel paths will output a predetermined percentage more asphalt material by volume than the nozzles over the wheel paths. Use a dual spray bar distributor as desired to provide for a transverse variable rate.

3.1.2. **Agitation for Asphalt-Rubber**. If using asphalt-rubber, furnish a distributor capable of keeping the rubber in uniform suspension and adequately mixing the asphalt, rubber, and any additional additives.

3.1.3. **Calibration**.

3.1.3.1. **Transverse Distribution**. Furnish a distributor test report, less than 1 yr. old, when tested in accordance with Tex-922-K, Part III. The Department reserves the right to witness the calibration testing. Notify the Engineer 3 days before calibration testing.

Include the following documentation on the test report:

- the serial number of the distributor,
- a method that identifies the actual nozzle set used in the test, and
- the fan width of the nozzle set at a 12-in. bar height.

When a transverse variable rate is required, and a single spray bar is to be used, perform the test using the type and grade of asphalt material to be used on the project. The Engineer may verify the transverse rate and distribution at any time. If verification does not meet the requirements, correct deficiencies and furnish a new test report.

3.1.3.2. **Tank Volume**. Furnish a volumetric calibration and strap stick for the distributor tank in accordance with Tex-922-K, Part I.

Provide documentation of distributor calibration performed not more than 5 yr. before the date first used on the project. The Engineer may verify calibration accuracy in accordance with Tex-922-K, Part II.

3.1.4. **Computerized Distributor**. When paying for asphalt material by weight, the Engineer may allow use of the computerized distributor display to verify application rates. Verify application rate accuracy at a frequency acceptable to the Engineer.

3.2. **Aggregate Spreader**. Use a continuous-feed, self-propelled spreader to apply aggregate uniformly at the specified rate or as directed. If racked in aggregate is specified on the plans, furnish a second aggregate spreader for the racked in aggregate to apply aggregate uniformly at the specified rate.

3.3. **Rollers**. Unless otherwise shown on the plans, furnish light pneumatic-tire rollers in accordance with Item 210, "Rolling."

3.4. **Broom**. Furnish rotary, self-propelled brooms.

3.5. **Asphalt Storage and Handling Equipment**. When the plans or the Engineer allows storage tanks, furnish a thermometer in each tank to indicate the asphalt temperature continuously. Keep equipment clean and free of leaks. Keep asphalt material free of contamination.

3.6. **Aggregate Haul Trucks**. Unless otherwise approved, use trucks of uniform capacity to deliver the aggregate. Provide documentation showing measurements and calculation in cubic yards. Clearly mark the calibrated level. Truck size may be limited when shown on the plans.

3.7. **Digital Distance Measuring Instrument**. Furnish a vehicle with a calibrated digital distance measuring instrument accurate to ±6 ft. per mile.

4. CONSTRUCTION

4.1. **General**. Comply with the seal coat season as shown on the plans. Asphalt and aggregate rates shown on the plans are for estimating purposes only. Adjust the rates for existing conditions as directed.

4.2. **Temporary Aggregate Stockpiles**. The Engineer will approve the location of temporary aggregate stockpiles on the right of way before delivery. Place stockpiles in a manner that will not:

- obstruct traffic or sight distance,
- interfere with the access from abutting property, or
- interfere with roadway drainage.

Locate stockpiles a minimum of 30 ft. from roadway when possible. Sign and barricade as shown on the plans.

4.3. **Aggregate Furnished by the Department**. When shown on the plans, the Department will furnish aggregate to the Contractor without cost. Stockpile locations are shown on the plans.

4.4. **Adverse Weather Conditions**. Do not place surface treatments when, in the Engineer's opinion, general weather conditions are unsuitable. Meet the requirements for air and surface temperature shown below.

4.4.1. **Standard Temperature Limitations**. Apply seal coat when air temperature is above 50°F and rising. Do not apply seal coat when air temperature is 60°F and falling. In all cases, do not apply seal coat when surface temperature is below 60°F.

4.4.2. **Polymer-Modified Asphalt Cement Temperature Limitations**. When using materials described in Section 300.2.2., "Polymer Modified Asphalt Cement," apply seal coat when air temperature is above 70°F and rising. Do not apply seal coat when air temperature is 80°F and falling. In all cases, do not apply seal coat when surface temperature is below 70°F.

4.4.3. **Asphalt-Rubber Temperature Limitations**. Do not place hot asphalt-rubber seal coat when, in the Engineer's opinion, general weather conditions are unsuitable. Apply seal coat when the air temperature is 80°F and above, or above 70°F and rising. In all cases, do not apply seal coat when surface temperature is below 70°F.

4.4.4. **Cool Weather Night Air Temperature**. The Engineer reserves the right to review the **National Oceanic and Atmospheric Administration (NOAA)** weather forecast and determine if the nightly air temperature is suitable for asphalt placement to prevent aggregate loss.

4.4.5. **Cold Weather Application**. When asphalt application is allowed outside of the above temperature restrictions, the Engineer will approve the binder grade and the air and surface temperatures for asphalt material application. Apply seal coat at air and surface temperatures as directed.

4.5. **Mixing Hot A-R Binder**. If using asphalt-rubber, mix in accordance with the approved blend design required in Section 316.2.1., "Asphalt."

At the end of each shift, provide the Engineer with production documentation, which includes the following:

- amount and temperature of asphalt cement before addition of rubber,
- amount of rubber and any extender added,
- viscosity of each hot A-R batch just before roadway placement, and
- time of the rubber additions and viscosity tests.

4.6. **Surface Preparation**. Remove existing raised pavement markers. Repair any damage incurred by removal as directed. Remove dirt, dust, or other harmful material before sealing. When shown on the plans, remove vegetation and blade pavement edges. When directed, apply a tack coat before applying the hot asphalt-rubber treatment on an existing wearing surface in accordance with Section 340.2.5., "Tack Coat."

4.7. **Rock Land and Shot**.

4.7.1. **Definitions**.

- A "rock land" is the area covered at the aggregate rate directed with 1 truckload of aggregate.

- A "shot" is the area covered by 1 distributor load of asphalt material.

4.7.2. **Setting Lengths**. Calculate the lengths of both rock land and shot. Adjust shot length to be an even multiple of the rock land. Verify that the distributor has enough asphalt material to complete the entire shot length. Mark shot length before applying asphalt. When directed, mark length of each rock land to verify the aggregate rate.

4.8. **Asphalt Placement**.

4.8.1. **General**. The maximum shot width is the width of the current transverse distribution test required under Section 316.3.1.3.1., "Transverse Distribution," or the width of the aggregate spreader box, whichever is less. Adjust the shot width so operations do not encroach on traffic or interfere with the traffic control plan, as directed. Use paper or other approved material at the beginning and end of each shot to construct a straight transverse joint and to prevent overlapping of the asphalt. Unless otherwise approved, match longitudinal joints with the lane lines. The Engineer may require a string line if necessary to keep joints straight with no overlapping. Use sufficient pressure to flare the nozzles fully.

Select an application temperature, as approved, in accordance with Item 300, "Asphalts, Oils, and Emulsions." Uniformly apply the asphalt material at the rate directed, within 15°F of the approved temperature, and not above the maximum allowable temperature.

4.8.2. **Limitations**. Do not apply asphalt to the roadway until:

- traffic control methods and devices are in place as shown on the plans or as directed,
- the loaded aggregate spreader is in position and ready to begin,
- haul trucks are loaded with enough aggregate to cover the shot area and are in place behind the spreader box, and
- rollers are in place behind the haul trucks.

4.8.3. **Nonuniform Application**. Stop application if it is not uniform due to streaking, ridging, puddling, or flowing off the roadway surface. Verify equipment condition, operating procedures, application temperature, and material properties. Determine and correct the cause of nonuniform application. If the cause is high or low emulsion viscosity, replace emulsion with material that corrects the problem.

4.8.4. **Test Strips**. The Engineer may stop asphalt application and require construction of test strips at the Contractor's expense if any of the following occurs:

- nonuniformity of application continues after corrective action;
- on 3 consecutive shots, application rate differs by more than 0.03 gal. per square yard from the rate directed; or
- any shot differs by more than 0.05 gal. per square yard from the rate directed.

The Engineer will approve the test strip location. The Engineer may require additional test strips until surface treatment application meets specification requirements.

4.9. **Aggregate Placement**. As soon as possible, apply aggregate uniformly at the rate directed without causing the rock to roll over.

4.9.1. **Nonuniform Application**. Stop application if it is not uniform in the transverse direction. Verify equipment condition, operating procedures, and transverse application rate. The transverse application rate should be within 1 lb. Determine and correct the cause of nonuniform application.

4.10. **Rolling**. Start rolling operation on each shot as soon as aggregate is applied. Use sufficient rollers to cover the entire mat width in 1 pass, i.e., 1 direction. Roll in a staggered pattern. Unless otherwise shown on the plans, make a minimum of:

- 5 passes or

- 3 passes when the asphalt material is an emulsion.

If rollers are unable to keep up with the spreader box, stop application until rollers have caught up, or furnish additional rollers. Keep roller tires asphalt-free.

4.11. **Patching**. Before rolling, repair spots where coverage is incomplete. Repair can be made by hand spotting or other approved method. When necessary, apply additional asphalt material to embed aggregate.

4.12. **Racked-in Aggregate**. If specified on the plans, apply racked-in aggregate after patching, uniformly at the rate directed. The racked-in aggregate must be applied before opening the roadway or intersection to traffic.

4.13. **Brooming**. After rolling, sweep as soon as aggregate has sufficiently bonded to remove excess. In areas of racked-in aggregate, sweep as directed.

4.14. **Final Acceptance**. Maintain seal coat until the Engineer accepts the work. Repair any surface failures. Before final project acceptance, remove all temporary stockpiles and restore the area to the original contour and grade.

5. MEASUREMENT

5.1. **Asphalt Material**. Unless otherwise shown on the plans, asphalt material will be measured by one of the following methods:

5.1.1. **Volume**. Asphalt material, including all components, will be measured at the applied temperature by strapping the tank before and after road application. The distributor calibrated strap stick will be used for measuring the asphalt level in the distributor asphalt tank. The certified tank chart will be used to determine the beginning gallons and the final gallons in the distributor tank. The quantity to be measured for payment will be the difference between the beginning gallons and the final gallons.

5.1.2. **Weight**. Asphalt material will be measured in tons using certified scales meeting the requirements of Item 520, "Weighing and Measuring Equipment," unless otherwise approved. The transporting truck must have a seal attached to the draining device and other openings. Random checking on public scales at the Contractor's expense may be required to verify weight accuracy.

Upon work completion or temporary suspension, any remaining asphalt material will be weighed by a certified public weigher, or measured by volume in a calibrated distributor or tank and the quantity converted to tons at the measured temperature. The quantity to be measured will be the number of tons received minus the number of tons remaining after all directed work is complete and minus the amount used for other items.

5.1.3. **Quantity Adjustments**. When shown on the plans, the measured quantity will be adjusted to compensate for variation in required application or residual rates for different types of asphalt.

5.2. **Aggregate**. Aggregate will be measured by the cubic yard in the trucks as applied on the road. Strike off the loaded aggregate for accurate measurement when directed.

5.3. **Loading, Hauling, and Distributing Aggregate**. When the Department furnishes the aggregate, the loading, hauling, and distributing will be measured by the cubic yard in the trucks as applied on the road.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt," "Aggregate," and "Loading, Hauling, and Distributing Aggregate" of the types-grades specified on the plans. These prices are full compensation for surface preparation; furnishing, preparing, hauling, and placing materials; removing existing pavement markers and excess aggregate; rolling; cleaning up stockpiles; and equipment, labor, tools, and incidentals.

Item 320
Equipment for Asphalt Concrete Pavement

1. DESCRIPTION

Provide equipment to produce, haul, place, compact, and core asphalt concrete pavement.

2. EQUIPMENT

Ensure weighing and measuring equipment complies with Item 520, "Weighing and Measuring Equipment." Synchronize equipment to produce a mixture meeting the required proportions.

2.1. **Production Equipment**. Provide:

- drum-mix type, weigh-batch, or modified weigh-batch mixing plants that ensure a uniform, continuous production;
- automatic proportioning and measuring devices with interlock cut-off circuits that stop operations if the control system malfunctions;
- visible readouts indicating the weight or volume of asphalt and aggregate proportions;
- safe and accurate means to take required samples by inspection forces;
- permanent means to check the output of metering devices and to perform calibration and weight checks; and
- additive-feed systems to ensure a uniform, continuous material flow in the desired proportion.

2.1.1. **Drum-Mix Plants**. Provide a mixing plant that complies with the requirements below.

2.1.1.1. **Aggregate Feed System**. Provide:

- a minimum of one cold aggregate bin for each stockpile of individual materials used to produce the mix;
- bins designed to prevent overflow of material;
- scalping screens or other approved methods to remove any oversized material, roots, or other objectionable materials;
- a feed system to ensure a uniform, continuous material flow in the desired proportion to the dryer;
- an integrated means for moisture compensation;
- belt scales, weigh box, or other approved devices to measure the weight of the combined aggregate; and
- cold aggregate bin flow indicators that automatically signal interrupted material flow.

2.1.1.2. **Reclaimed Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS) Feed Systems**. Provide a minimum of one bin for each stockpile of RAP and RAS to weigh and feed the recycled material into the hot-mix plant.

2.1.1.3. **Mineral Filler Feed System**. Provide a closed system for mineral filler that maintains a constant supply with minimal loss of material through the exhaust system. Interlock the measuring device into the automatic plant controls to automatically adjust the supply of mineral filler to plant production and provide a consistent percentage to the mixture.

2.1.1.4. **Heating, Drying, and Mixing Systems**. Provide:

- a dryer or mixing system to agitate the aggregate during heating;
- a heating system that controls the temperature during production to prevent aggregate and asphalt binder damage;

- a heating system that completely burns fuel and leaves no residue; and
- a recording thermometer that continuously measures and records the mixture discharge temperature.

2.1.1.5. **Dust Collection System**. Provide a dust collection system to collect fines generated by the drying and mixing process and reintroduce them into the mixing drum.

2.1.1.6. **Asphalt Binder Equipment**. Supply equipment to heat binder to the required temperature. Equip the heating apparatus with a continuously recording thermometer located at the highest temperature point. Produce a 24-hr. chart of the recorded temperature. Place a device with automatic temperature compensation that accurately meters the binder in the line leading to the mixer.

Furnish a sampling port on the line between the storage tank and mixer. Supply an additional sampling port between any additive blending device and mixer.

Supply an in-line viscosity-measuring device located between the blending unit and the mixing drum when A-R binder is specified. Provide a means to calibrate the meter on site when an asphalt mass flow meter is used.

2.1.1.7. **Mixture Storage and Discharge**. Provide a surge-storage system to minimize interruptions during operations unless otherwise approved. Furnish a gob hopper or other device to minimize segregation in the bin. Provide an automated system that weighs the mixture upon discharge and produces a ticket showing:

- date,
- project identification number,
- plant identification,
- mix identification,
- vehicle identification,
- total weight of the load,
- tare weight of the vehicle,
- weight of mixture in each load, and
- load number or sequential ticket number for the day.

2.1.1.8. **Truck Scales**. Provide standard platform scales at an approved location.

2.1.2. **Weigh-Batch Plants**. Provide a mixing plant that complies with Section 320.2.1.1., "Drum-Mix Plants," except as required below.

2.1.2.1. **Screening and Proportioning**. Provide enough hot bins to separate the aggregate and to control proportioning of the mixture type specified. Supply bins that discard excessive and oversized material through overflow chutes. Provide safe access for inspectors to obtain samples from the hot bins.

2.1.2.2. **Aggregate Weigh Box and Batching Scales**. Provide a weigh box and batching scales to hold and weigh a complete batch of aggregate. Provide an automatic proportioning system with low bin indicators that automatically stop when material level in any bin is not enough to complete the batch.

2.1.2.3. **Asphalt Binder Measuring System**. Provide bucket and scales with enough capacity to hold and weigh binder for one batch.

2.1.2.4. **Mixer**. Equip mixers with an adjustable automatic timer that controls the dry and wet mixing period and locks the discharge doors for the required mixing period. Furnish a pug mill with a mixing chamber large enough to prevent spillage.

2.1.3. **Modified Weigh-Batch Plants**. Provide a mixing plant that complies with Section 320.2.1.2., "Weigh-Batch Plants," except as specifically described below.

2.1.3.1. **Aggregate Feeds**. Aggregate control is required at the cold feeds. Hot bin screens are not required.

2.1.3.2. **Surge Bins**. Provide one or more bins large enough to produce 1 complete batch of mixture.

2.2. **Hauling Equipment**. Provide trucks with enclosed sides to prevent asphalt mixture loss. Cover each load of mixture with waterproof tarpaulins when shown on the plans or required by the Engineer. Clean all truck beds before use to ensure the mixture is not contaminated. Coat the inside truck beds, when necessary, with an approved release agent from the Department's MPL.

2.3. **Placement and Compaction Equipment**. Provide equipment that does not damage underlying pavement. Comply with laws and regulations concerning overweight vehicles. Use other equipment that will consistently produce satisfactory results, when approved.

2.3.1. **Asphalt Paver**. Furnish a paver that will produce a finished surface that meets longitudinal and transverse profile, typical section, and placement requirements. Ensure the paver does not support the weight of any portion of hauling equipment other than the connection. Provide loading equipment that does not transmit vibrations or other motions to the paver that adversely affect the finished pavement quality. Equip the paver with an automatic, dual, longitudinal-grade control system and an automatic, transverse-grade control system.

2.3.1.1. **Tractor Unit**. Supply a tractor unit that can push or propel vehicles, dumping directly into the finishing machine to obtain the desired lines and grades to eliminate any hand finishing. Equip the unit with a hitch able to maintain contact between the hauling equipment's rear wheels and the finishing machine's pusher rollers while mixture is unloaded.

2.3.1.2. **Screed**. Provide a heated compacting screed that will produce a finished surface that meets longitudinal and transverse profile, typical section, and placement requirements. Screed extensions must provide the same compacting action and heating as the main unit unless otherwise approved.

2.3.1.3. **Grade Reference**. Provide a grade reference with enough support that the maximum deflection does not exceed 1/16 in. between supports. Ensure that the longitudinal controls can operate from any longitudinal grade reference including a string line, ski, mobile reference, or joint matching shoes.

2.3.2. **Material Transfer Devices**. Provide the specified type of device when shown on the plans. Ensure the devices provide a continuous, uniform mixture flow to the asphalt paver. Provide windrow pick-up equipment, when used, constructed to pick up substantially all roadway mixture placed in the windrow.

2.3.3. **Remixing Equipment**. Provide equipment, when required, that includes a pug mill, variable pitch augers, or variable diameter augers operating under a storage unit with a minimum capacity of 8 tons.

2.3.4. **Motor Grader**. Provide a self-propelled grader, when allowed, with a blade length of at least 12 ft. and a wheelbase of at least 16 ft.

2.3.5. **Thermal Imaging System or Hand-Held Thermal Camera**. Provide a thermal imaging system or hand-held thermal camera meeting the requirements of Tex-244-F.

2.3.6. **Rollers**. Provide rollers meeting the requirements of Item 210, "Rolling," for each type of roller required for compaction.

2.3.7. **Straightedges and Templates**. Furnish 10-ft. straightedges and other templates as required or approved.

2.4. **Field Laboratory**. Provide and maintain a Type D Structure (Asphalt Mix Control Laboratory) unless otherwise shown on the plans in accordance with Item 504, "Field Office and Laboratory," and details shown on the plans.

2.5. **Coring Equipment**. Provide equipment suitable to obtain a pavement specimen meeting the dimensions for testing when coring is required.

3. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 330
Limestone Rock Asphalt Pavement

1. DESCRIPTION

Construct a base course, a surface course, a level-up course, or any combination of these courses of the types and grades shown on the plans using a cold-mixed material consisting of native limestone rock asphalt (LRA) aggregate, fluxing material, water, and when specified, additives and virgin aggregates.

2. MATERIALS

2.1. **LRA Mixture**. Furnish LRA according to DMS-9210, "Limestone Rock Asphalt (LRA)," of the type, grade, and Surface Aggregate Classification (SAC) shown on the plans.

2.2. **Tack Coat**. Furnish CSS-1H, SS-1H, or a performance-graded (PG) binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions," unless otherwise shown on the plans or approved. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use. Verify that emulsified asphalt proposed for use meets the minimum residual asphalt percentage specified in Item 300, "Asphalts, Oils, and Emulsions," if required.

The Engineer will obtain at least one sample of the tack coat per project and test the sample for specification compliance. The Engineer will obtain the sample from the asphalt distributor immediately before use.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Provide quality control (QC) testing as needed to meet the requirements of this Item. The Department will perform quality assurance (QA) testing.

4.1. **Quality Control Plan (QCP)**. Develop a written QCP and submit for approval before beginning production. Follow QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Include the following items in the QCP:

4.1.1. **Project Personnel**. For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action and
- current contact information for each individual listed.

4.1.2. **Loading and Transporting**. For loading and transporting, include:

- type and application method for release agents and
- truck and rail car loading procedures to avoid segregation.

4.1.3. **Placement and Compaction**. For placement and compaction, include:

- proposed arrangements for any required pre-paving meetings, including dates and locations;

- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver while avoiding segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations;
- paver operations (e.g., operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.2. **Stockpiling of LRA**. Provide a smooth and well-drained area, cleared of trash, weeds, and grass if storing LRA at the project site. Stockpile, handle, and load LRA in a manner that will minimize aggregate degradation and segregation. Avoid contamination and mixing of stockpiles. The Engineer may reject stockpiled materials that come in contact with the earth or other objectionable material.

4.3. **Hauling Operations**. Transport the LRA mixture to the project or delivery point in trucks or rail cars as needed. Clean all truck beds or rail cars before use to ensure mixture is not contaminated. Use a release agent on the Department's MPL to coat truck beds and inside rail cars when necessary. Waterproof tarpaulins are not required to cover loads.

4.4. **Placement Operations**. Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of mixture by at least 6 in. Place mixture so longitudinal joints on the surface course coincide with lane lines, or as directed. Ensure that all finished surfaces will drain properly.

When desired, dump the asphalt mixture in a windrow and then place it in the finishing machine with windrow pickup equipment unless otherwise shown on the plans. Prevent the windrow pickup equipment from contaminating the mixture.

Defer compaction after placing the paving mixture as directed to allow for volatilization. Allow the previous pavement course to dry and cure before placing the next course when placing more than one course. The course will be considered cured if the hydrocarbon volatile content of the mixture is 0.4% or less by weight of the mixture when tested according to Tex-213-F, unless otherwise directed.

Use a motor grader to spread the mixture when shown on the plans or as approved. Thoroughly aerate the mixture and spread into place with a power motor grader in a uniform layer. Placement in narrow strips or small irregular areas may require hand spreading.

4.4.1. **Weather Conditions**. Place the mixture when the roadway surface temperature is 60°F or higher unless otherwise approved. Place the mixture only when the weather conditions and moisture conditions of the roadway surface are suitable in the opinion of the Engineer.

4.4.2. **Tack Coat**. Clean the surface before placing the tack coat. Apply tack coat uniformly at the approved rate, unless otherwise directed. The Engineer will set the rate between 0.04 and 0.10 gallons of residual asphalt per square yard of surface area. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and joints. Prevent splattering of the tack coat when placed adjacent to curb, gutter, and structures. Roll the tack coat with a pneumatic-tire roller to remove streaks and other irregular patterns when directed.

4.5. **Compaction**. Furnish the type, size, and number or rollers required for compaction, as approved. Furnish at least one medium pneumatic-tire roller (minimum 12-ton weight). Use Tex-207-F, Part IV, to establish rolling patterns that achieve maximum compaction. Follow the selected rolling pattern unless changes that affect compaction occur in the mixture or placement conditions. Establish a new rolling pattern when such changes occur. Compact the pavement to the cross-section of the finished paving mixture meeting the requirements

of the plans and specifications. Operate vibratory rollers in static mode when not compacting or changing directions, or when the plan depth of the pavement mat is less than 1-1/2 in. unless otherwise directed.

Start by first rolling the joint with the adjacent pavement and then continue by rolling longitudinally at the sides when rolling with the 3-wheel, tandem, or vibratory rollers. Proceed toward the center of the pavement, overlapping on successive trips by at least 1 ft., unless otherwise directed. Make alternate trips of the roller slightly different in length. Begin rolling at the low side and progress toward the high side on superelevated curves unless otherwise directed.

Avoid displacement of the mixture. Correct any displacement that may occur to the satisfaction of the Engineer. Ensure pavement is fully compacted before allowing rollers to stand on the pavement. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed. Keep diesel, gasoline, oil, grease, and other foreign matter off the mixture.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with the rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

4.6. **Irregularities**. Immediately take corrective actions if surface irregularities, including segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, streaks, or uncoated aggregate particles are detected. The Engineer may allow placement to continue for no more than one day of production while the Contractor takes appropriate action. Suspend paving if the problem still exists after that day until it is corrected to the satisfaction of the Engineer.

Remove and replace any mixture that does not bond to the existing pavement or has other surface irregularities identified above at the expense of the Contractor and to the satisfaction of the Engineer.

4.7. **Ride Quality**. Use Surface Test Type A to evaluate ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

LRA pavement will be measured by the ton of composite LRA pavement of the type actually used in the completed and accepted work in accordance with the plans and specifications for the project. Measure on scales in accordance with Item 520, "Weighing and Measuring Equipment." Keep records on tare weight, gross weight, and net weight of the LRA paving mixture for each load of the same type of mixture. The Construction Division will measure and report the moisture content in accordance with Tex-212-F, Part II of the LRA paving mixture used to determine payment at the plant. All water and light hydrocarbon volatiles in the mixture measured in accordance with Tex-212-F, Part II, in excess of 6.0% by weight at the time of weighing, will be deducted from the net weight to determine the quantity for payment.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 330.5., "Measurement," will be paid for at the unit price bid for "Limestone Rock Asphalt Pavement" of the type, grade, and SAC specified.

These prices are full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

Pay adjustment for ride quality, when required, will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

Item 334
Hot-Mix Cold-Laid Asphalt Concrete Pavement

1. DESCRIPTION

Construct a cold-laid pavement layer composed of a compacted mixture of aggregate and asphalt material mixed hot in a mixing plant.

This Item governs mixtures designed for cold placement, defined as placement temperatures below 175°F. If the mixture placement temperature is greater than 175°F, then design, produce, place, and compact the mixture in accordance with the applicable hot-mix asphalt specification.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate**. Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. **Coarse Aggregate**. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces

other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates**. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300.

2.1.2. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. No more than 15% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.5
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note[1]
Los Angeles abrasion, %, Max	Tex-410-A	40
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	30[2]
Crushed face count,[3] %, Min	Tex-460-A, Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Combined Aggregates[4]		
Sand equivalent, %, Min	Tex-203-F	45

1. Not used for acceptance purposes. Used by the Engineer as an indicator of the need for further investigation.
2. Unless otherwise shown on the plans.
3. Only applies to crushed gravel.
4. Aggregates, without mineral filler or additives, combined as used in the job-mix formula (JMF).

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–15

2.2. **Mineral Filler**. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ashunless otherwise shown on the plans. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

2.3. **Baghouse Fines**. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. **Binder Material**. Furnish asphalt binder, primer, additives, and water, unless otherwise shown on the plans.

2.4.1. **Asphalt Binder**. Provide the asphalt shown on the plans, meeting the requirements of Item 300, "Asphalts, Oils, and Emulsions."

2.4.2. **Primer**. Provide an approved asphalt primer consisting of a blend of asphalt cement and hydrocarbon volatiles.

2.4.3. **Water**. Provide water that meets the requirements of Item 204, "Sprinkling."

2.4.4. **Additives**. Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing or improve the quality of the mixture may be allowed when approved. Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

When lime or liquid antistripping agents isused, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime back into the drum.

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, or a performance-graded (PG) binder with a minimum high-temperature grade of PG 58 for tack coat in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized or preferred tack coat materials may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use. The Department may sample the tack coat to verify specification compliance.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Design, produce, store, transport, place, and compact the specified paving mixture in accordance with the requirements of this Item. Provide the mix design unless otherwise shown on the plans. The Department will perform quality assurance (QA) testing. Provide quality control (QC) testing as needed to meet the requirements of this Item.

4.1. **Mixture Design**.

4.1.1. **Design Requirements**. Use the typical weight design example given in Tex-204-F, Part I to design a paving mixture that consists of a uniform mixture of aggregate, asphalt material, primer, additives, and water, if allowed, which meets the requirements shown in Tables 4 and 5, unless otherwise shown on the plans. Ensure that the mixture leaves the plant in a workable condition. Provide materials that remain workable in a stockpile for at least 6 mo.

Submit a new mixture design at any time during the project. The Engineer must approve all mixture designs before the Contractor can begin production.

4.1.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation and target asphalt percentage used to establish target values for mixture production. JMF1 is the original laboratory mixture design used to produce the trial batch. The Engineer will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. Provide the Engineer with split samples of the mixtures and blank samples used to determine the ignition oven correction factors. The Engineer will determine the aggregate and asphalt correction factors from the ignition oven using Tex-236-F.

Table 4
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirments

Sieve Size	A Coarse Base	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture
2"	100.0[1]	–	–	–	–
1-1/2"	98.0–100.0	100.0[1]	–	–	–
1"	78.0–94.0	98.0–100.0	100.0[1]	–	–
3/4"	64.0–85.0	84.0–98.0	95.0–100.0	100.0[1]	–
1/2"	50.0–70.0	–	–	98.0–100.0	100.0[1]
3/8"	–	60.0–80.0	70.0–85.0	85.0–100.0	98.0–100.0
#4	30.0–50.0	40.0–60.0	43.0–63.0	50.0–70.0	70.0–90.0
#8	22.0–36.0	29.0–43.0	32.0–44.0	35.0–46.0	38.0–48.0
#30	8.0–23.0	13.0–28.0	14.0–28.0	15.0–29.0	12.0–27.0
#50	3.0–19.0	6.0–20.0	7.0–21.0	7.0–20.0	6.0–19.0
#200	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0
Design VMA,[2] % Minimum					
–	12.0	13.0	14.0	15.0	16.0
Production (Plant-Produced) VMA,[2] % Minimum					
–	11.5	12.5	13.5	14.5	15.5

1. Defined as maximum sieve size. No tolerance allowed.
2. Voids in mineral aggregates.

Table 5
Laboratory Mixture Design Properties

Property	Test Method	Requirement
Target laboratory-molded density, %[1]	Tex-207-F	92.5 ±1.5
Hveem stability, Min	Tex-208-F	35
Hydrocarbon-volatile content, %, Max	Tex-213-F	0.6
Moisture content, %, Max[2]	Tex-212-F	1.0
Boil test, %, Max[3]	Tex-530-C	10

1. Unless otherwise shown on the plans.
2. Unless otherwise approved.
3. Limit may be increased or eliminated when approved.

4.2. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and obtain approval to proceed after any production suspension for noncompliance to the specification.

4.2.1. **Stockpiling of Aggregates**. Provide a smooth and well-drained area, cleared of trash, weeds, and grass. Build stockpiles in a manner that will minimize aggregate degradation and segregation. Avoid contamination and mixing of stockpiles. Provide aggregate stockpiles for a minimum of 2 days' production before beginning plant operations. Maintain at least a 2-day aggregate supply through the course of the project unless otherwise directed. Stockpile aggregate for each source and type separately. The Engineer may reject stockpiled materials that come in contact with the earth or other objectionable material.

4.2.2. **Storage and Heating of Asphalt Materials**. Provide enough asphalt material storage capacity to meet the requirements of the plant. Do not heat the asphalt binder above the temperatures specified in Item 300,

"Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Keep all equipment used in the storage and handling of asphalt material clean at all times and operate the equipment in a manner that will prevent contamination with foreign matter.

4.2.3. **Storage of the Asphalt Mixture**. Store the asphalt mixture in a surge-storage system or in a stockpile. Provide a smooth and well-drained area, cleared of trash, weeds, and grass if the asphalt mixture is stored in a stockpile. Build stockpiles in a manner that will minimize aggregate degradation and segregation. Avoid contamination and mixing of stockpiles.

4.2.4. **Mixing and Discharge of Materials**. Produce the mixture at a discharge temperature between 145°F and 275°F, as directed. Do not allow the temperature to vary from the selected temperature by more than 25°F. The Department will not pay for or allow placement of any mixture produced above 300°F.

4.2.5. **Moisture Content**. Furnish the mixture at a moisture content of no more than 1% by weight when discharged from the mixer, unless otherwise shown on the plans or approved. Cease operations at moisture contents above 1% until corrective actions reduce moisture content.

4.3. **Hauling Operations**. Clean all truck beds before use to ensure mixture is not contaminated. Use a release agent on the Department's MPL to coat truck beds when a release agent is necessary.

4.4. **Placement Operations**. Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place mixture on the road below 175°F. Place the mixture to produce a smooth, finished surface with a uniform appearance and texture that meet typical section requirements. Offset longitudinal joints of successive courses of mixture by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines, or as directed. Ensure that all finished surfaces will drain properly.

When desired, dump the asphalt mixture in a windrow and then place in the finishing machine with windrow pickup equipment unless otherwise shown on the plans. Prevent the windrow pickup equipment from contaminating the mixture.

Defer compaction after placing the paving mixture, as directed, to allow for volatilization. Allow the previous course to dry and cure before placing the next course when placing more than one pavement course. Consider the course cured if the hydrocarbon volatile content of the mixture is 0.4% or less by weight of the mixture when tested according to Tex-213-F unless otherwise directed.

Use a motor grader to spread the mixture when shown on the plans or approved. Thoroughly aerate the mixture and spread into place with a power motor grader in a uniform layer. Placement in narrow strips or small irregular areas may require hand spreading.

4.4.1. **Weather Conditions**. Place the mixture when the roadway surface temperature is 60°F or higher unless otherwise approved. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable in the opinion of the Engineer unless otherwise shown on the plans.

4.4.2. **Tack Coat**. Clean the surface before placing the tack coat. Apply tack coat uniformly at the approved rate unless otherwise directed. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and joints. Prevent splattering of the tack coat when placed adjacent to curb, gutter, and structures. Roll the tack coat with a pneumatic-tire roller when directed.

4.5. **Compaction**. Furnish the type, size, and number of rollers required for compaction as approved. Furnish at least one medium pneumatic-tire roller (minimum 12-ton weight). Use the control strip method given in Tex-207-F, Part IV, to establish rolling patterns that achieve maximum compaction. Follow the selected rolling pattern unless changes that affect compaction occur in the mixture or placement conditions. Establish a new rolling pattern when such changes occur. Compact the pavement to the cross-section of the finished paving mixture meeting the requirements of the plans and specifications. Operate vibratory rollers in static

mode when not compacting, changing directions, or when the plan depth of the pavement mat is less than 1-1/2 in. unless otherwise directed.

Start by first rolling the joint with the adjacent pavement and then continue by rolling longitudinally at the sides when rolling with 3-wheel tandem or vibratory rollers. Proceed toward the center of the pavement, overlapping on successive trips by at least 1 ft., unless otherwise directed. Make alternate trips of the roller slightly different in length. Begin rolling at the low side on superelevated curves and progress toward the high side unless otherwise directed.

Avoid displacement of the mixture. Correct any displacement that may occur to the satisfaction of the Engineer. Ensure pavement is fully compacted before allowing rollers to stand on the pavement. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed. Keep diesel, gasoline, oil, grease, and other foreign matter off the mixture.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with the rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.6. **Production Testing and Operational Tolerances**. The aggregate gradation and the asphalt binder content of the produced mixture must not vary from the JMF by more than the percentage point tolerances shown in Table 6. The gradation of the produced mixture may fall outside the master grading limits for any of the sieve sizes from the 1-1/2 in. through the No. 50 sieve if it is within the JMF tolerances. The aggregate gradation of the No. 200 sieve may not exceed the master gradations shown in Table 4. Any sieve size shown in Table 4 with 100% passing requirements will be allowed a 2% tolerance before the material is considered out of specification.

The Engineer may allow alternate methods for determining the asphalt content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F does not yield reliable results. Provide evidence to the Engineer that results from Tex-236-F are not reliable before an alternate method will be allowed. Use the applicable test procedure as directed if an alternate test method is allowed.

Cease production if 3 consecutive tests indicate that the material produced exceeds the tolerances shown in Table 6 for any individual sieve or laboratory-molded density until corrective actions are taken and the results approved. Cease production if 2 consecutive tests indicate that the asphalt binder content tolerances shown in Table 6 are exceeded until corrective actions are taken and the results approved.

Cease production if the Hveem stability shown in Table 5 is not met for 3 consecutive tests until corrective actions are taken and the results approved.

Table 6
Operational Tolerances

Property	Test Method	Operational Tolerance From JMF
Individual % retained for sieve sizes smaller than 1-1/2" and larger than #8	Tex-200-F	±5.0
Individual % retained for sieve sizes smaller than #8		±3.0
Asphalt binder content, %	Tex-236-F	±0.3
Laboratory-molded density, %	Tex-207-F	±1.0

4.7. **Irregularities**. Immediately take corrective action if surface irregularities, including segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, streaks, or uncoated aggregate particles are detected. The Engineer may suspend production or placement operations until the problem is corrected.

Remove and replace any mixture that does not bond to the existing pavement or has other surface irregularities identified above at the expense of the Contractor and to the satisfaction of the Engineer.

4.8. **Ride Quality**. Use Surface Test Type A to evaluate ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

This Item will be measured by the ton of composite asphalt concrete mixture of the type used in the completed and accepted work. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment. "

For mixture produced by a weigh-batch plant or a modified weigh-batch plant, measurement will be determined on the batch scales unless surge-storage or stockpiling is used. Keep records of the number of batches, batch design, and the weight of the composite asphalt concrete mixture. The composite asphalt concrete mixture is defined as the asphalt, primer, aggregate, additives, and any residual moisture that is not designated to be deducted. Where surge-storage or stockpiling is used, measurement of the material taken from the surge-storage bin or stockpile will be made on truck scales or suspended hopper scales.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Article 334.5., "Measurement," will be paid for at the unit bid price for "Hot-Mix Cold-Laid Asphalt Concrete Pavement" of the mixture type, SAC, and asphalt binder specified.

This price is full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

Pay adjustment for ride quality, when required, will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

Item 340
Dense-Graded Hot-Mix Asphalt (Small Quantity)

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant. This specification is intended for small quantity (SQ) HMA projects, typically under 5,000 tons total production.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate**. Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Aggregate from reclaimed asphalt pavement (RAP) is not required to meet Table 1 requirements unless otherwise shown on the plans. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. **Coarse Aggregate**. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates**. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Coarse aggregate from RAP and Recycled Asphalt Shingles (RAS) will be considered as Class B aggregate for blending purposes.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design Excel template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the Excel template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.2. **Intermediate Aggregate**. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used, that are free from organic impurities.

The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used, that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

2.1.3. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. No more than 15% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.5
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note[1]
Los Angeles abrasion, %, Max	Tex-410-A	40
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	30
Crushed face count,[2] %, Min	Tex-460-A, Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Combined Aggregate[3]		
Sand equivalent, %, Min	Tex-203-F	45

1. Not used for acceptance purposes. Optional test used by the Engineer as an indicator of the need for further investigation.
2. Only applies to crushed gravel.
3. Aggregates, without mineral filler, RAP, RAS, or additives, combined as used in the job-mix formula (JMF).

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler**. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

2.3. **Baghouse Fines**. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. **Asphalt Binder**. Furnish the type and grade of performance-graded (PG) asphalt specified on the plans.

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized or preferred tack coat materials may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

The Engineer will obtain at least one sample of the tack coat binder per project in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300, "Asphalts, Oils, and Emulsions." The Engineer will obtain the sample from the asphalt distributor immediately before use.

2.6. **Additives**. Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing, compaction, or improve the quality of the mixture are allowed when approved. Provide the Engineer

with documentation, such as the bill of lading, showing the quantity of additives used in the project unless otherwise directed.

2.6.1. **Lime and Liquid Antistripping Agent**. When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.6.2. **Warm Mix Asphalt (WMA)**. Warm Mix Asphalt (WMA) is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using approved WMA additives or processes from the Department's MPL.

WMA is allowed for use on all projects and is required when shown on the plans. When WMA is required, the maximum placement or target discharge temperature for WMA will be set at a value below 275°F.

Department-approved WMA additives or processes may be used to facilitate mixing and compaction of HMA produced at target discharge temperatures above 275°F; however, such mixtures will not be defined as WMA.

2.7. **Recycled Materials**. Use of RAP and RAS is permitted unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages shown in Table 4 may be decreased or increased when shown on the plans. Determine asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F. The Engineer may verify the asphalt binder content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 5 during mixture design and HMA production when RAP or RAS is used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes referenced in Tables 4 and 5 are defined as follows:

- **Surface**. The final HMA lift placed at or near the top of the pavement structure;
- **Intermediate**. Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. from the riding surface; and
- **Base**. Mixtures placed greater than 8.0 in. from the riding surface.

2.7.1. **RAP**. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Crush or break RAP so that 100% of the particles pass the 2 in. sieve. Fractionated RAP is defined as 2 or more RAP stockpiles, divided into coarse and fine fractions.

Use of Contractor-owned RAP, including HMA plant waste, is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. This allowance does not apply to a Contractor using unfractionated RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

The coarse RAP stockpile will contain only material retained by processing over a 3/8-in. or 1/2-in. screen unless otherwise approved. The fine RAP stockpile will contain only material passing the 3/8-in. or 1/2-in. screen unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in. or 1/2-in. screen to fractionate the RAP. The maximum percentages of fractionated RAP may be comprised of coarse or fine fractionated RAP or the combination of both coarse and fine fractionated RAP.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than 8. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Maximum Allowable Amounts of RAP[1]

Maximum Allowable Fractionated RAP[2] (%)			Maximum Allowable Unfractionated RAP[3] (%)		
Surface	**Intermediate**	**Base**	**Surface**	**Intermediate**	**Base**
20.0	30.0	40.0	10.0	10.0	10.0

1. Must also meet the recycled binder to total binder ratio shown in Table 5.
2. Up to 5% RAS may be used separately or as a replacement for fractionated RAP.
3. Unfractionated RAP may not be combined with fractionated RAP or RAS.

2.7.2. **RAS**. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is permitted unless otherwise shown on the plans. Up to 5% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements of Table 1 and Table 2 or fine RAP to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 5.0% of the HMA mixture in accordance with Table 4.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if it has not come into contact with any hazardous materials. Use RAS from shingle sources on the Department's MPL. Remove substantially all materials before use that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

2.8. **Substitute Binders**. Unless otherwise shown on the plans, the Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified, if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.10., "Performance-Graded Binders"; and
- the mixture has less than 10.0 mm of rutting on the Hamburg Wheel test (Tex-242-F) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg Wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

Originally Specified PG Binder	Allowable Substitute PG Binder	Maximum Ratio of Recycled Binder[1] to Total Binder (%)		
		Surface	Intermediate	Base
HMA				
76-22[2]	70-22 or 64-22	20.0	20.0	20.0
	70-28 or 64-28	30.0	35.0	40.0
70-22[2]	64-22	20.0	20.0	20.0
	64-28 or 58-28	30.0	35.0	40.0
64-22[2]	58-28	30.0	35.0	40.0
76-28[2]	70-28 or 64-28	20.0	20.0	20.0
	64-34	30.0	35.0	40.0
70-28[2]	64-28 or 58-28	20.0	20.0	20.0
	64-34 or 58-34	30.0	35.0	40.0
64-28[2]	58-28	20.0	20.0	20.0
	58-34	30.0	35.0	40.0
WMA[3]				
76-22[2]	70-22 or 64-22	30.0	35.0	40.0
70-22[2]	64-22 or 58-28	30.0	35.0	40.0
64-22[4]	58-28	30.0	35.0	40.0
76-28[2]	70-28 or 64-28	30.0	35.0	40.0
70-28[2]	64-28 or 58-28	30.0	35.0	40.0
64-28[4]	58-28	30.0	35.0	40.0

1. Combined recycled binder from RAP and RAS.
2. Use no more than 20.0% recycled binder when using this originally specified PG binder.
3. WMA as defined in Section 340.2.6.2., "Warm Mix Asphalt (WMA)."
4. When used with WMA, this originally specified PG binder is allowed for use at the maximum recycled binder ratios shown in this table.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a pre-paving meeting with the Engineer on or before the first day of paving unless otherwise directed.

4.1. **Certification**. Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 6. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist.

Table 6
Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate and Recycled Material Testing				
Sampling	Tex-221-F	✓	✓	1A
Dry sieve	Tex-200-F, Part I	✓	✓	1A
Washed sieve	Tex-200-F, Part II	✓	✓	1A
Deleterious material	Tex-217-F, Parts I & III	✓	✓	1A
Decantation	Tex-217-F, Part II	✓	✓	1A
Los Angeles abrasion	Tex-410-A		✓	TxDOT
Magnesium sulfate soundness	Tex-411-A		✓	TxDOT
Micro-Deval abrasion	Tex-461-A		✓	2
Crushed face count	Tex-460-A	✓	✓	2
Flat and elongated particles	Tex-280-F	✓	✓	2
Linear shrinkage	Tex-107-E	✓	✓	2
Sand equivalent	Tex-203-F	✓	✓	2
Organic impurities	Tex-408-A	✓	✓	2
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
VMA[2] (calculation only)	Tex-204-F	✓	✓	2
Rice gravity	Tex-227-F	✓	✓	1A
Ignition oven correction factors[3]	Tex-236-F	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	2
Hamburg Wheel test	Tex-242-F	✓	✓	2
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Mixture sampling	Tex-222-F	✓	✓	1A
Molding (TGC)	Tex-206-F		✓	1A
Molding (SGC)	Tex-241-F		✓	1A
Laboratory-molded density	Tex-207-F		✓	1A
VMA[2] (calculation only)	Tex-204-F		✓	1A
Rice gravity	Tex-227-F		✓	1A
Gradation & asphalt binder content[3]	Tex-236-F		✓	1A
Moisture content	Tex-212-F		✓	1A
Hamburg Wheel test	Tex-242-F		✓	2
Boil test	Tex-530-C		✓	1A
5. Placement Testing				
Trimming roadway cores	Tex-207-F	✓	✓	1A/1B
In-place air voids	Tex-207-F		✓	1A/1B
Establish rolling pattern	Tex-207-F	✓		1B
Ride quality measurement	Tex-1001-S	✓	✓	Note[4]

1. Level 1A, 1B, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Voids in mineral aggregates.
3. Refer to Section 340.4.8.3., "Production Testing," for exceptions to using an ignition oven.
4. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.

4.2. **Reporting, Testing, and Responsibilities**. Use Department-provided Excel templates to record and calculate all test data pertaining to the mixture design. The Engineer will use Department Excel templates for any production and placement testing. Obtain the latest version of the Excel templates at http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer.

The maximum allowable time for the Engineer to exchange test data with the Contractor is as given in Table 7 unless otherwise approved. The Engineer will immediately report to the Contractor any test result that requires suspension of production or placement or that fails to meet the specification requirements.

Subsequent mix placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 7
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Testing			
Gradation	Engineer	Contractor	1 working day of completion of the test
Asphalt binder content			
Laboratory-molded density			
VMA (calculation)			
Hamburg Wheel test			
Moisture content			
Boil test			
Binder tests			
Placement Testing			
In-place air voids	Engineer	Contractor	1 working day of completion of the test[1]

1. 2 days are allowed if cores cannot be dried to constant weight within 1 day.

4.3. **Mixture Design**.

4.3.1. **Design Requirements**. The Contractor may design the mixture using a Texas Gyratory Compactor (TGC) or a Superpave Gyratory Compactor (SGC) unless otherwise shown on the plans. Use the typical weight design example given in Tex-204-F, Part I, when using a TGC. Use the Superpave mixture design procedure given in Tex-204-F, Part IV, when using a SGC. Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

4.3.1.1. **Target Laboratory-Molded Density When The TGC Is Used**. Design the mixture at a 96.5% target laboratory-molded density. Increase the target laboratory-molded density to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.

4.3.1.2. **Design Number of Gyrations (Ndesign) When The SGC Is Used**. Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 9. The Ndesign level may be reduced to no less than 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test in accordance with Tex-242-F, and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided Excel template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles;
- the target laboratory-molded density (or Ndesign level when using the SGC);

- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	A Coarse Base	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture
2"	100.0[1]	–	–	–	–
1-1/2"	98.0–100.0	100.0[1]	–	–	–
1"	78.0–94.0	98.0–100.0	100.0[1]	–	–
3/4"	64.0–85.0	84.0–98.0	95.0–100.0	100.0[1]	–
1/2"	50.0–70.0	–	–	98.0–100.0	100.0[1]
3/8"	–	60.0–80.0	70.0–85.0	85.0–100.0	98.0–100.0
#4	30.0–50.0	40.0–60.0	43.0–63.0	50.0–70.0	70.0–90.0
#8	22.0–36.0	29.0–43.0	32.0–44.0	35.0–46.0	38.0–48.0
#30	8.0–23.0	13.0–28.0	14.0–28.0	15.0–29.0	12.0–27.0
#50	3.0–19.0	6.0–20.0	7.0–21.0	7.0–20.0	6.0–19.0
#200	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0
Design VMA, % Minimum					
–	12.0	13.0	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum					
–	11.5	12.5	13.5	14.5	15.5

1. Defined as maximum sieve size. No tolerance allowed.

Table 9
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, % (TGC)	Tex-207-F	96.5[1]
Design gyrations (Ndesign for SGC)	Tex-241-F	50[2]
Indirect tensile strength (dry), psi	Tex-226-F	85–200[3]
Boil test[4]	Tex-530-C	–

1. Increase to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.
2. Adjust within a range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor.
3. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
4. Used to establish baseline for comparison to production results. May be waived when approved.

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes[1] @ 12.5 mm[2] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000
PG 70		15,000
PG 76 or higher		20,000

1. May be decreased or waived when shown on the plans.
2. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the Ndesign level (SGC) to no less than 35 gyrations.

4.3.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or Ndesign level), and target asphalt percentage used to establish target values

for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive. When WMA is used, document the additive or process used and recommended rate on the JMF1 submittal. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design mixture and request that the Department perform the Hamburg Wheel test if opting to have the Department perform the test. The Engineer will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise determined. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. Provide split samples of the mixtures and blank samples used to determine the ignition oven correction factors. The Engineer will determine the aggregate and asphalt correction factors from the ignition oven used for production testing in accordance with Tex-236-F.

The Engineer will use a TGC calibrated in accordance with Tex-914-K in molding production samples. Provide an SGC at the Engineer's field laboratory for use in molding production samples if the SGC is used to design the mix.

The Engineer may perform Tex-530-C and retain the tested sample for comparison purposes during production. The Engineer may waive the requirement for the boil test.

4.3.3. **JMF Adjustments**. If JMF adjustments are necessary to achieve the specified requirements, the adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of the current JMF listed in Table 11.

The Engineer may adjust the asphalt binder content to maintain desirable laboratory density near the optimum value while achieving other mix requirements.

Table 11
Operational Tolerances

Description	Test Method	Allowable Difference Between Trial Batch and JMF1 Target	Allowable Difference from Current JMF Target
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be within master grading limits in Table 8	±5.0[1,2]
Individual % retained for sieves smaller than #8 and larger than #200			±3.0[1,2]
% passing the #200 sieve			±2.0[1,2]
Asphalt binder content, %	Tex-236-F	±0.5	±0.3[2]
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0
VMA, %, min	Tex-204-F	Note[3]	Note[3]

1. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
2. Only applies to mixture produced for Lot 1 and higher.
3. Mixture is required to meet Table 8 requirements.

4.4. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

4.4.1. **Storage and Heating of Materials**. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and

discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.4.2. **Mixing and Discharge of Materials**. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed 350°F (or 275°F for WMA) and is not lower than 215°F. The Department will not pay for or allow placement of any mixture produced above 350°F.

Produce WMA within the target discharge temperature range of 215°F and 275°F when WMA is required. Take corrective action any time the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor's corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. The Engineer may determine the moisture content by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. The Engineer will obtain the sample immediately after discharging the mixture into the truck, and will perform the test promptly.

4.5. **Hauling Operations**. Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department's MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 340.4.6.3.2., "Hauling Equipment." Use other hauling equipment only when allowed.

4.6. **Placement Operations**. Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket unless otherwise directed. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines, or as directed. Ensure that all finished surfaces will drain properly.

Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 12 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 12
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Minimum Untrimmed Core Height (in.) Eligible for Testing
	Minimum (in.)	Maximum (in.)	
A	3.00	6.00	2.00
B	2.50	5.00	1.75
C	2.00	4.00	1.50
D	1.50	3.00	1.25
F	1.25	2.50	1.25

4.6.1. **Weather Conditions**. Place mixture when the roadway surface temperature is at or above 60°F unless otherwise approved. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving.

4.6.2. **Tack Coat**. Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. Roll the tack coat with a pneumatic-tire roller to remove streaks and other irregular patterns when directed.

4.6.3. **Lay-Down Operations**.

4.6.3.1. **Windrow Operations**. Operate windrow pickup equipment so that when hot-mix is placed in windrows substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.6.3.2. **Hauling Equipment**. Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability unless otherwise allowed.

4.6.3.3. **Screed Heaters**. Turn off screed heaters, to prevent overheating of the mat, if the paver stops for more than 5 min.

4.7. **Compaction**. Compact the pavement uniformly to contain between 3.8% and 8.5% in-place air voids.

Furnish the type, size, and number of rollers required for compaction as approved. Use a pneumatic-tire roller to seal the surface unless excessive pickup of fines occurs. Use additional rollers as required to remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.8. **Production Acceptance**.

4.8.1. **Production Lot**. Each day of production is defined as a production lot. Lots will be sequentially numbered and correspond to each new day of production. Note that lots are not subdivided into sublots for this specification.

4.8.2. **Production Sampling**.

4.8.2.1. **Mixture Sampling**. The Engineer may obtain mixture samples in accordance with Tex-222-F at any time during production.

4.8.2.2. **Asphalt Binder Sampling**. The Engineer may obtain or require the Contractor to obtain 1 qt. samples of the asphalt binder at any time during production from a port located immediately upstream from the mixing drum or pug mill in accordance with Tex-500-C, Part II. The Engineer may test any of the asphalt binder samples to verify compliance with Item 300, "Asphalts, Oils, and Emulsions."

4.8.3. **Production Testing**. The Engineer will test at the frequency listed in the Department's *Guide Schedule of Sampling and Testing* and this specification. The Engineer may suspend production if production tests do not meet specifications or are not within operational tolerances listed in Table 11. Take immediate corrective action if the Engineer's laboratory-molded density on any sample is less than 95.0% or greater than 98.0%, to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may use alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F does not yield reliable results. Use the applicable test procedure if an alternate test method is selected.

Table 13
Production and Placement Testing

Description	Test Method
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F
Individual % retained for sieves smaller than #8 and larger than #200	
% passing the #200 sieve	
Laboratory-molded density	Tex-207-F
Laboratory-molded bulk specific gravity	
In-Place air voids	
VMA	Tex-204-F
Moisture content	Tex-212-F, Part II
Theoretical maximum specific (Rice) gravity	Tex-227-F
Asphalt binder content	Tex-236-F
Hamburg Wheel test	Tex-242-F
Recycled Asphalt Shingles (RAS)[1]	Tex-217-F, Part III
Asphalt binder sampling and testing	Tex-500-C
Tack coat sampling and testing	Tex-500-C, Part III
Boil test	Tex-530-C

1. Testing performed by the Construction Division or designated laboratory.

4.8.3.1. **Voids in Mineral Aggregates (VMA)**. The Engineer may determine the VMA for any production lot. Take immediate corrective action if the VMA value for any lot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the lot to be left in place without payment.

4.8.3.2. **Hamburg Wheel Test**. The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 10. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire lot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department-approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Construction Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

4.8.4. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9. **Placement Acceptance**.

4.9.1. **Placement Lot**. A placement lot is defined as the area placed during a production lot (one day's production). Placement lot numbers will correspond with production lot numbers.

4.9.2. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 12. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of pavement unless another rate is shown on the plans. Compact miscellaneous areas in accordance with Section 340.4.7., "Compaction." Miscellaneous areas are not subject to in-place air void determination except for temporary detours when shown on the plans.

4.9.3. **Placement Sampling**. Provide the equipment and means to obtain and trim roadway cores on site. On site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement lot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side at each location selected by the Engineer for in-place air void determination unless otherwise shown on the plans. For Type D and Type F mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness.

Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with Tex-207-F if the core heights meet the minimum untrimmed value listed in Table 12. Trim the cores on site in the presence of the Engineer. Use a permanent marker or paint pen to record the date and lot number on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after they are trimmed and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at http://www.txdot.gov/business/specifications.htm to provide a secure means and process that protects the integrity of the cores during transport.

Instead of the Contractor trimming the cores on site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

4.9.4. **Placement Testing**. The Engineer may measure in-place air voids at any time during the project to verify specification compliance.

4.9.4.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Cores not meeting the height requirements in Table 12 will not be tested. Before drying to a constant weight, cores may be pre-dried using a Corelok or similar vacuum device to remove excess moisture. The Engineer will use the corresponding theoretical maximum specific gravity to determine the air void content of each core. The Engineer will use the average air void content of the 2 cores to determine the in-place air voids at the selected location.

The Engineer will use the vacuum method to seal the core if required by Tex-207-F. The Engineer will use the test results from the unsealed core if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

Take immediate corrective action when the in-place air voids exceed the range of 3.8% and 8.5% to bring the operation within these tolerances. The Engineer may suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or greater than 9.9%. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.8% and 8.5% in-place air voids. Areas defined in Section 340.9.2., "Miscellaneous Areas," are not subject to in-place air void determination.

4.9.5. **Irregularities**. Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities and areas where the mixture does not bond to the existing pavement. If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.6. **Ride Quality**. Use Surface Test Type A to evaluate ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 340.5., "Measurement," will be paid for at the unit bid price for "Dense Graded Hot-Mix Asphalt (SQ)" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Pay adjustment for ride quality, if applicable, will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

Item 341
Dense-Graded Hot-Mix Asphalt

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant. Pay adjustments will apply to HMA placed under this specification unless the HMA is deemed exempt in accordance with Section 341.4.9.4., "Exempt Production."

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate**. Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Aggregate from reclaimed asphalt pavement (RAP) is not required to meet Table 1 requirements unless otherwise shown on the plans. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. **Coarse Aggregate**. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces

other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates**. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Coarse aggregate from RAP and Recycled Asphalt Shingles (RAS) will be considered as Class B aggregate for blending purposes.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design Excel template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the Excel template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.1.2. **Micro-Deval Abrasion**. The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
$MD_{act.}$ = actual Micro-Deval percent loss
$RSMD$ = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Geotechnical, Soils, and Aggregates Branch of the Construction Division, and additional testing may be required before granting approval.

2.1.2. **Intermediate Aggregate**. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used, that are free from organic impurities. The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used, that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

2.1.3. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free

from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. No more than 15% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.5
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note[1]
Los Angeles abrasion, %, Max	Tex-410-A	40
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	30
Crushed face count,[2] %, Min	Tex-460-A, Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Combined Aggregate[3]		
Sand equivalent, %, Min	Tex-203-F	45

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 341.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.
3. Aggregates, without mineral filler, RAP, RAS, or additives, combined as used in the job-mix formula (JMF).

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Weight or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler**. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Weight or Volume
#8	100
#200	55–100

2.3. **Baghouse Fines**. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. **Asphalt Binder**. Furnish the type and grade of performance-graded (PG) asphalt specified on the plans.

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized or preferred tack coat materials may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

The Engineer will obtain at least one sample of the tack coat binder per project in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300, "Asphalts, Oils, and Emulsions." The Engineer will obtain the sample from the asphalt distributor immediately before use.

2.6. **Additives**. Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing, compaction, or improve the quality of the mixture are allowed when approved. Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

2.6.1. **Lime and Liquid Antistripping Agent**. When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.6.2. **Warm Mix Asphalt (WMA)**. Warm Mix Asphalt (WMA) is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using approved WMA additives or processes from the Department's MPL.

WMA is allowed for use on all projects and is required when shown on the plans. When WMA is required, the maximum placement or target discharge temperature for WMA will be set at a value below 275°F.

Department-approved WMA additives or processes may be used to facilitate mixing and compaction of HMA produced at target discharge temperatures above 275°F; however, such mixtures will not be defined as WMA.

2.7. **Recycled Materials**. Use of RAP and RAS is permitted unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages shown in Table 4 may be decreased or increased when shown on the plans. Determine asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F. The Engineer may verify the asphalt binder content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 5 during mixture design and HMA production when RAP or RAS is used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes referenced in Tables 4 and 5 are defined as follows:

- **Surface**. The final HMA lift placed at or near the top of the pavement structure;
- **Intermediate**. Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. from the riding surface; and
- **Base**. Mixtures placed greater than 8.0 in. from the riding surface.

2.7.1. **RAP**. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Crush or break RAP so that 100% of the particles pass the 2 in. sieve. Fractionated RAP is defined as 2 or more RAP stockpiles, divided into coarse and fine fractions.

Use of Contractor-owned RAP including HMA plant waste is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. This allowance does not apply to a Contractor using unfractionated RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans.

Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

The coarse RAP stockpile will contain only material retained by processing over a 3/8-in. or 1/2-in. screen unless otherwise approved. The fine RAP stockpile will contain only material passing the 3/8-in. or 1/2-in. screen unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in. or 1/2-in. screen to fractionate the RAP. The maximum percentages of fractionated RAP may be comprised of coarse or fine fractionated RAP or the combination of both coarse and fine fractionated RAP.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than 8. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Maximum Allowable Amounts of RAP[1]

Maximum Allowable Fractionated RAP[2] (%)			Maximum Allowable Unfractionated RAP[3] (%)		
Surface	**Intermediate**	**Base**	**Surface**	**Intermediate**	**Base**
20.0	30.0	40.0	10.0	10.0	10.0

1. Must also meet the recycled binder to total binder ratio shown in Table 5.
2. Up to 5% RAS may be used separately or as a replacement for fractionated RAP.
3. Unfractionated RAP may not be combined with fractionated RAP or RAS.

2.7.2. **RAS**. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is permitted unless otherwise shown on the plans. Up to 5% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements of Table 1 and Table 2 or fine RAP to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 5.0% of the HMA mixture in accordance with Table 4.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if it has not come into contact with any hazardous materials. Use RAS from shingle sources on the Department's MPL. Remove substantially all materials before use that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

2.8. **Substitute Binders**. Unless otherwise shown on the plans, the Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified, if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.10., "Performance-Graded Binders"; and
- the mixture has less than 10.0 mm of rutting on the Hamburg Wheel test (Tex-242-F) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg Wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

Originally Specified PG Binder	Allowable Substitute PG Binder	Maximum Ratio of Recycled Binder[1] to Total Binder (%)		
		Surface	Intermediate	Base
HMA				
76-22[2]	70-22 or 64-22	20.0	20.0	20.0
	70-28 or 64-28	30.0	35.0	40.0
70-22[2]	64-22	20.0	20.0	20.0
	64-28 or 58-28	30.0	35.0	40.0
64-22[2]	58-28	30.0	35.0	40.0
76-28[2]	70-28 or 64-28	20.0	20.0	20.0
	64-34	30.0	35.0	40.0
70-28[2]	64-28 or 58-28	20.0	20.0	20.0
	64-34 or 58-34	30.0	35.0	40.0
64-28[2]	58-28	20.0	20.0	20.0
	58-34	30.0	35.0	40.0
WMA[3]				
76-22[2]	70-22 or 64-22	30.0	35.0	40.0
70-22[2]	64-22 or 58-28	30.0	35.0	40.0
64-22[4]	58-28	30.0	35.0	40.0
76-28[2]	70-28 or 64-28	30.0	35.0	40.0
70-28[2]	64-28 or 58-28	30.0	35.0	40.0
64-28[4]	58-28	30.0	35.0	40.0

1. Combined recycled binder from RAP and RAS.
2. Use no more than 20.0% recycled binder when using this originally specified PG binder.
3. WMA as defined in Section 341.2.6.2., "Warm Mix Asphalt (WMA)."
4. When used with WMA, this originally specified PG binder is allowed for use at the maximum recycled binder ratios shown in this table.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

4.1. **Certification**. Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 6. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests.

Table 6
Test Methods, Test Responsibility, and Minimum Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate and Recycled Material Testing				
Sampling	Tex-221-F	✓	✓	1A
Dry sieve	Tex-200-F, Part I	✓	✓	1A
Washed sieve	Tex-200-F, Part II	✓	✓	1A
Deleterious material	Tex-217-F, Parts I & III	✓	✓	1A
Decantation	Tex-217-F, Part II	✓	✓	1A
Los Angeles abrasion	Tex-410-A		✓	TxDOT
Magnesium sulfate soundness	Tex-411-A		✓	TxDOT
Micro-Deval abrasion	Tex-461-A		✓	2
Crushed face count	Tex-460-A	✓	✓	2
Flat and elongated particles	Tex-280-F	✓	✓	2
Linear shrinkage	Tex-107-E	✓	✓	2
Sand equivalent	Tex-203-F	✓	✓	2
Organic impurities	Tex-408-A	✓	✓	2
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
VMA[2] (calculation only)	Tex-204-F	✓	✓	2
Rice gravity	Tex-227-F	✓	✓	1A
Ignition oven correction factors[3]	Tex-236-F	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	2
Hamburg Wheel test	Tex-242-F	✓	✓	2
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F, Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
VMA[2] (calculation only)	Tex-204-F	✓	✓	1A
Rice gravity	Tex-227-F	✓	✓	1A
Gradation & asphalt binder content[3]	Tex-236-F	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	2
Micro-Deval abrasion	Tex-461-A		✓	2
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
Overlay test	Tex-248-F		✓	TxDOT
Cantabro loss	Tex-245-F		✓	2
5. Placement Testing				
Selecting placement random numbers	Tex-225-F, Part II		✓	1A/1B
Trimming roadway cores	Tex-207-F	✓	✓	1A/1B
In-place air voids	Tex-207-F	✓	✓	1A/1B
Establish rolling pattern	Tex-207-F	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note[4]
Segregation (density profile)	Tex-207-F, Part V	✓	✓	1B
Longitudinal joint density	Tex-207-F, Part VII	✓	✓	1B
Thermal profile	Tex-244-F	✓	✓	1B

1. Level 1A, 1B, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Voids in mineral aggregates.
3. Refer to Section 341.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.
4. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.

4.2. **Reporting and Responsibilities**. Use Department-provided Excel templates to record and calculate all test data, including mixture design, production and placement QC/QA, control charts, thermal profiles, segregation density profiles, and longitudinal joint density. Obtain the latest version of the Excel templates at http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The maximum allowable time for the Contractor and Engineer to exchange test data is as given in Table 7 unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement, a payment penalty, or that fails to meet the specification requirements. Record and submit all test results and pertinent information on Department-provided Excel templates to the Engineer electronically by means of a portable USB flash drive, compact disc, or via email.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 7
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[2]			
Moisture content[3]			
Boil test[3]			
Production Quality Assurance			
Gradation[3]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[3]			
Laboratory-molded density[1]			
Hamburg Wheel test[2]			
Boil test[3]			
Binder tests[2]			
Placement Quality Control			
In-place air voids[2]	Contractor	Engineer	1 working day of completion of the lot
Segregation[1]			
Longitudinal joint density[1]			
Thermal profile[1]			
Placement Quality Assurance			
In-place air voids[1]	Engineer	Contractor	1 working day of receipt of the trimmed cores for in-place air voids[4]
Segregation[2]			
Longitudinal joint density[2]			
Thermal profile[2]			
Aging ratio[2]			
Pay adjustment summary	Engineer	Contractor	2 working days of performing all required tests and receiving Contractor test data

1. These tests are required on every sublot.
2. Optional test. To be reported as soon as results become available.
3. To be performed at the frequency specified on the plans.
4. 2 days are allowed if cores cannot be dried to constant weight within 1 day.

The Engineer will use the Department-provided Excel template to calculate all pay adjustment factors for the lot. Sublot samples may be discarded after the Engineer and Contractor sign off on the pay adjustment summary documentation for the lot.

Use the procedures described in Tex-233-F to plot the results of all quality control (QC) and quality assurance (QA) testing. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. **Quality Control Plan (QCP)**. Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting. Receive approval of the QCP before beginning production. Include the following items in the QCP:

4.3.1. **Project Personnel**. For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and
- current copies of certification documents for individuals performing specified QC functions.

4.3.2. **Material Delivery and Storage**. For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

4.3.3. **Production**. For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, RAP, RAS, lime, liquid antistrip, WMA);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

4.3.4. **Loading and Transporting**. For loading and transporting, include:

- type and application method for release agents; and
- truck loading procedures to avoid segregation.

4.3.5. **Placement and Compaction**. For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver, while avoiding segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.4. **Mixture Design**.

4.4.1. **Design Requirements**. The Contractor may design the mixture using a Texas Gyratory Compactor (TGC) or a Superpave Gyratory Compactor (SGC) unless otherwise shown on the plans. Use the typical weight design example given in Tex-204-F, Part I, when using a TGC. Use the Superpave mixture design procedure given

in Tex-204-F, Part IV, when using a SGC. Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

4.4.1.1. **Target Laboratory-Molded Density When The TGC Is Used**. Design the mixture at a 96.5% target laboratory-molded density. Increase the target laboratory-molded density to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.

4.4.1.2. **Design Number of Gyrations (Ndesign) When The SGC Is Used**. Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 9. The Ndesign level may be reduced to no less than 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test, and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided Excel template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles;
- the target laboratory-molded density (or Ndesign level when using the SGC);
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	A Coarse Base	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture
2"	100.0[1]	–	–	–	–
1-1/2"	98.0–100.0	100.0[1]	–	–	–
1"	78.0–94.0	98.0–100.0	100.0[1]	–	–
3/4"	64.0–85.0	84.0–98.0	95.0–100.0	100.0[1]	–
1/2"	50.0–70.0	–	–	98.0–100.0	100.0[1]
3/8"	–	60.0–80.0	70.0–85.0	85.0–100.0	98.0–100.0
#4	30.0–50.0	40.0–60.0	43.0–63.0	50.0–70.0	70.0–90.0
#8	22.0–36.0	29.0–43.0	32.0–44.0	35.0–46.0	38.0–48.0
#30	8.0–23.0	13.0–28.0	14.0–28.0	15.0–29.0	12.0–27.0
#50	3.0–19.0	6.0–20.0	7.0–21.0	7.0–20.0	6.0–19.0
#200	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0	2.0–7.0
Design VMA, % Minimum					
–	12.0	13.0	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum					
–	11.5	12.5	13.5	14.5	15.5

1. Defined as maximum sieve size. No tolerance allowed.

Table 9
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, % (TGC)	Tex-207-F	96.5[1]
Design gyrations (Ndesign for SGC)	Tex-241-F	50[2]
Indirect tensile strength (dry), psi	Tex-226-F	85–200[3]
Boil test[4]	Tex-530-C	–

1. Increase to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.
2. Adjust within a range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor.
3. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
4. Used to establish baseline for comparison to production results. May be waived when approved.

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes[1] @ 12.5 mm² Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000
PG 70		15,000
PG 76 or higher		20,000

1. May be decreased or waived when shown on the plans.
2. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the Ndesign level (SGC) to no less than 35 gyrations.

4.4.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or Ndesign level), and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive. When WMA is used, document the additive or process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than 2 trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities**.

4.4.2.1.1. **Providing Gyratory Compactor**. Use a TGC calibrated in accordance with Tex-914-K when electing or required to design the mixture in accordance with Tex-204-F, Part I, for molding production samples. Furnish an SGC calibrated in accordance with Tex-241-F when electing or required to design the mixture in accordance with Tex-204-F, Part IV, for molding production samples. Locate the SGC, if used, at the Engineer's field laboratory and make the SGC available to the Engineer for use in molding production samples.

4.4.2.1.2. **Gyratory Compactor Correlation Factors**. Use Tex-206-F, Part II, to perform a gyratory compactor correlation when the Engineer uses a different gyratory compactor. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1**. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture, and request that the Department perform the test.

4.4.2.1.4. **Supplying Aggregates**. Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.5. **Supplying Asphalt**. Provide at least 1 gal. of the asphalt material and sufficient quantities of any additives proposed for use.

4.4.2.1.6. **Ignition Oven Correction Factors**. Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for QA testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used, unless otherwise directed.

4.4.2.1.7. **Boil Test**. Perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production. The Engineer may waive the requirement for the boil test.

4.4.2.1.8. **Trial Batch Production**. Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch, including the WMA additive or process if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in Table 4, Table 5, and Table 11. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment**. Use only equipment and materials proposed for use on the project to produce the trial batch.

4.4.2.1.10. **Trial Batch Quantity**. Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.11. **Number of Trial Batches**. Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.12. **Trial Batch Sampling**. Obtain a representative sample of the trial batch and split it into 3 equal portions in accordance with Tex-222-F. Label these portions as "Contractor," "Engineer," and "Referee." Deliver samples to the appropriate laboratory as directed.

4.4.2.1.13. **Trial Batch Testing**. Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in Table 11. Ensure the trial batch mixture is also in compliance with the Hamburg Wheel requirement in Table 10. Use a Department-approved laboratory to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2**. Evaluate the trial batch test results after the Engineer grants full approval of JMF1 based on results from the trial batch, determine the optimum mixture proportions, and submit as JMF2. Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the voids in mineral aggregates (VMA) requirements for production shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi. Verify that JMF2 meets the mixture requirements in Table 5.

4.4.2.1.15. **Mixture Production**. Use JMF2 to produce Lot 1 as described in Section 341.4.9.3.1.1., "Lot 1 Placement," after receiving approval for JMF2 and a passing result from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. If desired, proceed to Lot 1 production, once JMF2 is approved, at the Contractor's risk without receiving the results from the Department's Hamburg Wheel test on the trial batch.

Notify the Engineer if electing to proceed without Hamburg Wheel test results from the trial batch. Note that the Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

4.4.2.1.16. **Development of JMF3**. Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.17. **JMF Adjustments**. If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of JMF2 listed in Table 11.

4.4.2.1.18. **Requesting Referee Testing**. Use referee testing, if needed, in accordance with Section 341.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 11
Operational Tolerances

Description	Test Method	Allowable Difference Between Trial Batch and JMF1 Target	Allowable Difference from Current JMF Target	Allowable Difference between Contractor and Engineer[1]
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be Within Master Grading Limits in Table 8	±5.0[2,3]	±5.0
Individual % retained for sieves smaller than #8 and larger than #200			±3.0[2,3]	±3.0
% passing the #200 sieve			±2.0[2,3]	±1.6
Asphalt binder content, %	Tex-236-F	±0.5	±0.3[3]	±0.3
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±1.0
In-place air voids, %		N/A	N/A	±1.0
Laboratory-molded bulk specific gravity		N/A	N/A	±0.020
VMA, %, min	Tex-204-F	Note[4]	Note[4]	N/A
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	N/A	±0.020

1. Contractor may request referee testing only when values exceed these tolerances.
2. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
3. Only applies to mixture produced for Lot 1 and higher.
4. Test and verify that Table 8 requirements are met.

4.4.2.2. **Engineer's Responsibilities**.

4.4.2.2.1. **Gyratory Compactor**. For mixtures designed in accordance with Tex-204-F, Part I, the Engineer will use a Department TGC, calibrated in accordance with Tex-914-K, to mold samples for trial batch and production testing. The Engineer will make the Department TGC and the Department field laboratory available to the Contractor for molding verification samples, if requested by the Contractor.

For mixtures designed in accordance with Tex-204-F, Part IV, the Engineer will use a Department SGC, calibrated in accordance with Tex-241-F, to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location. The Engineer will make the Contractor-provided SGC in the Department field laboratory available to the Contractor for molding verification samples.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch**. The Engineer will review and verify conformance of the following information within 2 working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results;

- all required materials including aggregates, asphalt, additives, and recycled materials; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 341.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after 2 working days, conditional approval of JMF1 will still be granted within 2 working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

After conditionally approving JMF1, including either Contractor- or Department-supplied Hamburg Wheel test results, the Contractor is authorized to produce a trial batch.

4.4.2.2.3. **Hamburg Wheel Testing of JMF1**. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the laboratory mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

4.4.2.2.4. **Ignition Oven Correction Factors**. The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for QA testing during production in accordance with Tex-236-F.

4.4.2.2.5. **Testing the Trial Batch**. Within 1 full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements in Table 11. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

The Engineer will have the option to perform the following tests on the trial batch:

- Tex-226-F, to verify that the indirect tensile strength meets the requirement shown in Table 9; and
- Tex-530-C, to retain and use for comparison purposes during production.

4.4.2.2.6. **Full Approval of JMF1**. The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in Table 11. The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. **Approval of JMF2**. The Engineer will approve JMF2 within one working day if the mixture meets the requirements in Table 5 and the gradation meets the master grading limits shown in Table 8. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi.

4.4.2.2.8. **Approval of Lot 1 Production**. The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2) as soon as a passing result is achieved from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. The Contractor may proceed at its own risk with Lot 1 production without the results from the Hamburg Wheel test on the trial batch.

If the Department's or Department-approved laboratory's sample from the trial batch fails the Hamburg Wheel test, the Engineer will suspend production until further Hamburg Wheel tests meet the specified values. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test be removed and replaced at the Contractor's expense.

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes**. JMF3 and subsequent JMF changes are approved if they meet the mixture requirements shown in Table 4, Table 5, and the master grading limits shown in Table 8, and are within the operational tolerances of JMF2 shown in Table 11.

4.5. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

4.5.1. **Storage and Heating of Materials**. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. **Mixing and Discharge of Materials**. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed 350°F (or 275°F for WMA) and is not lower than 215°F. The Department will not pay for or allow placement of any mixture produced above 350°F.

Produce WMA within the target discharge temperature range of 215°F and 275°F when WMA is required. Take corrective action any time the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor's corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck, and perform the test promptly.

4.6. **Hauling Operations**. Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department's MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 341.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. **Placement Operations**. Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines, or as

directed. Ensure that all finished surfaces will drain properly. Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 12 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 12
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Minimum Untrimmed Core Height (in.) Eligible for Testing
	Minimum (in.)	Maximum (in.)	
A	3.00	6.00	2.00
B	2.50	5.00	1.75
C	2.00	4.00	1.50
D	1.50	3.00	1.25
F	1.25	2.50	1.25

4.7.1. **Weather Conditions**.

4.7.1.1. **When Using a Thermal Imaging System**. The Contractor may pave any time the roadway is dry and the roadway surface temperature is at least 32°F; however, the Engineer may restrict the Contractor from paving surface mixtures if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 341.4.7.3.1.2., "Thermal Imaging System."

4.7.1.2. **When Not Using a Thermal Imaging System**. Place mixture when the roadway surface temperature is at or above the temperatures listed in Table 13 unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving.

Table 13
Minimum Pavement Surface Temperatures

Originally Specified High Temperature Binder Grade	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64 or lower	45	50
PG 70	55[1]	60[1]
PG 76 or higher	60[1]	60[1]

1. Contractors may pave at temperatures 10°F lower than these values when utilizing a paving process including WMA or equipment that eliminates thermal segregation. In such cases, use a hand-held thermal camera operated in accordance with Tex-244-F to demonstrate to the satisfaction of the Engineer that the uncompacted mat has no more than 10°F of thermal segregation.

4.7.2. **Tack Coat**. Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. Roll the tack coat with a pneumatic-tire roller to remove streaks and other irregular patterns when directed.

4.7.3. **Lay-Down Operations**.

4.7.3.1. **Thermal Profile**. Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F. Thermal profiles are not applicable in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas."

4.7.3.1.1. **Thermal Segregation**.

4.7.3.1.1.1. **Moderate**. Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F, are deemed as having moderate thermal segregation.

4.7.3.1.1.2. **Severe**. Any areas that have a temperature differential greater than 50°F are deemed as having severe thermal segregation.

4.7.3.1.2. **Thermal Imaging System**. Review the output results when a thermal imaging system is used, and provide the automated report described in Tex-244-F to the Engineer daily unless otherwise directed. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system. The Engineer may suspend paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe thermal segregation. Density profiles are not required and not applicable when using a thermal imaging system. Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots upon completion of the project or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera**. Take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Evaluate areas with moderate thermal segregation by performing density profiles in accordance with Section 341.4.9.3.3.2., "Segregation (Density Profile)." Provide the Engineer with the thermal profile of every sublot within one working day of the completion of each lot. Report the results of each thermal profile in accordance with Section 341.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. No production or placement bonus will be paid for any sublot that contains severe thermal segregation. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section. Evaluate areas with severe thermal segregation by performing density profiles in accordance with Section 341.4.9.3.3.2., "Segregation (Density Profile)." Remove and replace the material in any areas that have both severe thermal segregation and a failing result for Segregation (Density Profile) unless otherwise directed. The sublot in question may receive a production and placement bonus if applicable when the defective material is successfully removed and replaced.

4.7.3.2. **Windrow Operations**. Operate windrow pickup equipment so that when hot-mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.7.3.3. **Hauling Equipment**. Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability or when a thermal imaging system is used unless otherwise allowed.

4.7.3.4. **Screed Heaters**. Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 341.4.9.3.3.4., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. **Compaction**. Compact the pavement uniformly to contain between 3.8% and 8.5% in-place air voids. Take immediate corrective action to bring the operation within 3.8% and 8.5% when the in-place air voids exceed the range of these tolerances. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.8% and 8.5% in-place air voids.

Obtain cores in areas placed under Exempt Production, as directed, at locations determined by the Engineer. The Engineer may test these cores and suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or more than 9.9%. Areas defined in Section 341.4.9.3.1.4., "Miscellaneous Areas," are not subject to in-place air void determination.

Furnish the type, size, and number of rollers required for compaction as approved. Use a pneumatic-tire roller to seal the surface unless excessive pickup of fines occurs. Use additional rollers as required to

remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. **Acceptance Plan**. Pay adjustments for the material will be in accordance with Section 341.6., "Payment."

Sample and test the hot-mix on a lot and sublot basis. Suspend production until test results or other information indicates to the satisfaction of the Engineer that the next material produced or placed will result in pay factors of at least 1.000, if the production pay factor given in Section 341.6.1., "Production Pay Adjustment Factors," for 2 consecutive lots or the placement pay factor given in Section 341.6.2., "Placement Pay Adjustment Factors," for 2 consecutive lots is below 1.000.

4.9.1. **Referee Testing**. The Construction Division is the referee laboratory. The Contractor may request referee testing if a "remove and replace" condition is determined based on the Engineer's test results, or if the differences between Contractor and Engineer test results exceed the maximum allowable difference shown in Table 11 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within 5 working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the sublot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than 3 referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

The Construction Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample. The in-place air voids will be determined based on the bulk specific gravity of the cores, as determined by the referee laboratory and the Engineer's average maximum theoretical specific gravity for the lot. With the exception of "remove and replace" conditions, referee test results are final and will establish pay adjustment factors for the sublot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement pay adjustment factor for any sublot results in a "remove and replace" condition. Placement sublots subject to be removed and replaced will be further evaluated in accordance with Section 341.6.2.2., "Placement Sublots Subject to Removal and Replacement."

4.9.2. **Production Acceptance**.

4.9.2.1. **Production Lot**. A production lot consists of 4 equal sublots. The default quantity for Lot 1 is 1,000 tons; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 4,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately 3 to 4 sublots are produced each day. The lot size will be between 1,000 tons and 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot.

If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 to

confirm the indirect tensile strength does not exceed 200 psi. Take corrective action to bring the mixture within specification compliance if the indirect tensile strength exceeds 200 psi unless otherwise directed.

4.9.2.1.1. **Incomplete Production Lots**. If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Adjust the payment for the incomplete lot in accordance with Section 341.6.1., "Production Pay Adjustment Factors." Close all lots within 5 working days unless otherwise allowed.

4.9.2.2. **Production Sampling**.

4.9.2.2.1. **Mixture Sampling**. Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into 3 equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample**. At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample**. For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.2.2.2. **Informational Cantabro and Overlay Testing**. When requested or shown on the plans, select one random sublot from Lot 2 or higher for Cantabro and Overlay testing during the first week of production. Obtain and provide the Engineer with approximately 90 lb. (40 kg) of mixture in sealed containers, boxes, or bags labeled with the Control-Section-Job (CSJ), mixture type, lot, and sublot number. The Engineer will ship the mixture to the Construction Division for Cantabro and Overlay testing. Results from these tests will not be used for specification compliance.

4.9.2.2.3. **Asphalt Binder Sampling**. Obtain a 1-qt. sample of the asphalt binder for each lot of mixture produced. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers and deliver the sample to the Engineer. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample, the Engineer will split a sample of the asphalt binder with the Contractor. The Engineer will test at least one asphalt binder sample per project to verify compliance with Item 300, "Asphalts, Oils, and Emulsions."

4.9.2.3. **Production Testing**. The Contractor and Engineer must perform production tests in accordance with Table 14. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances listed in Table 11 for all sublots.

Take immediate corrective action if the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 98.0% to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F does not yield reliable results. Provide evidence that results from Tex-236-F are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 14
Production and Placement Testing Frequency

Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	1 per sublot	1 per 12 sublots[1]
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	N/A	1 per sublot[1]
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	Tex-204-F		
Segregation (density profile)[2]	Tex-207-F, Part V	1 per sublot	1 per project
Longitudinal joint density	Tex-207-F, Part VII		
Moisture content	Tex-212-F, Part II	When directed	
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	1 per sublot[1]
Asphalt binder content	Tex-236-F	1 per sublot	1 per lot[1]
Hamburg Wheel test	Tex-242-F	N/A	1 per project
Recycled Asphalt Shingles (RAS)[3]	Tex-217-F, Part III	N/A	
Thermal profile[2]	Tex-244-F	1 per sublot	
Asphalt binder sampling and testing	Tex-500-C	1 per lot (sample only)	
Tack coat sampling and testing	Tex-500-C, Part III	N/A	
Boil test[4]	Tex-530-C	1 per lot	
Cantabro loss[5]	Tex-245-F	1 per project (sample only)	
Overlay test[5]	Tex-248-F		

1. For production defined in Section 341.4.9.4., "Exempt Production," the Engineer will test one per day if 100 tons or more are produced. For Exempt Production, no testing is required when less than 100 tons are produced.
2. Not required when a thermal imaging system is used.
3. Testing performed by the Construction Division or designated laboratory.
4. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.
5. Testing performed by the Construction Division and for informational purposes only.

4.9.2.4. **Operational Tolerances**. Control the production process within the operational tolerances listed in Table 11. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.2.4.1. **Gradation**. Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size shown in Table 8. A sublot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances for 3 consecutive sublots on the same sieve or 4 consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

4.9.2.4.2. **Asphalt Binder Content**. A sublot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values listed in Table 11. No production or placement bonus will be paid for any sublot that is out of operational tolerance for asphalt binder content. Suspend production and shipment of the mixture if the Engineer's or the Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any sublot.

4.9.2.4.3. **Voids in Mineral Aggregates (VMA)**. The Engineer will determine the VMA for every sublot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any sublot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA results on 2 consecutive sublots are below the minimum VMA requirement for production listed in Table 8. No production or placement bonus will be paid for any sublot that does not meet the minimum VMA requirement for production listed in Table 8 based on the Engineer's VMA determination.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment.

4.9.2.4.4. **Hamburg Wheel Test**. The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 10. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Construction Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

4.9.2.5. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.3. **Placement Acceptance**.

4.9.3.1. **Placement Lot**. A placement lot consists of 4 placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.3.1.1. **Lot 1 Placement**. Placement bonuses for Lot 1 will be in accordance with Section 341.6.2., "Placement Pay Adjustment Factors"; however, no placement penalty will be assessed for any sublot placed in Lot 1 when the in-place air voids are greater than or equal to 2.7% and less than or equal to 9.9%. Remove and replace any sublot with in-place air voids less than 2.7% or greater than 9.9%.

4.9.3.1.2. **Incomplete Placement Lots**. An incomplete placement lot consists of the area placed as described in Section 341.4.9.2.1.1., "Incomplete Production Lots," excluding areas defined in Section 341.4.9.3.1.4., "Miscellaneous Areas." Placement sampling is required if the random sample plan for production resulted in a sample being obtained from an incomplete production sublot.

4.9.3.1.3. **Shoulders, Ramps, Etc**. Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are subject to in-place air void determination and pay adjustments unless designated on the plans as not eligible for in-place air void determination. Intersections may be considered miscellaneous areas when determined by the Engineer.

4.9.3.1.4. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Temporary detours are subject to in-place air void determination when shown on the plans. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 12. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of pavement unless another rate is shown on the plans. When "level up" is listed as part of the item bid description code, a pay adjustment factor of 1.000 will be assigned for all placement sublots as described in Section 341.6, "Payment." Miscellaneous areas are not eligible for random placement sampling locations. Compact miscellaneous areas in accordance with Section 341.4.8., "Compaction." Miscellaneous areas are not subject to in-place air void determination, thermal profiles testing, segregation (density profiles), or longitudinal joint density evaluations.

4.9.3.2. **Placement Sampling**. The Engineer will select random numbers for all placement sublots at the beginning of the project. The Engineer will provide the Contractor with the placement random numbers immediately after the sublot is completed. Mark the roadway location at the completion of each sublot and record the station number. Determine one random sample location for each placement sublot in accordance with Tex-225-F. Adjust the random sample location by no more than necessary to achieve a 2-ft. clearance if the location is within 2 ft. of a joint or pavement edge.

Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are always eligible for selection as a random sample location; however, if a random sample location falls on one of these areas and the area is designated on the plans as not subject to in-place air void determination, cores will not be taken for the sublot and a 1.000 pay factor will be assigned to that sublot.

Provide the equipment and means to obtain and trim roadway cores on site. On-site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement sublot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side from within 1 ft. of the random location provided for the placement sublot. For Type D and Type F mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness. Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with Tex-207-F if the core heights meet the minimum untrimmed value listed in Table 12. Trim the cores on site in the presence of the Engineer. Use a permanent marker or paint pen to record the lot and sublot numbers on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after they are trimmed and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at http://www.txdot.gov/business/specifications.htm to provide a secure means and process that protects the integrity of the cores during transport.

Decide whether to include the pair of cores in the air void determination for that sublot if the core height before trimming is less than the minimum untrimmed value shown in Table 12. Trim the cores as described above before delivering to the Engineer if electing to have the cores included in the air void determination. Deliver untrimmed cores to the Engineer and inform the Engineer of the decision to not have the cores included in air void determination if electing to not have the cores included in air void determination. The placement pay factor for the sublot will be 1.000 if cores will not be included in air void determination.

Instead of the Contractor trimming the cores on site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

4.9.3.3. **Placement Testing**. Perform placement tests in accordance with Table 14. After the Engineer returns the cores, the Contractor may test the cores to verify the Engineer's test results for in-place air voids. The allowable differences between the Contractor's and Engineer's test results are listed in Table 11.

4.9.3.3.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores may be pre-dried using a Corelok or similar vacuum device to remove excess moisture. The Engineer will average the values obtained for all sublots in the production lot to determine the theoretical maximum specific gravity. The Engineer will use the average air void content for in-place air voids.

The Engineer will use the vacuum method to seal the core if required by Tex-207-F. The Engineer will use the test results from the unsealed core to determine the placement pay adjustment factor if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

4.9.3.3.2. **Segregation (Density Profile)**. Test for segregation using density profiles in accordance with Tex-207-F, Part V. Density profiles are not required and are not applicable when using a thermal imaging system. Density profiles are not applicable in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas."

Perform a density profile every time the paver stops for more than 60 sec. on areas that are identified by either the Contractor or the Engineer as having thermal segregation and on any visibly segregated areas unless otherwise approved. Perform a minimum of one profile per sublot if the paver does not stop for more than 60 sec. and there are no visibly segregated areas or areas that are identified as having thermal segregation.

Provide the Engineer with the density profile of every sublot in the lot within one working day of the completion of each lot. Report the results of each density profile in accordance with Section 341.4.2., "Reporting and Responsibilities."

The density profile is considered failing if it exceeds the tolerances in Table 15. No production or placement bonus will be paid for any sublot that contains a failing density profile. When a hand-held thermal camera is used instead of a thermal imaging system, the Engineer will measure the density profile at least once per project. The Engineer's density profile results will be used when available. The Engineer may require the Contractor to remove and replace the area in question if the area fails the density profile and has surface irregularities as defined in Section 341.4.9.3.3.5., "Irregularities." The sublot in question may receive a production and placement bonus if applicable when the defective material is successfully removed and replaced.

Investigate density profile failures and take corrective actions during production and placement to eliminate the segregation. Suspend production if 2 consecutive density profiles fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Table 15
Segregation (Density Profile) Acceptance Criteria

Mixture Type	Maximum Allowable Density Range (Highest to Lowest)	Maximum Allowable Density Range (Average to Lowest)
Type A & Type B	8.0 pcf	5.0 pcf
Type C, Type D & Type F	6.0 pcf	3.0 pcf

4.9.3.3.3. **Longitudinal Joint Density**.

4.9.3.3.3.1. **Informational Tests**. Perform joint density evaluations while establishing the rolling pattern and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern, if needed, to achieve the desired joint density. Perform additional joint density evaluations, at least once per sublot, unless otherwise directed.

4.9.3.3.3.2. **Record Tests**. Perform a joint density evaluation for each sublot at each pavement edge that is or will become a longitudinal joint. Joint density evaluations are not applicable in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas." Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results on Department forms to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer will make independent joint density verification at least once per project and may make independent joint density verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Provide the Engineer with the joint density of every sublot in the lot within one working day of the completion of each lot. Report the results of each joint density in accordance with Section 341.4.2., "Reporting and Responsibilities."

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if the evaluations on 2 consecutive sublots fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

4.9.3.3.4. **Recovered Asphalt Dynamic Shear Rheometer (DSR)**. The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Construction Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with Tex-211-F.

4.9.3.3.5. **Irregularities**. Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities and areas where the mixture does not bond to the existing pavement.

If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.4. **Exempt Production**. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is less than 1,000 tons;
- total production for the project is less than 5,000 tons;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements, and the production and placement pay factors are 1.000. All other specification requirements apply, and the Engineer will perform acceptance tests for production and placement listed in Table 14 when 100 tons or more per day are produced.

For exempt production:

- produce, haul, place, and compact the mixture in compliance with the specification and as directed;
- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target laboratory-molded density as tested by the Engineer;
- compact the mixture in accordance with Section 341.4.8., "Compaction"; and

- when a thermal imaging system is not used, the Engineer may perform segregation (density profiles) and thermal profiles in accordance with the specification.

4.9.5. **Ride Quality**. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 341.5., "Measurement," will be paid for at the unit bid price for "Dense Graded Hot-Mix Asphalt" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

Pay adjustments for bonuses and penalties will be applied as determined in this Item; however, a pay adjustment factor of 1.000 will be assigned for all placement sublots for "level ups" only when "level up" is listed as part of the item bid description code. A pay adjustment factor of 1.000 will be assigned to all production and placement sublots when "exempt" is listed as part of the item bid description code.

Payment for each sublot, including applicable pay adjustment bonuses, will only be paid for sublots when the Contractor supplies the Engineer with the required documentation for production and placement QC/QA, thermal profiles, segregation density profiles, and longitudinal joint densities in accordance with Section 341.4.2., "Reporting and Responsibilities." When a thermal imaging system is used, documentation is not required for thermal profiles or segregation density profiles on individual sublots; however, the thermal imaging system automated reports described in Tex-244-F are required.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Pay adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

6.1. **Production Pay Adjustment Factors**. The production pay adjustment factor is based on the laboratory-molded density using the Engineer's test results. A pay adjustment factor will be determined from Table 16 for each sublot using the deviation from the target laboratory-molded density defined in Table 9. The production pay adjustment factor for completed lots will be the average of the pay adjustment factors for the 4 sublots sampled within that lot.

Table 16
Production Pay Adjustment Factors for Laboratory-Molded Density[1]

Absolute Deviation from Target Laboratory-Molded Density	Production Pay Adjustment Factor (Target Laboratory-Molded Density)
0.0	1.050
0.1	1.050
0.2	1.050
0.3	1.044
0.4	1.038
0.5	1.031
0.6	1.025
0.7	1.019
0.8	1.013
0.9	1.006
1.0	1.000
1.1	0.965
1.2	0.930
1.3	0.895
1.4	0.860
1.5	0.825
1.6	0.790
1.7	0.755
1.8	0.720
> 1.8	Remove and replace

1. If the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 98.0%, take immediate corrective action to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

6.1.1. **Payment for Incomplete Production Lots**. Production pay adjustments for incomplete lots, described under Section 341.4.9.2.1.1., "Incomplete Production Lots," will be calculated using the average production pay factors from all sublots sampled. A production pay factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples.

6.1.2. **Production Sublots Subject to Removal and Replacement**. If after referee testing, the laboratory-molded density for any sublot results in a "remove and replace" condition as listed in Table 16, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.2. **Placement Pay Adjustment Factors**. The placement pay adjustment factor is based on in-place air voids using the Engineer's test results. A pay adjustment factor will be determined from Table 17 for each sublot that requires in-place air void measurement. A placement pay adjustment factor of 1.000 will be assigned to the entire sublot when the random sample location falls in an area designated on the plans as not subject to in-place air void determination. A placement pay adjustment factor of 1.000 will be assigned to quantities placed in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas." The placement pay adjustment factor for completed lots will be the average of the placement pay adjustment factors for up to 4 sublots within that lot.

Table 17
Placement Pay Adjustment Factors for In-Place Air Voids

In-Place Air Voids	Placement Pay Adjustment Factor	In-Place Air Voids	Placement Pay Adjustment Factor
< 2.7	Remove and Replace	6.4	1.042
2.7	0.710	6.5	1.040
2.8	0.740	6.6	1.038
2.9	0.770	6.7	1.036
3.0	0.800	6.8	1.034
3.1	0.830	6.9	1.032
3.2	0.860	7.0	1.030
3.3	0.890	7.1	1.028
3.4	0.920	7.2	1.026
3.5	0.950	7.3	1.024
3.6	0.980	7.4	1.022
3.7	0.998	7.5	1.020
3.8	1.002	7.6	1.018
3.9	1.006	7.7	1.016
4.0	1.010	7.8	1.014
4.1	1.014	7.9	1.012
4.2	1.018	8.0	1.010
4.3	1.022	8.1	1.008
4.4	1.026	8.2	1.006
4.5	1.030	8.3	1.004
4.6	1.034	8.4	1.002
4.7	1.038	8.5	1.000
4.8	1.042	8.6	0.998
4.9	1.046	8.7	0.996
5.0	1.050	8.8	0.994
5.1	1.050	8.9	0.992
5.2	1.050	9.0	0.990
5.3	1.050	9.1	0.960
5.4	1.050	9.2	0.930
5.5	1.050	9.3	0.900
5.6	1.050	9.4	0.870
5.7	1.050	9.5	0.840
5.8	1.050	9.6	0.810
5.9	1.050	9.7	0.780
6.0	1.050	9.8	0.750
6.1	1.048	9.9	0.720
6.2	1.046	> 9.9	Remove and Replace
6.3	1.044		

6.2.1. **Payment for Incomplete Placement Lots**. Pay adjustments for incomplete placement lots described under Section 341.4.9.3.1.2., "Incomplete Placement Lots," will be calculated using the average of the placement pay factors from all sublots sampled and sublots where the random location falls in an area designated on the plans as not eligible for in-place air void determination. A placement pay adjustment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples.

6.2.2. **Placement Sublots Subject to Removal and Replacement**. If after referee testing, the placement pay adjustment factor for any sublot results in a "remove and replace" condition as listed in Table 17, the Engineer will choose the location of 2 cores to be taken within 3 ft. of the original failing core location. The Contractor will obtain the cores in the presence of the Engineer. The Engineer will take immediate possession of the untrimmed cores and submit the untrimmed cores to the Construction Division, where they will be trimmed if necessary and tested for bulk specific gravity within 10 working days of receipt.

The average bulk specific gravity of the cores will be divided by the Engineer's average maximum theoretical specific gravity for that lot to determine the new pay adjustment factor of the sublot in question. If the new pay adjustment factor is 0.700 or greater, the new pay adjustment factor will apply to that sublot. If the new pay adjustment factor is less than 0.700, no payment will be made for the sublot. Remove and replace the

failing sublot, or the Engineer may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.3. **Total Adjusted Pay Calculation**. Total adjusted pay (TAP) will be based on the applicable pay adjustment factors for production and placement for each lot.

TAP = (A+B)/2

where:
A = Bid price × production lot quantity × average pay adjustment factor for the production lot
B = Bid price × placement lot quantity × average pay adjustment factor for the placement lot + (bid price × quantity placed in miscellaneous areas × 1.000)

Production lot quantity = Quantity actually placed - quantity left in place without payment

Placement lot quantity = Quantity actually placed - quantity left in place without payment - quantity placed in miscellaneous areas

Item 360
Concrete Pavement

1. DESCRIPTION

Construct hydraulic cement concrete pavement with or without curbs on the concrete pavement.

2. MATERIALS

2.1. **Hydraulic Cement Concrete**. Provide hydraulic cement concrete in accordance with Item 421, "Hydraulic Cement Concrete." Use compressive strength testing unless otherwise shown on the plans. Provide Class P concrete designed to meet a minimum average compressive strength of 3,200 psi or a minimum average flexural strength of 450 psi at 7 days or a minimum average compressive strength of 4,000 psi or a minimum average flexural strength of 570 psi at 28 days. Test in accordance with Tex-448-A or Tex-418-A.

Obtain written approval if the concrete mix design exceeds 520 lb. of cementitious material.

Use coarse aggregates for continuously reinforced concrete pavements to produce concrete with a coefficient of thermal expansion not more than 5.5×10^{-6} in./in./°F. Provide satisfactory Tex-428-A test data from an approved testing laboratory if the coarse aggregate coefficient of thermal expansion listed on the Department's *Concrete Rated Source Quality Catalog* is not equal to or less than 5.5×10^{-6} in./in./°F.

Provide Class HES concrete for very early opening of small pavement areas or leave-outs to traffic when shown on the plans or allowed. Design Class HES to meet the requirements of Class P and a minimum average compressive strength of 3,200 psi or a minimum average flexural strength of 450 psi in 24 hr., unless other early strength and time requirements are shown on the plans or allowed.

Use Class A or P concrete for curbs that are placed separately from the pavement. Provide concrete that is workable and cohesive, possesses satisfactory finishing qualities, and conforms to the mix design and mix design slump.

2.2. **Reinforcing Steel**. Provide Grade 60 or above, deformed steel for bar reinforcement in accordance with Item 440, "Reinforcement for Concrete." Provide positioning and supporting devices (baskets and chairs) capable of securing and holding the reinforcing steel in proper position before and during paving. Provide corrosion protection when shown on the plans.

2.2.1. **Dowels**. Provide smooth, straight dowels of the size shown on the plans, free of burrs, and conforming to the requirements of Item 440, "Reinforcement for Concrete." Coat dowels with a thin film of grease, wax, silicone or other approved de-bonding material. Provide dowel caps on the lubricated end of each dowel bar used in an expansion joint. Provide dowel caps filled with a soft compressible material with enough range of movement to allow complete closure of the expansion joint.

2.2.2. **Tie Bars**. Provide straight deformed steel tie bars. Provide either multiple-piece tie bars or single-piece tie bars as shown on the plans. Furnish multiple piece tie bar assemblies from the list of approved multiple-piece tie bars that have been prequalified in accordance with DMS-4515 "Multiple Piece Tie Bars for Concrete Pavements," when used. Multiple-piece tie bars used on individual projects must be sampled in accordance with Tex-711-I, and tested in accordance with DMS-4515 "Multiple Piece Tie Bars for Concrete Pavements."

2.3. **Alternative Reinforcing Materials**. Provide reinforcement materials of the dimensions and with the physical properties specified when allowed or required by the plans. Provide manufacturer's certification of required material properties.

2.4. **Curing Materials**. Provide Type 2 membrane curing compound conforming to DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants." Provide SS-1 emulsified asphalt conforming to Item 300, "Asphalts, Oils, and Emulsions," for concrete pavement to be overlaid with asphalt concrete under this Contract unless otherwise shown on the plans or approved. Provide materials for other methods of curing conforming to the requirements of Item 422, "Concrete Superstructures." Provide insulating blankets for curing fast track concrete pavement with a minimum thermal resistance (R) rating of 0.5 hour-square foot F/BTU. Use insulating blankets that are free from tears and are in good condition.

2.5. **Epoxy**. Provide Type III, Class C epoxy in accordance with DMS-6100, "Epoxies and Adhesives," for installing all drilled-in reinforcing steel. Submit a work plan and request approval for the use of epoxy types other than Type III, Class C.

2.6. **Evaporation Retardant**. Provide evaporation retardant conforming to DMS-4650., "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

2.7. **Joint Sealants and Fillers**. Provide Class 5 or Class 8 joint-sealant materials and fillers unless otherwise shown on the plans or approved and other sealant materials of the size, shape, and type shown on the plans in accordance with DMS-6310, "Joint Sealants and Fillers."

3. EQUIPMENT

Furnish and maintain all equipment in good working condition. Use measuring, mixing, and delivery equipment conforming to the requirements of Item 421, "Hydraulic Cement Concrete." Obtain approval for other equipment used.

3.1. **Placing, Consolidating, and Finishing Equipment**. Provide approved self-propelled paving equipment that uniformly distributes the concrete with minimal segregation and provides a smooth machine-finished consolidated concrete pavement conforming to plan line and grade. Provide an approved automatic grade control system on slip-forming equipment. Provide approved mechanically-operated finishing floats capable of producing a uniformly smooth pavement surface. Provide equipment capable of providing a fine, light water fog mist.

Provide mechanically-operated vibratory equipment capable of adequately consolidating the concrete. Provide immersion vibrators on the paving equipment at sufficiently close intervals to provide uniform vibration and consolidation of the concrete over the entire width and depth of the pavement and in accordance with the manufacturer's recommendations. Provide immersion vibrator units that operate at a frequency in air of at least 8,000 cycles per minute. Provide enough hand-operated immersion vibrators for timely and proper consolidation of the concrete along forms, at all joints and in areas not covered by other vibratory equipment. Surface vibrators may be used to supplement equipment-mounted immersion vibrators. Provide tachometers to verify the proper operation of all vibrators.

For small or irregular areas or when approved, the paving equipment described in this Section is not required.

3.2. **Forming Equipment**.

3.2.1. **Pavement Forms**. Provide metal side forms of sufficient cross-section, strength, and rigidity to support the paving equipment and resist the impact and vibration of the operation without visible springing or settlement. Use forms that are free from detrimental kinks, bends, or warps that could affect ride quality or alignment. Provide flexible or curved metal or wood forms for curves of 100-ft. radius or less.

3.2.2. **Curb Forms**. Provide curb forms for separately placed curbs that are not slipformed that conform to the requirements of Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter."

3.3. **Reinforcing Steel Inserting Equipment**. Provide inserting equipment that accurately inserts and positions reinforcing steel in the plastic concrete parallel to the profile grade and horizontal alignment in accordance to plan details when approved.

3.4. **Texturing Equipment**.

3.4.1. **Carpet Drag**. Provide a carpet drag mounted on a work bridge or a manual moveable support system. Provide a single piece of carpet of sufficient transverse length to span the full width of the pavement being placed and adjustable so that a sufficient longitudinal length of carpet is in contact with the concrete being placed to produce the desired texture. Obtain approval to vary the length and width of the carpet to accommodate specific applications.

3.4.2. **Tining Equipment**. Provide a self-propelled metal tine device equipped with steel tines with cross-section approximately 1/32 in. thick × 1/12 in. wide. Provide tines for transverse tining equipment spaced at approximately 1 in., center-to-center, or provide tines for longitudinal tining equipment spaced at approximately 3/4 in., center-to-center. Manual methods that produce an equivalent texture may be used when it is impractical to use self-propelled equipment, such as for small areas, narrow width sections, and in emergencies due to equipment breakdown.

3.5. **Curing Equipment**. Provide a self-propelled machine for applying membrane curing compound using mechanically-pressurized spraying equipment with atomizing nozzles. Provide equipment and controls that maintain the required uniform rate of application over the entire paving area. Provide curing equipment that is independent of all other equipment when required to meet the requirements of Section 360.4.9., "Curing." Hand-operated pressurized spraying equipment with atomizing nozzles may only be used on small or irregular areas, narrow width sections, or in emergencies due to equipment breakdown.

3.6. **Sawing Equipment**. Provide power-driven concrete saws to saw the joints shown on the plans. Provide standby power-driven concrete saws during concrete sawing operations. Provide adequate illumination for nighttime sawing.

3.7. **Grinding Equipment**. Provide self-propelled powered grinding equipment that is specifically designed to smooth and texture concrete pavement using circular diamond blades when required. Provide equipment with automatic grade control capable of grinding at least a 3-ft. width longitudinally in each pass without damaging the concrete.

3.8. **Testing Equipment**. Provide testing equipment regardless of job-control testing responsibilities in accordance with Item 421, "Hydraulic Cement Concrete," unless otherwise shown on the plans or specified.

3.9. **Coring Equipment**. Provide coring equipment capable of extracting cores in accordance with the requirements of Tex-424-A when required.

3.10. **Miscellaneous Equipment**. Furnish both 10-ft. and 15-ft. steel or magnesium long-handled, standard straightedges. Furnish enough work bridges, long enough to span the pavement, for finishing and inspection operations.

4. CONSTRUCTION

Obtain approval for adjustments to plan grade-line to maintain thickness over minor subgrade or base high spots while maintaining clearances and drainage. Maintain subgrade or base in a smooth, clean, compacted condition in conformity with the required section and established grade until the pavement concrete is placed. Keep subgrade or base damp with water before placing pavement concrete.

Adequately light the active work areas for all nighttime operations. Provide and maintain tools and materials to perform testing.

4.1. **Paving and Quality Control Plan**. Submit a paving and quality control plan for approval before beginning pavement construction operations. Include details of all operations in the concrete paving process, including methods to construct transverse joints, methods to consolidate concrete at joints, longitudinal construction joint layout, sequencing, curing, lighting, early opening, leave-outs, sawing, inspection, testing, construction methods, other details and description of all equipment. List certified personnel performing the testing. Submit revisions to the paving and quality control plan for approval.

4.2. **Job-Control Testing**. Perform all fresh and hardened concrete job-control testing at the specified frequency unless otherwise shown on the plans. Provide job-control testing personnel meeting the requirements of Item 421, "Hydraulic Cement Concrete." Provide and maintain testing equipment, including strength testing equipment at a location acceptable to the Engineer. Use of a commercial laboratory is acceptable. Maintain all testing equipment calibrated in accordance with pertinent test methods. Make strength-testing equipment available to the Engineer for verification testing.

Provide the Engineer the opportunity to witness all tests. The Engineer may require a retest if not given the opportunity to witness. Furnish a copy of all test results to the Engineer daily. Check the first few concrete loads for slump and temperature to verify concrete conformance and consistency on start-up production days. Sample and prepare strength-test specimens (2 specimens per test) on the first day of production and for each 3,000 sq. yd. or fraction thereof of concrete pavement thereafter. Prepare at least 1 set of strength-test specimens for each production day. Perform slump and temperature tests each time strength specimens are made. Monitor concrete temperature to ensure that concrete is consistently within the temperature requirements. The Engineer will direct random job-control sampling and testing. Immediately investigate and take corrective action as approved if any Contractor test result, including tests performed for verification purposes, does not meet specification requirements.

The Engineer will perform job-control testing when the testing by the Contractor is waived by the plans; however, this does not waive the Contractor's responsibility for providing materials and work in accordance with this Item.

4.2.1. **Job-Control Strength**. Use 7-day job-control concrete strength testing in accordance with Tex-448-A or Tex-418-A unless otherwise shown on the plans or permitted.

Use a compressive strength of 3,200 psi or a lower job-control strength value proven to meet a 28-day compressive strength of 4,000 psi as correlated in accordance with Tex-427-A for 7-day job-control by compressive strength. Use a flexural strength of 450 psi or a lower job-control strength value proven to meet a 28-day flexural strength of 570 psi as correlated in accordance with Tex-427-A for 7-day job-control by flexural strength.

Job control of concrete strength may be correlated to an age other than 7 days in accordance with Tex-427-A when approved. Job-control strength of Class HES concrete is based on the required strength and time.

Investigate the strength test procedures, the quality of materials, the concrete production operations, and other possible problem areas to determine the cause when a job-control concrete strength test value is more than 10% below the required job-control strength or when 3 consecutive job-control strength values fall below the required job-control strength. Take necessary action to correct the problem, including redesign of the concrete mix if needed. The Engineer may suspend concrete paving if the Contractor is unable to identify, document, and correct the cause of low-strength test values in a timely manner. The Engineer will evaluate the structural adequacy of the pavements if any job-control strength is more than 15% below the required job-control strength. Remove and replace pavements found to be structurally inadequate at no additional cost when directed.

4.2.2. **Split-Sample Verification Testing**. Perform split-sample verification testing with the Engineer on random samples taken and split by the Engineer at a rate of at least 1 for every 10 job-control samples. The Engineer will evaluate the results of split-sample verification testing. Immediately investigate and take corrective action as approved when results of split-sample verification testing differ more than the allowable differences shown in Table 1, or the average of 10 job-control strength results and the Engineer's split-sample strength result differ by more than 10%.

Table 1
Verification Testing Limits

Test Method	Allowable Differences
Temperature, Tex-422-A	2°F
Slump, Tex-415-A	1 in.
Flexural strength, Tex-448-A	19%
Compressive strength, Tex-418-A	10%

4.3. **Reinforcing Steel and Joint Assemblies**. Accurately place and secure in position all reinforcing steel as shown on the plans. Place dowels at mid-depth of the pavement slab, parallel to the surface. Place dowels for transverse contraction joints parallel to the pavement edge. Tolerances for location and alignment of dowels will be shown on the plans. Stagger the lap locations so that no more than 1/3 of the longitudinal steel is spliced in any given 12-ft. width and 2-ft. length of the pavement. Use multiple-piece tie bars, drill and epoxy grout tie bars, or, if approved, mechanically-inserted single-piece tie bars at longitudinal construction joints. Verify that tie bars that are drilled and epoxied or mechanically inserted into concrete at longitudinal construction joints develop a pullout resistance equal to a minimum of 3/4 of the yield strength of the steel after 7 days. Test 15 bars using ASTM E488, except that alternate approved equipment may be used. All 15 tested bars must meet the required pullout strength. Perform corrective measures to provide equivalent pullout resistance if any of the test results do not meet the required minimum pullout strength. Repair damage from testing. Acceptable corrective measures include but are not limited to installation of additional or longer tie bars.

4.3.1. **Manual Placement**. Secure reinforcing bars at alternate intersections with wire ties or locking support chairs. Tie all splices with wire.

4.3.2. **Mechanical Placement**. Complete the work using manual placement methods described above if mechanical placement of reinforcement results in steel misalignment or improper location, poor concrete consolidation, or other inadequacies.

4.4. **Joints**. Install joints as shown on the plans. Joint sealants are not required on concrete pavement that is to be overlaid with asphaltic materials. Clean and seal joints in accordance with Item 438, "Cleaning and Sealing Joints." Repair excessive spalling of the joint saw groove using an approved method before installing the sealant. Seal all joints before opening the pavement to all traffic. Install a rigid transverse bulkhead, for the reinforcing steel, and shaped accurately to the cross-section of the pavement when placing of concrete is stopped.

4.4.1. **Placing Reinforcement at Joints**. Complete and place the assembly of parts at pavement joints at the required location and elevation, with all parts rigidly secured in the required position, when shown on the plans.

4.4.2. **Transverse Construction Joints**.

4.4.2.1. **Continuously Reinforced Concrete Pavement (CRCP)**. Install additional longitudinal reinforcement through the bulkhead when shown on the plans. Protect the reinforcing steel immediately beyond the construction joint from damage, vibration, and impact.

4.4.2.2. **Concrete Pavement Contraction Design (CPCD)**. Install and rigidly secure a complete joint assembly and bulkhead in the planned transverse contraction joint location when the placing of concrete is intentionally stopped. Install a transverse construction joint either at a planned transverse contraction joint location or mid-slab between planned transverse contraction joints when the placing of concrete is unintentionally stopped. Install tie bars of the size and spacing used in the longitudinal joints for mid-slab construction joints.

4.4.2.3. **Curb Joints**. Provide joints in the curb of the same type and location as the adjacent pavement. Use expansion joint material of the same thickness, type, and quality required for the pavement and of the section shown for the curb. Extend expansion joints through the curb. Construct curb joints at all transverse pavement joints. Place reinforcing steel into the plastic concrete pavement for non-monolithic curbs as shown on the plans unless otherwise approved. Form or saw the weakened plane joint across the full width

of concrete pavement and through the monolithic curbs. Construct curb joints in accordance with Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter."

4.5. **Placing and Removing Forms**. Use clean and oiled forms. Secure forms on a base or firm subgrade that is accurately graded and that provides stable support without deflection and movement by form riding equipment. Pin every form at least at the middle and near each end. Tightly join and key form sections together to prevent relative displacement.

Set side forms far enough in advance of concrete placement to permit inspection. Check conformity of the grade, alignment, and stability of forms immediately before placing concrete, and make all necessary corrections. Use a straightedge or other approved method to test the top of forms to ensure that the ride quality requirements for the completed pavement will be met. Stop paving operations if forms settle or deflect more than 1/8 in. under finishing operations. Reset forms to line and grade, and refinish the concrete surface to correct grade.

Avoid damage to the edge of the pavement when removing forms. Repair damage resulting from form removal and honeycombed areas with a mortar mix within 24 hr. after form removal unless otherwise approved. Clean joint face and repair honeycombed or damaged areas within 24 hr. after a bulkhead for a transverse construction joint has been removed unless otherwise approved. Promptly apply membrane curing compound to the edge of the concrete pavement when forms are removed before 72 hr. after concrete placement.

Forms that are not the same depth as the pavement, but are within 2 in. of that depth are permitted if the subbase is trenched or the full width and length of the form base is supported with a firm material to produce the required pavement thickness. Promptly repair the form trench after use. Use flexible or curved wood or metal forms for curves of 100-ft. radius or less.

4.6. **Concrete Delivery**. Clean delivery equipment as necessary to prevent accumulation of old concrete before loading fresh concrete. Use agitated delivery equipment for concrete designed to have a slump of more than 5 in. Segregated concrete is subject to rejection.

Begin the discharge of concrete delivered in agitated delivery equipment conforming to the requirements of Item 421, "Hydraulic Cement Concrete." Place non-agitated concrete within 45 min. after batching. Reduce times as directed when hot weather or other conditions cause quick setting of the concrete.

4.7. **Concrete Placement**. Do not allow the pavement edge to deviate from the established paving line by more than 1/2 in. at any point. Place the concrete as near as possible to its final location, and minimize segregation and rehandling. Distribute concrete using shovels where hand spreading is necessary. Do not use rakes or vibrators to distribute concrete.

4.7.1. **Consolidation**. Consolidate all concrete by approved mechanical vibrators operated on the front of the paving equipment. Use immersion-type vibrators that simultaneously consolidate the full width of the placement when machine finishing. Keep vibrators from dislodging reinforcement. Use hand-operated vibrators to consolidate concrete along forms, at all joints and in areas not accessible to the machine-mounted vibrators. Do not operate machine-mounted vibrators while the paving equipment is stationary. Vibrator operations are subject to review.

4.7.2. **Curbs**. Conform to the requirements of Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter" where curbs are placed separately.

4.7.3. **Temperature Restrictions**. Place concrete that is between 40°F and 95°F when measured in accordance with Tex-422-A at the time of discharge, except that concrete may be used if it was already in transit when the temperature was found to exceed the allowable maximum. Take immediate corrective action or cease concrete production when the concrete temperature exceeds 95°F.

Do not place concrete when the ambient temperature in the shade is below 40°F and falling unless approved. Concrete may be placed when the ambient temperature in the shade is above 35°F and rising or

above 40°F. Protect the pavement with an approved insulating material capable of protecting the concrete for the specified curing period when temperatures warrant protection against freezing. Submit for approval proposed measures to protect the concrete from anticipated freezing weather for the first 72 hr. after placement. Repair or replace all concrete damaged by freezing.

4.8. **Spreading and Finishing**. Finish all concrete pavement with approved self-propelled equipment. Use power-driven spreaders, power-driven vibrators, power-driven strike-off, screed, or approved alternate equipment. Use the transverse finishing equipment to compact and strike-off the concrete to the required section and grade without surface voids. Use float equipment for final finishing. Use concrete with a consistency that allows completion of all finishing operations without addition of water to the surface. Use the minimal amount of water fog mist necessary to maintain a moist surface. Reduce fogging if float or straightedge operations result in excess slurry.

4.8.1. **Finished Surface**. Perform sufficient checks with long-handled 10-ft. and 15-ft. straightedges on the plastic concrete to ensure the final surface is within the tolerances specified in Surface Test A in Item 585, "Ride Quality for Pavement Surfaces." Check with the straightedge parallel to the centerline.

4.8.2. **Maintenance of Surface Moisture**. Prevent surface drying of the pavement before application of the curing system by means that may include water fogging, the use of wind screens, and the use of evaporation retardants. Apply evaporation retardant at the manufacturer's recommended rate. Reapply the evaporation retardant as needed to maintain the concrete surface in a moist condition until curing system is applied. Do not use evaporation retardant as a finishing aid. Failure to take acceptable precautions to prevent surface drying of the pavement will be cause for shutdown of pavement operations.

4.8.3. **Surface Texturing**. Complete final texturing before the concrete has attained its initial set. Drag the carpet longitudinally along the pavement surface with the carpet contact surface area adjusted to provide a satisfactory coarsely textured surface. Prevent the carpet from getting plugged with grout. Do not perform carpet dragging operations while there is excessive bleed water.

A metal-tine texture finish is required unless otherwise shown on the plans. Provide transverse tining unless otherwise shown on the plans. Immediately following the carpet drag, apply a single coat of evaporation retardant, if needed, at the rate recommended by the manufacturer. Provide the metal-tine finish immediately after the concrete surface has set enough for consistent tining. Operate the metal-tine device to obtain grooves approximately 3/16 in. deep, with a minimum depth of 1/8 in., and approximately 1/12 in. wide. Do not overlap a previously tined area. Use manual methods to achieve similar results on ramps, small or irregular areas, and narrow width sections of pavements. Repair damage to the edge of the slab and joints immediately after texturing. Do not tine pavement that will be overlaid or that is scheduled for blanket diamond grinding or shot blasting.

Target a carpet drag texture of 0.04 in., as measured by Tex-436-A, when carpet drag is the only surface texture required on the plans. Ensure adequate and consistent macro-texture is achieved by applying enough weight to the carpet and by keeping the carpet from getting plugged with grout. Correct any location with a texture less than 0.03 in. by diamond grinding or shot blasting. The Engineer will determine the test locations at points located transversely to the direction of traffic in the outside wheel path.

4.8.4. **Small, Irregular Area, or Narrow Width Placements**. Use hand equipment and procedures that produce a consolidated and finished pavement section to the line and grade where machine placements and finishing of concrete pavement are not practical.

4.8.5. **Emergency Procedures**. Use hand-operated equipment for applying texture, evaporation retardant, and cure in the event of equipment breakdown.

4.9. **Curing**. Keep the concrete pavement surface from drying as described in Section 360.4.8.2., "Maintenance of Surface Moisture," until the curing material has been applied. Maintain and promptly repair damage to curing materials on exposed surfaces of concrete pavement continuously for at least 3 curing days. A curing day is defined as a 24-hr. period when either the temperature taken in the shade away from artificial heat is above 50°F for at least 19 hr. or the surface temperature of the concrete is maintained above 40°F for 24 hr.

Curing begins when the concrete curing system has been applied. Stop concrete paving if curing compound is not being applied promptly and maintained adequately. Other methods of curing in accordance with Item 422, "Concrete Superstructures," may be used when specified or approved.

4.9.1. **Membrane Curing**. Spray the concrete surface uniformly with 2 coats of membrane curing compound at an individual application rate of no more than 180 sq. ft. per gallon. Apply the curing compound before allowing the concrete surface to dry.

Manage finishing and texturing operations to ensure placement of curing compound on a moist concrete surface, relatively free of bleed water, to prevent any plastic shrinkage cracking. Time the application of curing compound to prevent plastic shrinkage cracking.

Maintain curing compounds in a uniformly agitated condition, free of settlement before and during application. Do not thin or dilute the curing compound.

Apply additional compound at the same rate of coverage to correct damage where the coating shows discontinuities or other defects or if rain falls on the newly coated surface before the film has dried enough to resist damage. Ensure that the curing compound coats the sides of the tining grooves.

4.9.2. **Asphalt Curing**. Apply a uniform coating of asphalt curing at a rate of 90 to 180 sq. ft. per gallon when an asphaltic concrete overlay is required. Apply curing immediately after texturing and once the free moisture (sheen) has disappeared. Obtain approval to add water to the emulsion to improve spray distribution. Maintain the asphalt application rate when using diluted emulsions. Maintain the emulsion in a mixed condition during application.

4.9.3. **Curing Class HES Concrete**. Provide membrane curing in accordance with Section 360.4.9.1., "Membrane Curing," for all Class HES concrete pavement. Promptly follow by wet mat curing in accordance with Section 422.4.8., "Final Curing," until opening strength is achieved but not less than 24 hr.

4.9.4. **Curing Fast-Track Concrete**. Provide wet mat curing unless otherwise shown on the plans or as directed. Cure in accordance with Section 422.4.8., "Final Curing." Apply a Type 1-D or Type 2 membrane cure instead of wet mat curing if the air temperature is below 65°F and insulating blankets are used.

4.10. **Sawing Joints**. Saw joints to the depth shown on the plans as soon as sawing can be accomplished without damage to the pavement regardless of time of day or weather conditions. Some minor raveling of the saw-cut is acceptable. Use a chalk line, string line, sawing template, or other approved method to provide a true joint alignment. Provide enough saws to match the paving production rate to ensure sawing completion at the earliest possible time to avoid uncontrolled cracking. Reduce paving production if necessary to ensure timely sawing of joints. Promptly restore membrane cure damaged within the first 72 hr. of curing.

4.11. **Protection of Pavement and Opening to Traffic**. Testing for early opening is the responsibility of the Contractor regardless of job-control testing responsibilities unless otherwise shown on the plans or as directed. Testing result interpretation for opening to traffic is subject to approval.

4.11.1. **Protection of Pavement**. Erect and maintain barricades and other standard and approved devices that will exclude all vehicles and equipment from the newly placed pavement for the periods specified. Protect the pavement from damage due to crossings using approved methods before opening to traffic. Where a detour is not readily available or economically feasible, an occasional crossing of the roadway with overweight equipment may be permitted for relocating equipment only but not for hauling material. When an occasional crossing of overweight equipment is permitted, temporary matting or other approved methods may be required.

Maintain an adequate supply of sheeting or other material to cover and protect fresh concrete surface from weather damage. Apply as needed to protect the pavement surface from weather.

4.11.2. **Opening Pavement to All Traffic**. Pavement that is 7 days old may be opened to all traffic. Clean pavement, place stable material against the pavement edges, seal joints, and perform all other traffic safety related work before opening to traffic.

4.11.3. **Opening Pavement to Construction Equipment**. Unless otherwise shown on the plans, concrete pavement may be opened early to concrete paving equipment and related delivery equipment after the concrete is at least 48 hr. old and opening strength has been demonstrated in accordance with Section 360.4.11.4., "Early Opening to All Traffic," before curing is complete. Keep delivery equipment at least 2 ft. from the edge of the concrete pavement. Keep tracks of the paving equipment at least 1 ft. from the pavement edge. Protect textured surfaces from the paving equipment. Restore damaged membrane curing as soon as possible. Repair pavement damaged by paving or delivery equipment before opening to all traffic.

4.11.4. **Early Opening to All Traffic**. Concrete pavement may be opened after curing is complete and the concrete has attained a flexural strength of 450 psi or a compressive strength of 3,200 psi, except that pavement using Class HES concrete may be opened after 24 hr. if the specified strength is achieved.

4.11.4.1. **Strength Testing**. Test concrete specimens cured under the same conditions as the portion of the pavement involved.

4.11.4.2. **Maturity Method**. Use the maturity method, Tex-426-A, to estimate concrete strength for early opening pavement to traffic unless otherwise shown on the plans. Install at least 2 maturity sensors for each day's placement in areas where the maturity method will be used for early opening. Maturity sensors, when used, will be installed near the day's final placement for areas being evaluated for early opening. Use test specimens to verify the strength–maturity relationship in accordance with Tex-426-A, starting with the first day's placement corresponding to the early opening pavement section.

Verify the strength–maturity relationship at least every 10 days of production after the first day. Establish a new strength–maturity relationship when the strength specimens deviate more than 10% from the maturity-estimated strengths. Suspend use of the maturity method for opening pavements to traffic when the strength–maturity relationship deviates by more than 10% until a new strength–maturity relationship is established.

The Engineer will determine the frequency of verification when the maturity method is used intermittently or for only specific areas.

4.11.5. **Fast Track Concrete Pavement**. Open the pavement after the concrete has been cured for at least 8 hr. and attained a minimum compressive strength of 1,800 psi or a minimum flexural strength of 255 psi when tested in accordance with Section 360.4.11.4.1., "Strength Testing," or Section 360.4.11.4.2., "Maturity Method," unless otherwise directed. Cover the pavement with insulating blankets when the air temperature is below 65°F until the pavement is opened to traffic.

4.11.6. **Emergency Opening to Traffic**. Open the pavement to traffic under emergency conditions, when the pavement is at least 72 hr. old when directed in writing. Remove all obstructing materials, place stable material against the pavement edges, and perform other work involved in providing for the safety of traffic as required for emergency opening.

4.12. **Pavement Thickness**. The Engineer will check the thickness in accordance with Tex-423-A unless other methods are shown on the plans. The Engineer will perform 1 thickness test consisting of 1 reading at approximately the center of each lane every 500 ft. or fraction thereof. Core where directed, in accordance with Tex-424-A, to verify deficiencies of more than 0.2 in. from plan thickness and to determine the limits of deficiencies of more than 0.75 in. from plan thickness. Fill core holes using an approved concrete mixture and method.

4.12.1. **Thickness Deficiencies Greater than 0.2 in.** Take one 4-in. diameter core at that location to verify the measurement when any depth test measured in accordance with Tex-423-A is deficient by more than 0.2 in. from the plan thickness.

Take 2 additional cores from the unit (as defined in Section 360.4.12.3., "Pavement Units for Payment Adjustment") at intervals of at least 150 ft. and at selected locations if the core is deficient by more than 0.2 in., but not by more than 0.75 in. from the plan thickness, and determine the thickness of the unit for payment purposes by averaging the length of the 3 cores. In calculations of the average thickness of this unit of pavement, measurements in excess of the specified thickness by more than 0.2 in. will be considered as the specified thickness plus 0.2 in.

4.12.2. **Thickness Deficiencies Greater than 0.75 in.** Take additional cores at 10-ft. intervals in each direction parallel to the centerline to determine the boundary of the deficient area if a core is deficient by more than 0.75 in. The Engineer will evaluate any area of pavement found deficient in thickness by more than 0.75 in., but not more than 1 in. Remove and replace the deficient areas without additional compensation or retain deficient areas without compensation, as directed. Remove and replace any area of pavement found deficient in thickness by more than 1 in. without additional compensation.

4.12.3. **Pavement Units for Payment Adjustment**. Limits for applying a payment adjustment for deficient pavement thickness from 0.20 in. to not more than 0.75 in. are 500 ft. of pavement in each lane. Lane width will be as shown on typical sections and pavement design standards.

For greater than 0.75 in. deficient thickness, the limits for applying zero payment or requiring removal will be defined by coring or equivalent nondestructive means as determined by the Engineer. The remaining portion of the unit determined to be less than 0.75 in. deficient will be subject to the payment adjustment based on the average core thickness at each end of the 10-ft. interval investigation as determined by the Engineer.

Shoulders will be measured for thickness unless otherwise shown on the plans. Shoulders 6 ft. wide or wider will be considered as lanes. Shoulders less than 6 ft. wide will be considered part of the adjacent lane.

Limits for applying payment adjustment for deficient pavement thickness for ramps, widenings, acceleration and deceleration lanes, and other miscellaneous areas are 500 ft. in length. Areas less than 500 ft. in length will be individually evaluated for payment adjustment based on the plan area.

4.13. **Ride Quality**. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

This Item will be measured as follows:

5.1. **Concrete Pavement**. Concrete pavement will be measured by the square yard of surface area in place. The surface area includes the portion of the pavement slab extending beneath the curb.

5.2. **Curb**. Curb on concrete pavement will be measured by the foot in place.

6. PAYMENT

These prices are full compensation for materials, equipment, labor, tools, and incidentals.

6.1. **Concrete Pavement**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the adjusted unit price bid for "Concrete Pavement" of the type and depth specified as adjusted in accordance with Section 360.6.2., "Deficient Thickness Adjustment."

6.2. **Deficient Thickness Adjustment**. Where the average thickness of pavement is deficient in thickness by more than 0.2 in. but not more than 0.75 in., payment will be made using the adjustment factor as specified in Table 2 applied to the bid price for the deficient area for each unit as defined under Section 360.4.12.3., "Pavement Units for Payment Adjustment."

Table 2
Deficient Thickness Price Adjustment Factor

Deficiency in Thickness Determined by Cores (in.)	Proportional Part of Contract Price Allowed (Adjustment Factor)
Not deficient	1.00
Over 0.00 through 0.20	1.00
Over 0.20 through 0.30	0.80
Over 0.30 through 0.40	0.72
Over 0.40 through 0.50	0.68
Over 0.50 through 0.75	0.57

6.3. **Curb**. Work performed and furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Curb" of the type specified.

Item 361
Repair of Concrete Pavement

1. DESCRIPTION

Repair concrete pavement to half-depth or full-depth in accordance with the details shown on the plans and the requirements of this Item.

2. MATERIALS

Provide materials that meet the pertinent requirements of the following:

- Item 360, "Concrete Pavement"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- DMS-6100, "Epoxies and Adhesives"
- DMS-4655, "Concrete Repair Materials"

2.1. **Half-Depth Repair**. Obtain approval for the repair material mix design. The selection of repair material should be based on the time for opening to traffic and temperature range during the repair.

Provide Class HES concrete designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the timeframe designated for opening to traffic if it is less than 72 hr. after concrete placement. Otherwise, provide Class S conforming to Item 421, "Hydraulic Cement Concrete" or Class P concrete conforming to Item 360, "Concrete Pavement."

Provide material meeting the requirements of DMS-4655, "Concrete Repair Materials," Type A-1 or A-2 when concrete in accordance with Item 421, "Hydraulic Cement Concrete," does not meet the strength requirement within the designated timeframe.

2.2. **Full-Depth Repair**. Obtain approval for the repair material mix design. The selection of repair material should be based on the time for opening to traffic and temperature range during the repair.

2.2.1. **Hydraulic Cement Concrete for Pavement**. Provide Class HES concrete designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the designated timeframe if the timeframe designated for opening to traffic is less than 72 hr. after concrete placement. Otherwise, provide Class P concrete conforming to Item 360, "Concrete Pavement."

2.2.2. **Base Material**. Furnish cold-mix asphaltic materials for replacement base material when shown on the plans. The Engineer may waive quality control (QC) tests for base material.

2.2.3. **Asphalt Concrete**. Furnish asphalt concrete material for overlay and asphalt shoulder repair as shown on the plans. The Engineer may waive QC tests for this material.

3. EQUIPMENT

Provide tools and equipment necessary for proper execution of the work that meet the pertinent requirements of the following:

- **Item 360, "Concrete Pavement"**
- **Concrete Demolition Equipment**. Provide chipping hammers or hydro-demolition equipment for the bulk removal of concrete.

- **Concrete Lift-Out Equipment**. Provide steel chains, lift pins, and a crane or front-end loader capable of lifting the concrete and loading it onto a flatbed or dump truck.
- **Drill**. Use a maximum 40-lb. drill with tungsten carbide bits.
- **Air Compressor**. Provide compressor equipped with filters designed to remove oil from the air and capable of delivering air to remove dust and debris.

4. CONSTRUCTION

Submit for approval all materials and methods of application at least 2 weeks before beginning any repair work. Repair locations will be as indicated on the plans or as directed. Repair areas may be adjusted after removing distressed concrete. Switch the half-depth repair to the full-repair if exposed existing longitudinal bars are deficient, as approved. Compensation will be made for unexpected volumes of repair areas or changes in scope of work.

4.1. **Half-Depth Repair**. Repair locations will be as indicated on the plans or as directed. Repair boundaries should be square or rectangular with a minimum length and width of 12 in.

Saw-cut repair boundaries to a minimum depth of 1-1/2 in. Do not saw-cut longitudinal or transverse steel. If the longitudinal steel is cut, a full-depth repair may be required as directed without additional compensation.

Remove concrete from the repair area as designated. Start at the center of the repair area. Ensure all loose concrete materials are removed and only sound concrete is left in place. Increase the repair area and perform a full-depth repair as directed if longitudinal steel bars were damaged by the removal operations. No additional compensation will be made.

Clean the area to be repaired by approved methods. Remove all loose particles, dirt, deteriorated concrete, or other substances that would impair the bond of the repair material.

Mix, place, and cure in accordance with the manufacturer's recommendation when material in DMS-4655, "Concrete Repair Materials," is used. Mix, place, and cure concrete in accordance with Item 360, "Concrete Pavement." when Class S, Class P, or Class HES is used. Test Class S, Class P, and Class HES concrete to the requirements of Section 360.4.2., "Job-Control Testing."

Match the grade and alignment of existing concrete pavement unless otherwise shown on the plans. Concrete pavement may be opened to traffic when specified strength is achieved.

4.2. **Full-Depth Repair**. Repair areas identified by the Engineer. Make repair areas rectangular, at least 6 ft. long and at least 1/2 a full lane in width unless otherwise shown on the plans. Accept ownership of all removed material, and dispose of it in accordance with federal, state, and local regulations unless otherwise shown on the plans. Saw-cut and remove existing asphalt concrete overlay at least 2 ft. longer than the repair patch in each longitudinal direction when there is existing asphalt concrete overlay over the repair area.

Saw-cut the full depth through the concrete around the perimeter of the repair area before removal. Schedule work so that concrete placement follows full-depth saw-cutting by no more than 7 days unless otherwise shown on the plans or approved.

Remove the slab by lifting the slab with a minimum disturbance to the base materials and surrounding concrete. Do not spall or fracture concrete adjacent to the repair area. Saw-cut and remove additional concrete as directed, after slab removal, if distresses are found in the surrounding concrete pavement. Repair damages to concrete pavement caused by the Contractor's operation without additional compensation. Perform repairs as directed.

Remove loose or damaged base material completely, leaving no loose base material.

Recompact base materials to the satisfaction of the Engineer. Level the base layer with cold-mix asphalt to the original bottom line and grade of the concrete slab before repair concrete is placed when shown on the plans. Place concrete directly onto the compacted base layer unless otherwise directed.

Use tie bars to restore the continuity of the concrete pavement. Demonstrate, through simulated job conditions, that the bond strength of the epoxy-grouted tie bars meets a pullout strength of at least 3/4 of the yield strength of the tie bar when tested in accordance with ASTM E488 within the epoxy manufacturer's recommended curing time. Increase embedment depth and retest when necessary to meet testing requirements. Perform tie bar testing before starting repair work.

Place tie bars as shown on the plans. Drill holes into the existing concrete at least 10 in. deep unless otherwise directed. Use a drill bit with a diameter that is 1/8 in. greater than that of tie bars. Clean the holes with a wire brush and compressed air to remove all the dust and moisture. Follow the epoxy manufacturer's instructions to apply the epoxy. Insert the tip of the epoxy cartridge or the tip of the machine applicator to the end of the tie bar hole, and inject Type III, Class C epoxy to fill the entire hole. Insert tie bars.

Place new deformed reinforcing steel bars of the same size and spacing as shown on the plans for Continuously Reinforced Concrete Pavement (CRCP) repairs. Lap all longitudinal reinforcing steel at least 25 in. Provide and place approved supports to firmly hold the new reinforcing steel in place when needed.

Place dowel bars as shown on the plans for Concrete Pavement Contraction Design (CPCD) repairs. Provide and place approved supports to firmly hold the dowel bars in place.

Mix, place, cure, and test concrete to the requirements of Item 360, "Concrete Pavement," and Item 421, "Hydraulic Cement Concrete." Broom-finish the concrete surface unless otherwise shown on the plans.

Perform a timely saw-cut over the dowel bars and restore the transverse contraction joint for CPCD. Restore the existing longitudinal joints to the requirements of Section 360.4.4., "Joints."

Match the grade and alignment of existing concrete pavement. Replace any asphalt overlay and shoulder material removed with new asphalt concrete material after concrete strength requirements have been met.

Remove repair area debris from the right of way each day. Concrete pavement may be opened to traffic when specified strength is achieved.

5. MEASUREMENT

This Item will be measured by the square foot in place of the completed concrete surface area repaired.

6. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as specified under "Measurement" will be paid for at the unit price bids for "Repair of Concrete Pavement (Half-Depth)" and "Repair of Concrete Pavement (Full-Depth)." This price is full compensation for removal, stockpiling, and disposal of waste material and for equipment, materials, labor, tools, and incidentals. Asphalt concrete, base material, and curbing will not be paid for directly but will be considered subsidiary to this Item.

Item 400
Excavation and Backfill for Structures

1. DESCRIPTION

Excavate for placement and construction of structures and backfill structures. Cut and restore pavement.

2. MATERIALS

Use materials that meet the requirements of the following Items.

- Item 401, "Flowable Backfill"
- Item 421, "Hydraulic Cement Concrete"
- DMS-4600, "Hydraulic Cement"

3. CONSTRUCTION

3.1. **Excavation**.

3.1.1. **General**. Excavate to the lines and grades shown on the plans or as directed. Provide slopes, benching, sheeting, bracing, pumping, and bailing as necessary to maintain the stability and safety of excavations up to 5 ft. deep. Excavation protection for excavations deeper than 5 ft. are governed by Item 402, "Trench Excavation Protection," and Item 403, "Temporary Special Shoring." Use satisfactory excavated material as backfill or as embankment fill in accordance with Item 132, "Embankment." Dispose of material not incorporated into the final project off the right of way in accordance with federal, state, and local regulations.

Keep any topsoil that has been removed separate, and replace it, as nearly as feasible, in its original position when excavating for installation of structures across private property or beyond the limits of the embankment. Restore the area to an acceptable condition.

Excavate drilled shafts in accordance with Item 416, "Drilled Shaft Foundations."

3.1.1.1. **Obstructions**. Remove obstructions to the proposed construction, including trees and other vegetation, debris, and structures, over the width of the excavation to a depth of 1 ft. below the bottom of excavation. Remove as required to clear the new structure and plug in an approved manner if abandoned storm drains, sewers, or other drainage systems are encountered. Restore the bottom of the excavation to grade by backfilling after removing obstructions in accordance with this Item. Dispose of surplus materials in accordance with federal, state, and local regulations.

3.1.1.2. **Excavation in Streets**. Cut pavement and base to neat lines when structures are installed in streets, highways, or other paved areas. Restore pavement structure after completion of excavation and backfilling.

Maintain and control traffic in accordance with the approved traffic control plan and the TMUTCD.

3.1.1.3. **Utilities**. Comply with the requirements of Article 7.19., "Responsibility for Damage Claims." Conduct work with minimum disturbance of existing utilities, and coordinate work in or near utilities with the utility owners. Inform utility owners before work begins, allowing them enough time to identify, locate, reroute, or make other adjustments to utility lines.

Avoid cutting or damaging underground utility lines that are to remain in place. Promptly notify the utility company if damage occurs. Provide temporary flumes across the excavation while open if an active sanitary

sewer line is damaged during excavation, and restore the lines when backfilling has progressed to the original bedding lines of the cut sewer.

3.1.1.4. **De-Watering**. Construct or place structures in the presence of water only if approved. Place precast members, pipe, and concrete only on a dry, firm surface. Remove water by bailing, pumping, well-point installation, deep wells, underdrains, or other approved method.

Remove standing water in a manner that does not allow water movement through or alongside concrete being placed if structures are approved for placement in the presence of water. Pump or bail only from a suitable sump separated from the concrete work while placing structural concrete or for a period of at least 36 hr. thereafter. Pump or bail during placement of seal concrete only to the extent necessary to maintain a static head of water within the cofferdam. Pump or bail to de-water inside a sealed cofferdam only after the seal has aged at least 36 hr.

Place a stabilizing material in the bottom of the excavation if the bottom of an excavation cannot be de-watered to the point the subgrade is free of mud or it is difficult to keep reinforcing steel clean. Use flexible base, cement-stabilized base or backfill, lean concrete, or other approved stabilizing material. Provide concrete with at least 275 lb. of cement per cubic yard, if lean concrete is used, and place to a minimum depth of 3 in. Stabilizing material placed for the convenience of the Contractor will be at the Contractor's expense.

3.1.2. **Bridge Foundations and Retaining Walls**. Do not disturb material below the bottom of footing grade. Do not backfill to compensate for excavation that has extended below grade. Fill the area with concrete at the time the footing is placed if excavation occurs below the proposed footing grade. Additional concrete placed will be at the Contractor's expense.

Take core samples to determine the character of the supporting materials if requested. Provide an intact sample adequate to judge the character of the founding material. Take these cores when the excavation is close to completion. Cores should be approximately 5 ft. deeper than the proposed founding grade.

Remove loose material if the founding stratum is rock or another hard material, and clean and cut it to a firm surface that is level, stepped, or serrated, as directed. Clean out soft seams, and fill with concrete at the time the footing is placed.

Place the foundation once the Engineer has inspected the excavation and authorized changes have been made to provide a uniform bearing condition if the material at the footing grade of a retaining wall, bridge bent, or pier is a mixture of compressible and incompressible material.

3.1.3. **Cofferdams**. The term "cofferdam" designates any temporary or removable structure constructed to hold surrounding earth, water, or both out of the excavation whether the structure is formed of soil, timber, steel, concrete, or a combination of these. Use pumping wells or well points for de-watering cofferdams if required.

Submit details and design calculations for sheet-pile or other types of cofferdams requiring structural members bearing the seal of a licensed professional engineer for review before constructing the cofferdam. The Department reserves the right to reject designs. Design structural systems to comply with the AASHTO *Standard Specifications for Highway Bridges* or AASHTO LRFD *Bridge Design Specifications*. Interior dimensions of cofferdams must provide enough clearance for the construction, inspection, and removal of required forms and, if necessary, enough room to allow pumping outside the forms. Extend sheet-pile cofferdams well below the bottom of the footings, and make concrete seals as well braced and watertight as practicable.

Use Class E concrete for foundation seals unless otherwise specified. Place concrete foundation seals in accordance with Item 420, "Concrete Substructures." Seals placed for the convenience of the Contractor will be at the Contractor's expense.

Make the excavation deep enough to allow for swelling of the material at the base of the excavation during pile-driving operations when the Engineer judges it to be impractical to de-water inside a cofferdam and a

concrete seal is to be placed around piling driven within the cofferdam. Remove swelling material to the bottom of the seal grade after driving the piling. Remove the foundation material to exact footing grades where it is possible to de-water inside the cofferdam without placing a seal after driving piling. Do not backfill a foundation to compensate for excavation that has been extended below grade; fill such areas below grade with concrete at the time the seals or footings are placed.

Remove cofferdams after completing the substructure without disturbing or damaging the structure unless otherwise provided.

3.1.4. **Culverts and Storm Drains**. When the design requires special bedding conditions for culverts or storm drains, an excavation diagram will be shown on the plans. Do not exceed these limits of excavation.

Construct pipe structures in an open cut with vertical sides extending to a point 1 ft. above the pipe unless otherwise shown on the plans. When site conditions or the plans do not prohibit sloping the cut, the excavation may be stepped or laid back to a stable slope beginning 1 ft. above the pipe. Maintain the stability of the excavation throughout the construction period.

Construct the embankment for pipe to be installed in fill above natural ground to an elevation at least 1 ft. above the top of the pipe, and then excavate for the pipe.

3.1.4.1. **Unstable Material**. Remove the material to a depth of no more than 2 ft. below the grade of the structure when unstable soil is encountered at established footing grade, unless the Engineer authorizes additional depth. Replace soil removed with stable material in uniform layers no greater than 8 in. deep (loose measurement). Each layer must have enough moisture to be compacted by rolling or tamping as required to provide a stable foundation for the structure.

Use special materials such as flexible base, cement-stabilized base, cement-stabilized backfill, or other approved material when it is not feasible to construct a stable foundation as outlined above.

3.1.4.2. **Incompressible Material**. Remove the incompressible material to 6 in. below the footing grade, backfill with an approved compressible material, and compact in accordance with Section 400.3.3., "Backfill," if rock, part rock, or other incompressible material is encountered at established footing grade while placing prefabricated elements.

3.2. **Shaping and Bedding**. Place at least 2 in. of fine granular material for precast box sections on the base of the excavation before placing the box sections. Use bedding as shown in Figure 1 for pipe installations. Use Class C bedding unless otherwise shown on the plans. The Engineer may require the use of a template to secure reasonably accurate shaping of the foundation material. Undercut the excavation at least 4 in. where cement-stabilized backfill is indicated on the plans and backfill with stabilized material to support the pipe or box at the required grade.

B_c - Outside diameter or horizontal dimension

D - Inside diameter of pipe

d - Min. bedding material below pipe

D	d
≤ 27"	3"
30" to 60"	4"
≥ 66"	6"

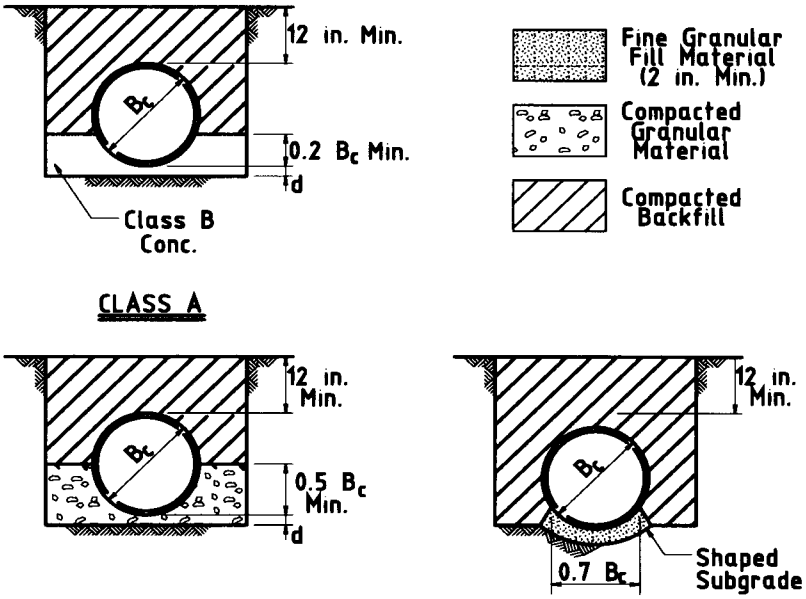


Figure 1
Bedding Diagrams

3.3. **Backfill.**

3.3.1. **General.** Backfill the excavation after placement of the permanent structure as soon as practical. Use backfill free from stones large enough to interfere with compaction; large or frozen lumps that will not break down readily under compaction; and wood or other extraneous material. Obtain backfill material from excavation or from other sources.

Place backfill in layers no greater than 10 in. deep (loose measurement) in areas not supporting a completed roadbed, retaining wall, or embankment. Place backfill in uniform layers no greater than 8 in. deep (loose measurement) in areas supporting a portion of a roadbed, retaining wall, or embankment. Compact each layer to meet the density requirements of the roadbed, retaining wall, embankment material, or as shown on the plans.

Bring each layer of backfill material to the moisture content needed to obtain the required density. Use mechanical tamps or rammers to compact the backfill. Rollers may be used to compact backfill if feasible.

Cohesionless materials may be used for backfilling. Use cohesionless materials that conform to the requirements of Table 1.

Table 1
Cohesionless Material Gradation Limits

Sieve Size	Percent Retained
3"	0
#10	See Note[1]
#200	90–100

1. No. 10 sieve requirements are 0 to 30% retained when used as aggregate for cement-stabilized backfill.

Compact cohesionless materials using vibratory equipment, water-ponding, or a combination of both.

3.3.2. **Bridge Foundations, Retaining Walls, Manholes/Inlets, and Box Culverts**. Place backfill against the structure only after the concrete has reached the design strength required in Item 421, "Hydraulic Cement Concrete."

Backfill retaining walls with material meeting the requirements of Item 423, "Retaining Walls." Backfill around bridge foundations, manholes/inlets and culverts using material with particles no more than 4 in. in greatest dimension and a gradation that permits thorough compaction. Use rock or gravel mixed with soil if the percentage of fines is enough to fill all voids and ensure a uniform and thoroughly compacted mass of proper density.

Use mechanical tamps and rammers to avoid damage to the structure where backfill material is being placed too close to the structure to permit compaction with blading and rolling equipment.

Avoid wedging action of backfill against structures. Step or serrate slopes bounding the excavation to prevent such action. Place backfill uniformly around bridge foundations. Place backfill equally and in uniform layers along both sides of manholes/inlets and culverts.

The Engineer may require backfilling of structures excavated into hard, erosion-resistant material, and subject to erosive forces, with stone or lean concrete.

Box culverts may be opened to traffic as soon as enough backfill and embankment has been placed over the top to protect culverts against damage from heavy construction equipment. Repair damage to culvert caused by construction traffic at no additional expense to the Department.

3.3.3. **Pipe**. Bring backfill material to the proper moisture condition after installing bedding and pipe as required and place it equally along both sides of the pipe in uniform layers no greater than 8 in. deep (loose measurement). Compact each lift mechanically. Thoroughly compact materials placed under the haunches of the pipe to prevent damage or displacement of the pipe. Place backfill in this manner to the top-of-pipe elevation. Place and compact backfill above the top of the pipe in accordance with Section 400.3.3.1., "General."

The Engineer may reject backfill material containing more than 20% by weight of material retained on a 3 in. sieve with large lumps not easily broken down or that cannot be spread in loose layers. Material excavated by a trenching machine will generally meet the requirements of this Section as long as large stones are not present.

Place and compact additional material where pipe extends beyond the toe of slope of the embankment and the depth of cover provided by backfill to the original ground level is less than the minimum required by the specifications for the type of pipe involved until the minimum cover has been provided.

3.3.4. **Cement-Stabilized Backfill**. Backfill the excavation to the elevations shown with cement-stabilized backfill when shown on the plans. Use cement-stabilized backfill that contains aggregate conforming to the gradation limits shown in Table 1, water, and a minimum of 7% hydraulic cement based on the dry weight of the aggregate, in accordance with Tex-120-E.

Place cement-stabilized backfill equally along the sides of structures to prevent strain on or displacement of the structure. Fill voids when placing cement-stabilized backfill. Use hand-operated tampers if necessary to fill voids.

3.3.5. **Flowable Backfill**. Backfill the excavation with flowable backfill to the elevations indicated when shown on the plans. Prevent the structure from being displaced during the placement of the flowable fill, and prevent flowable fill from entering manholes/inlets and culverts, and drainage structures.

4. MEASUREMENT

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

4.1. **Structural Excavation**. Unless shown on the plans as a pay item, structural excavation quantities shown are for information purposes only.

When structural excavation is specified as a pay item, structural excavation for pipe headwalls, inlets, manholes, culvert or storm drain extensions less than 15 ft. long, bridge abutments, retaining walls, and side road and private entrance pipe culverts will not be measured. No allowance will be made for variance from plans quantity incurred by an alternate bid.

When specified as a pay item, structural excavation will be measured by the cubic yard as computed by the average end areas method. Excavation diagrams on the plans take precedence over the provisions of this Article.

4.1.1. **Boundaries of Measurement**.

4.1.1.1. **Pipe**.

4.1.1.1.1. **Pipe up to 42 Inches**. For pipe up to 42 in. nominal or equivalent diameter, no material outside of vertical planes 1 ft. beyond and parallel to the horizontal projection of the outside surfaces of the pipe will be included.

4.1.1.1.2. **Pipe Larger than 42 Inches**. For pipes larger than 42 in. nominal or equivalent diameter, no material outside of vertical planes located 2 ft. beyond and parallel to the horizontal projection of the outside surfaces of the pipe will be included.

Quantities for excavation in fill above natural ground include 1 ft. above the top of the pipe regardless of the height of completed fill. Excavation for pipe will be measured between the extreme ends of the completed structure including end appurtenances as shown on the plans and from centerline to centerline of inlets, manholes, etc.

4.1.1.2. **Structural Plate Structures**. No material outside of vertical planes 3 ft. beyond and parallel to the horizontal projection of the outside surfaces of the structure will be included. When the quality of the existing soil or embankment is less than that of the proposed backfill material, the limits of measurement will be extended to vertical planes located 1/2 of the span beyond the horizontal projection of the outside surfaces of the structure.

4.1.1.3. **Footings, Walls, Boxes, and Other Excavation**. No material outside of vertical planes 1 ft. beyond and parallel to the edges of the footings or outside walls will be included whether or not a cofferdam or shoring is

used. When plans provide the option of cast-in-place or precast boxes, measurement will be based on the cast-in-place option.

Where excavation in addition to that allowed for the footings is required for other portions of the structure, measurement for the additional excavation will be limited laterally by vertical planes 1 ft. beyond the face of the member and parallel to it, and vertically to a depth of 1 ft. below the bottom of the member.

4.1.1.4. **Excavation near Roadways and Channels**. At structure sites other than culverts and pipe excavations, the measurement of structural excavation will include only material below or outside the limits of the completed road or channel excavation. Roadway and channel excavation will be paid under Item 110, "Excavation." For culverts except side road and private entrance culverts, excavation within the limits of the structure and below or outside the limits of the completed roadway excavation will be measured as structural excavation.

4.1.2. **Falsework**. No measurement will be made for excavation necessary for placing forms or falsework that exceeds the limits given in Section 400.4.1.1., "Boundaries of Measurement."

4.1.3. **Swelling**. Measurement will not include materials removed below footing grades to compensate for anticipated swelling due to pile-driving, nor will it include material required to be removed due to swelling beyond the specified limits during pile-driving operations.

4.1.4. **Cave-Ins**. Measurement will not include additional volume caused by slips, slides, cave-ins, silting, or fill material resulting from the action of the elements or the Contractor's operation.

4.1.5. **Undercut**. Where rock or other incompressible or unstable material is undercut to provide a suitable foundation for pipe or box sections, such material below grade directed to be removed will be measured for payment.

4.1.6. **Grade Change**. Additional measurement will be made of the volume of excavation involved in the lowering or raising of the elevation of a footing, foundation, or structure unit, when such grade change is authorized.

4.2. **Cement-Stabilized Backfill**. Cement-stabilized backfill will be measured by the cubic yard as shown on the plans.

4.3. **Cutting and Restoring Pavement**. Cutting and restoring pavement will be measured by the square yard as shown on the plans. Excavation below pavement or base will be measured as structural excavation of the pertinent type.

5. PAYMENT

5.1. **Structural Excavation**. Unless specified as a pay item, structural excavation and backfill performed, and material furnished in accordance with this Item will not be paid for directly but are subsidiary to pertinent Items.

When structural excavation is specified as a pay item, the excavation and backfill work performed, and materials furnished will be paid for at the unit price bid for "Structural Excavation," "Structural Excavation (Box)," "Structural Excavation (Pipe)," and "Structural Excavation (Bridge)." This price includes concrete to compensate for excavation that has extended below grade for bridge foundations and retaining walls, and backfilling and compacting areas that were removed as part of structural excavation.

Cofferdams or other measures necessary for supporting excavations less than 5 ft. deep will not be measured or paid for directly but will be subsidiary to the Contract.

Foundation seal concrete for cofferdams, when required, will be paid for as provided in the pertinent Items. If no direct method of payment is provided in the Contract, the work will be measured and paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Seal placed for the convenience of the Contractor will not be paid for.

Unless otherwise provided, stone or lean concrete backfill around structures as provided for in Section 400.3.3.2., "Bridge Foundations, Retaining Walls, Manholes/Inlets, and Box Culverts," will be measured and paid for as extra work in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

When structural excavation is specified as a pay item, a partial payment of 50% of the bid price will be made for structural excavation completed to the satisfaction of the Engineer but not backfilled. The remaining amount will be paid upon completion of backfilling. When the Contractor elects to excavate beyond plan requirements, no measurement will be made of the additional volume.

5.2. **Removal and Replacement of Unsuitable or Incompressible Material**. Removal and replacement of material will be paid for if directed. Removal and replacement of material or placement of special material made necessary by the softening of founding material due to the Contractor's sequence of work or operation, will be at the Contractor's expense. Special material used or additional excavation made for the Contractor's convenience will not be paid for.

5.2.1. **Structural Excavation as a Pay Item**. Where special materials are not required or specified, payment for the removal and replacement of unstable or incompressible material will be made at a price equal to 200% of the unit price bid per cubic yard for Structural Excavation. When the Contractor elects to remove and replace material deeper than directed, no measurement will be made on that portion below the directed elevation. This price is full compensation for removing the unstable or incompressible material; furnishing, hauling, placing, and compacting suitable replacement material; and equipment, labor, tools, and incidentals.

When the plans specify or when directed, the use of special materials such as flexible base, cement-stabilized base, cement-stabilized backfill, or other special material, payment for excavation below footing grades will be made at the unit price bid for Structural Excavation. Payment for furnishing, hauling, placing, and compacting the flexible base, cement-stabilized base, cement-stabilized backfill, or other special materials will be made at the unit price bid for these items in the Contract, or, if the required material is not a bid item, in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

5.2.2. **Structural Excavation Not a Pay Item**. Where special materials for backfill are not required or specified, payment for the authorized removal and replacement of unstable or incompressible material will be measured and paid for at $15 per cubic yard of material removed. This price is full compensation for removing the unstable or incompressible material; furnishing, hauling, placing, and compacting suitable replacement material; and equipment, labor, tools, and incidentals.

When the plans specify or when directed, the use of special materials such as flexible base, cement-stabilized base, cement-stabilized backfill, or other special material, excavation below the footing grades will be paid for at $10 per cubic yard. Payment for furnishing, hauling, placing, and compacting the flexible base, cement-stabilized base, cement-stabilized backfill, or other special materials will be made at the unit price bid for these items, or, if the required material is not a bid item, in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

5.3. **Lowering of a Structure Foundation**. If the Engineer requires a structure foundation to be lowered to an elevation below the grade shown on the plans, overexcavation will be paid in accordance with Table 2.

Table 2
Payment for Required Overexcavation

Variance of Revised Footing Grade from Plan Grade	Payment Terms	Variance of Revised Footing Grade from Plan Grade
	"Structural Excavation" is a Bid Item	"Structural Excavation" is not a Bid Item
Up to and including 5 ft.	Unit price equal to 115% of unit price bid for "Structural Excavation"	$10 per cubic yard
Over 5 ft. up to 10 ft.	Unit price equal to 125% of unit price bid for "Structural Excavation"	$12 per cubic yard
Over 10 ft.	In accordance with Article 9.7., "Payment for Extra Work and Force Account Method."	

5.4. **Cement-Stabilized Backfill**. Cement-stabilized backfill will be paid for at the unit price bid for "Cement-Stabilized Backfill."

5.5. **Cutting and Restoring Pavement**. Cutting and restoring pavement will be paid for at the unit price bid for "Cutting and Restoring Pavement" of the type specified.

Work done to repair damage to base or pavement incurred outside the limits shown on the plans, or the limits authorized, will not be measured for payment.

The unit prices bid are full compensation for excavation including removing obstructions and plugging drainage systems; bedding and backfilling including placing, sprinkling and compaction of material; soundings; cleaning and filling seams; constructing and removing cofferdams; de-watering, sheeting, or bracing excavations up to and including 5 ft. deep; pumps; drills; explosives; disposition of surplus material; cutting pavement and base to neat lines; and materials, hauling, equipment, labor, tools, and incidentals.

Flowable backfill will be paid for as provided in Item 401, "Flowable Backfill." Protection methods for open excavations deeper than 5 ft. will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring."

Item 401
Flowable Backfill

1. DESCRIPTION

Furnish and place flowable backfill for trench, hole, or other void.

2. MATERIALS

Use materials from prequalified sources listed on the Department website. Use materials from non-listed sources only when tested and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources. Do not combine approved material with unapproved material.

2.1. **Cement**. Furnish cement in accordance with DMS-4600, "Hydraulic Cement."

2.2. **Fly Ash**. Furnish fly ash in accordance with DMS-4610, "Fly Ash."

2.3. **Chemical Admixtures**. Furnish chemical admixtures in accordance with DMS-4640, "Chemical Admixtures for Concrete." Use specialty type admixtures to enhance the flowability, reduce shrinkage, and reduce segregation by maintaining solids in suspension when necessary. Use and proportion all admixtures in accordance with the manufacturer's recommendations.

2.4. **Fine Aggregate**. Provide fine aggregate that will stay in suspension in the mortar to the extent required for proper flow and that meets the gradation requirements of Table 1.

Table 1
Aggregate Gradation Chart

Sieve Size	Percent Passing
3/4"	100
#200	0–30

Test fine aggregate gradation in accordance with Tex-401-A.

Plasticity Index (PI) must not exceed 6 when tested in accordance with Tex-106-E.

2.5. **Mixing Water**. Use mixing water in accordance with Item 421, "Hydraulic Cement Concrete."

3. CONSTRUCTION

Submit a construction method and plan, including mix design, for approval. Provide a means of filling the entire void area, and be able to demonstrate this has been accomplished. Prevent the movement of any inserted structure from its designated location. Remove and replace or correct the problem if voids are found in the fill or any of the requirements are not met as shown on the plans without additional cost to the Department.

Furnish a mix meeting the requirements of Table 2 unless otherwise shown on the plans.

Table 2
Flowable Fill Mix Design Requirements

Property	Excavatable	Non-Excavatable	Test Method
28-day Compressive Strength,[1] psi	80 to 200	> 200	ASTM D4832
Consistency,[2] Min diameter, in.	8		ASTM D6103
Unit Weight, pcf	90 to 125	100 to 145	ASTM D6023
Air Content, %	10 to 30	5 to 15	ASTM D6023

1. Average of 2 specimens.
2. Mixture must not segregate.

Mix the flowable fill using a central-mixed concrete plant, ready-mix concrete truck, pug mill, or other approved method.

Furnish all labor, equipment, tools, containers, and molds required for sampling, making, transporting, curing, removal, and disposal of test specimens. Furnish test molds meeting the requirements of Tex-447-A. Transport, strip, and cure the test specimens as scheduled at the designated location. Cure test specimens in accordance with Tex-447-A. The Engineer will sample, make, and test all specimens. Dispose of used, broken specimens in an approved location and manner. The frequency of job-control testing will be at the direction of the Engineer.

4. MEASUREMENT

This Item will be measured by the cubic yard of material placed. Measurement will not include additional volume caused by slips, slides, or cave-ins resulting from the Contractor's operations.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flowable Backfill." This price is full compensation for furnishing, hauling, and placing materials and for equipment, tools, labor, and incidentals.

Item 402
Trench Excavation Protection

1. DESCRIPTION

Furnish and place excavation protection for trenches 5 ft. or greater in depth.

2. CONSTRUCTION

Provide vertical or sloped cuts, benches, shields, support systems, or other systems providing the necessary protection in accordance with OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations."

3. MEASUREMENT

This Item will be measured by the foot along the long axis of the trench where the depth of trench exceeds 5 ft. This measurement includes all required trench protection, including trench ends.

4. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Trench Excavation Protection." This price is full compensation for excavation and backfill required for excavation protection; furnishing, placing, and removing shoring, sheeting, or bracing; de-watering or diversion of water; jacking and jack removal; and equipment, labor, materials, tools, and incidentals.

Item 403
Temporary Special Shoring

1. DESCRIPTION

Furnish and install temporary shoring to hold the surrounding earth, water, or both out of the work area.

2. MATERIALS

Furnish new or used materials. Furnish materials that meet the requirements of Item 423, "Retaining Walls," when using temporary Mechanically Stabilized Earth (MSE) walls. Furnish materials that meet the requirements of Item 410, "Soil Nail Anchors," or Item 411, "Rock Nail Anchors," when using temporary nailed walls (rock or soil).

3. CONSTRUCTION

The Contractor is responsible for the temporary special shoring design unless complete details are included on the plans. Submit details and design calculations bearing the seal of a licensed professional engineer before constructing the shoring. The Department reserves the right to reject designs. Design the shoring to comply with OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, "Excavations." Design structural systems to comply with AASHTO *Standard Specifications for Highway Bridges* or AASHTO LRFD *Bridge Design Specifications*. Design shoring subject to railroad loading to comply with the AREMA *Manual for Railway Engineering* and any additional requirements of the railway being supported.

Provide vertical or sloped cuts, benches, shields, support systems, or other systems to provide the necessary protection in accordance with the approved design. Construct temporary MSE walls, when used, in accordance with Item 423, "Retaining Walls." Construct temporary nailed walls (rock or soil), when used, in accordance with Item 410, "Soil Nail Anchors," or Item 411, "Rock Nail Anchors."

4. MEASUREMENT

This Item will be measured by the square foot of surface area of a vertical plane at the face of the shoring between the top of the ground being supported and the minimum protection grade line shown on the plans. If no minimum protection grade is shown on the plans, the lowest required excavated elevation will be used. Shoring projecting above the level of the ground being supported will not be measured. When excavation techniques (e.g., sloped cuts or benching) are used to provide the necessary protection, the surface area for payment will be calculated based on the area described by a vertical plane adjacent to the structure.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Temporary Special Shoring." This price is full compensation for excavation and backfill; furnishing, placing and removing shoring, sheeting, or bracing; de-watering or diversion of water; jacking and jack removal; and equipment, labor, materials, tools, and incidentals.

No payment will be made for special shoring made necessary by the selection of an optional design or sequence of work that creates the need for shoring.

Item 404
Driving Piling

1. DESCRIPTION

Drive piling.

2. EQUIPMENT

2.1. **Driving Equipment**. Use power hammers for driving piling with specified bearing resistance. Use power hammers that comply with Table 1. Gravity hammers may be used for driving sheet piling and timber piling if no required design load is shown on the plans.

For initial rating of diesel hammers to determine compliance with the requirements of Table 1, the height of fall of the ram of the single-acting (open-end) hammer must be 7 ft. For a double-acting (enclosed ram) hammer, the energy rating must be 85% of the rated output by the manufacturer.

A hammer that produces less energy than required by Table 1 may be approved if a wave equation analysis indicates the hammer can drive the specified pile against a bearing resistance of 3 times the required design load before reaching 0.1 in. of penetration per blow. The bearing resistance of the piling driven with this particular equipment will be determined in accordance with the Wave Equation Method.

Use an air compressor that supplies the volume and pressure specified by the manufacturer of the hammer. Provide an accurate pressure gauge.

Maintain the valve mechanism and other parts of power hammers so the hammer will operate at the speed and stroke length specified by the manufacturer.

Equip enclosed ram diesel hammers with a gauge and provide charts to evaluate the equivalent energy being produced. Calibrate the gauge before work begins, whenever gauge accuracy is in question, and at least once each 6 months.

Table 1
Size of Driving Equipment

Piling Type	Hammer Type	Ram Weight (lb.)	Maximum Ram Stroke (ft.)	Minimum Hammer Energy (ft.-lb.)[1]
Timber	Air, Hydraulic	2,000 Min	5	330R
	Diesel	2,000 Min	10	330R
Steel	Air, Hydraulic	3,000 Min	5	Larger of 250R or 2-1/2 Wp
	Diesel	2,000 Min	10	Larger of 250R or 2-1/2 Wp
Concrete	Air, Hydraulic	3,000 Min, but not less than 1/4 Wp	5	250R, but not less than 1 ft.-lb. per pound of pile weight
	Diesel	2,700 Min, but not less than 1/4 Wp	8[2]	250R, but not less than 1 ft.-lb. per pound of pile weight

1. R = Design load in tons. Wp = Weight of pile in pounds based on plan length.
2. Diesel hammers with less ram weight or greater ram stroke are permitted if a wave equation analysis indicates the combination of ram weight, stroke, and cushioning will not overstress the piling.

Provide hammer cushion consisting of layers of micarta and aluminum or other material specifically produced and approved for this application. Use a wood, wire rope, or asbestos hammer cushion only if permitted.

Regulate the height of fall when using gravity hammers to avoid damage to the piling.

Drive all test piling in a structure or in any approved segment of it with the same hammer, and use the same type and size hammer to drive the remainder of the piling in the structure or segment.

Equip pile drivers with leads constructed to allow freedom of movement of the hammer and to provide adequate support to the pile during driving. The longitudinal axis of the leads, hammer, and pile should coincide.

Ensure leads are long enough, except where piling is driven through water, that a follower will not be necessary. Use 1 pile in each 10 that is long enough to permit driving without a follower when driving piling underwater and a follower is required. Drive it as a test pile for proper correlation of the follower-driven piling. Payment will be made as regular piling.

Hammers designed to operate underwater may be used for underwater driving without a follower and without the correlation required for other hammers.

2.2. **Protection of Pile Heads**. Use a steel driving head (helmet) suitable for the type and size of piling. Drive steel H-piling and sheet piling with a helmet compatible with the specific pile shape driven.

Provide a cushion block for concrete piling between the driving head and the top of the pile. Use a cushion block that is a minimum of 4 in. thick for short piling (50 ft. or less) and at least 6 in. thick for longer piling unless otherwise directed. Use multiple layers of one of the following:

- 3/4-in. or 1-in. structural grade southern pine or fir plywood;
- green oak or gum, with the grain of the wood horizontal; or
- other approved material specifically produced for this application.

Pay special attention to the condition of the cushioning material. Drive no more than 3 piles with one cushion block. Change cushioning more frequently if necessary to prevent damage. Immediately replace any cushion block that has ignited. Do not use a tight-fitting driving helmet for concrete piling. Allow room for slight movement, but ensure the driving helmet is not large enough for the pile head to rotate freely. Center concrete piling and cushion within the helmet throughout the driving operation.

3. CONSTRUCTION

This Item uses the following terms:

- **Foundation Piling**. Piling placed under interior bent footings or retaining wall abutment footings.
- **Trestle Piling**. Piling embedded directly into the abutment cap or interior bent cap.
- **Sheet Piling**. Retaining piling not considered either foundation or trestle piling.
- **Test Piling**. Specific piling driven to investigate site conditions and determine regular piling lengths.
- **Test-Loaded Piling**. Specific piling driven and test-loaded to investigate site conditions and determine regular piling lengths. Do not fabricate regular piling until test loading and analysis is completed.
- **Regular Piling**. All piling other than test piling and test-loaded piling.

Do not fabricate regular piling until test pile-driving and analysis or test loading and analysis is completed.

Complete the embankment at bridge ends before driving abutment piling. Refer to Item 423, "Retaining Walls," for provisions on piling that passes through the structural volume of retaining walls.

Do not drive foundation piling until the footing excavation is complete. Drive concrete piling once the piling concrete, including build-ups, has aged at least 14 days. Do not drive piling in a saltwater environment until the piling concrete, including build-ups, has aged at least 21 days after concrete placement.

Re-drive any piling that is raised when driving adjacent piling. Withdraw and replace any broken, split, or displaced piling, or correct it as directed after a design analysis.

To control excessive stresses resulting in damage to the piling during driving, the following, alone or in combination, may be required:

- increase in cushion thickness,
- reduction of ram stroke,
- heavier ram with a shorter stroke,
- use of pilot holes or jetting when driving through hard or alternating hard and soft strata.

3.1. **Tolerance for Driving**. Drive piling to the required vertical or batter alignment, within the tolerances of this Section. Drive piling in pilot holes or with templates when necessary to comply with tolerances. Cut off piling reasonably square at the elevation shown on the plans, with a tolerance of no more than 2 in. above or below established cutoff grade. Submit for approval a structural analysis and proposed corrective action, signed and sealed by a licensed professional engineer when tolerances are exceeded and the Engineer requires corrective action.

3.1.1. **Trestle Piling**.

- Transverse to the centerline of the bent, the top of the piling may be no more than 2 in. from the position shown on the plans.
- Parallel to the centerline of the bent, the top of the piling may be no more than 4 in. from the position shown on the plans.

3.1.2. **Foundation Piling**.

- The top of each pile may be no more than 4 in. in any direction from the position shown on the plans.
- The center of gravity of the piling group may be no more than 3 in. from the center of gravity determined from plan location.
- The minimum edge distance for piling in a footing is 5 in. Additional concrete required to obtain this edge distance and specified reinforcing steel cover will be at the Contractor's expense.

3.2. **Penetration**. Piling lengths shown on the plans are the lengths estimated to give required bearing and for estimating purposes only. Drive piling to plan tip elevations or to greater depths as necessary to obtain the required bearing resistance shown on the plans.

The Engineer will establish regular pile lengths on the basis of the test data when test piling or test-loaded piling is used. Drive regular piling to this approximate elevation in these cases and to greater depths as required to obtain the plan bearing resistance.

Provide either pilot holes, jetting, or a combination of both for unusually hard driving conditions, typically less than 0.1 in. of penetration per blow if plan penetration is not obtained. Reduce penetration upon approval when the piling is advanced to within 5 ft. of plan length unless other penetration requirements or bearing evaluation methods govern.

3.3. **Pilot Holes**. Extend pilot holes no more than 5 ft. below the bottom of footings for foundation piling or 10 ft. below finished ground line for trestle piling, unless the specified penetration cannot be obtained by using the depth of holes indicated or specified. Determine the size and depth of pilot holes from the results of trial operations on the first piling driven or from available test pile data when deeper ones are required. Obtain approval for any excess depth or size of pilot holes. The maximum hole diameter permitted will be approximately 4 in. less than the diagonal of square piling or steel H-piling and 1 in. less than the diameter of round piling. The Engineer may vary hole size and depth to obtain penetration and bearing resistance.

Extend pilot holes through all embankments to natural ground when driving concrete piling.

Where a pilot hole is required in granular material that cannot be sealed off by ordinary drilling methods, a casing may be required around the boring device deep enough to prevent loose material from falling into the pilot hole.

Drive the piling below the depth of the pilot hole a minimum of 1 ft. or 100 blows, but not less than the required bearing resistance shown on the plans. Do not drive piling beyond the point where the penetration per blow is less than 0.1 in. as determined by an average of 10 blows unless directed otherwise. Stop driving if damage to the pile is apparent.

3.4. **Jetting**. Jetting is permitted when the specified penetration cannot be obtained by driving and pilot holes or other methods are not feasible. Submit details of the proposed methods for approval before jetting. The Engineer may authorize varying depths of jetting to achieve the desired results.

Jet as required in conjunction with driving but only to the approved depth. Use enough power for jetting operations to simultaneously operate at least two 2-1/2 in. diameter pipes equipped with 3/4-in. nozzles at a pressure of 150 psi. Perform the jetting with 1 or 2 jets as determined and approved from results of trial operations.

Drive the piling below the depth of the jetting a minimum of 1 ft. or 100 blows, but not less than the required bearing resistance shown on the plans. Do not drive piling beyond the point where the penetration per blow is less than 0.1 in. as determined by an average of 10 blows unless directed otherwise. Stop driving if damage to the pile is apparent.

3.5. **Hammer Formula Method of Bearing Evaluation**. Determine the allowable dynamic bearing resistance of piling by one of the hammer formulas in this Section unless otherwise shown on the plans. If the Engineer has determined a K factor based on test piling, test-loaded piling, or other methods, the computed allowable resistance will be the driving resistance determined based on the appropriate formula multiplied by the K factor. The computed allowable resistance should be greater than or equal to the foundation load shown on the plans.

3.5.1. **Single-Acting Power Hammers**. Use the following formula:

$$P_a = \frac{2WH}{S+0.1}$$

where:
P_a = allowable dynamic resistance in pounds
W = weight of ram in pounds
H = height of fall of ram in feet (field measured)
S = average penetration in inches per blow for the last 20 blows

Determine H by an approved electronic stroke indicator and blow count logging device provided by the Contractor. Pending approval, H can be determined by visual observation of the ram against a calibrated rod mounted on the hammer or by the following formula:

$$H = 16.1 \times \left(\frac{30}{B}\right)^2 - 0.3$$

where B = blows per minute

3.5.2. **Double-Acting Power Hammers**. Use the following formula:

$$P_a = \frac{2E}{S+0.1}$$

where:
P_a = allowable dynamic resistance in pounds
E = manufacturer's rated energy in foot-pounds (for double-acting power hammers), or the equivalent energy in foot-pounds determined by a calibrated gauge attached to the hammer and taken when the average

penetration in inches per blow is determined (for enclosed ram diesel hammer)
S = average penetration in inches per blow for the last 20 blows

3.5.3. **Other Hammer Types**. Provide a wave equation analysis for each pile, hammer, soil, and load combination for which the driving system is to be used. The analysis will determine the bearing capacity of the piling.

3.6. **Wave Equation Method of Bearing Evaluation**. Submit the following data when plans specify the bearing capacity of the piling be determined by the wave equation method:

- manufacturer's specification data for the hammer proposed for use, including all modifications and
- complete description and dimensions of all cushioning material used between the pile and helmet and in the cap block, including total thickness of each, and the direction of grain if wood is used.

These data are used by the Engineer to determine the required number of blows per unit of penetration the hammer must deliver to obtain the required bearing resistance.

After evaluation by the wave equation method, any change in the driving equipment may require re-evaluation. Such changes must be approved before further driving.

3.7. **Test Piling**. Drive test piling at locations shown on the plans or as directed. Make test piling part of the completed work, cut off or built up to grade as necessary. Use the required bearing evaluation method to determine bearing resistance.

Initially drive test piling to 3 ft. above plan tip elevation of the regular piling for the structure with the blow count recorded for each foot of driving (for example, drive test piling to 13 ft. above its plan tip elevation if the test piling is 10 ft. longer than regular piling). Retain the cushion if used.

Re-drive the test piling the additional length required by the plans at least 7 days after the original driving with the same hammer and cushion originally used. Record the blow count for each inch of driving for the first foot, for every 3 in. for the next 2 ft., and for each foot thereafter.

Provide the data to the Engineer for use in determining regular piling lengths and K factors. The K factor will be determined based on the following formula:

$$K = P_R / P$$

where:
K = a static correction factor applied to the evaluation method
P_R = re-drive bearing (tons) of the test pile determined by the evaluation method
P = original bearing (tons) of test pile determined by the evaluation method

3.8. **Test-Loaded Piling**. Conduct test load in accordance with Item 405, "Foundation Load Test."

Provide the data to the Engineer for use in determining regular piling lengths and K factors. The K factor will be determined based on the following formula:

$$K = L / P$$

where:
K = a static correction factor applied to the evaluation method
L = maximum safe static load proven by test load
P = bearing resistance of the test-loaded pile determined by the evaluation method

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be paid for directly but will be considered subsidiary to pertinent Items.

Item 405
Foundation Load Test

1. DESCRIPTION

Load-test piling or drilled shafts.

2. MATERIALS

Provide piling or drilled shafts for test loading as shown on the plans.

3. EQUIPMENT

Furnish all necessary tools and equipment required to perform the foundation load test.

4. CONSTRUCTION

Furnish and drive the piling in accordance with Item 404, "Driving Piling," or construct the shaft in accordance with Item 416, "Drilled Shaft Foundations," to be test-loaded. Use the same procedure for drilling the test shaft as for the shafts required in the structure.

Keep a complete record of pile-driving data and shaft-drilling data for all foundations used in the test load. Apply the test load no earlier than the seventh day after driving the test piling or after placing concrete in the test shaft. Load the test shaft only after the concrete design strength has been attained.

Perform the foundation load test as stated on the plans and in accordance with the following:

- ASTM D1143
- ASTM D4945
- ASTM D7383

Dismantle the test setup after completing the test if applicable.

Remove piling or shafts that are not part of the structure upon completion of the test load, or cut off at least 1 ft. below the bottom of the footing or the finished grade. Re-drive permanent piling to its original grade and bearing if it is raised during the test load.

5. MEASUREMENT

Measurement will be made for each complete test load satisfactorily performed, reported, and accepted.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for each "Foundation Load Test." This price is full compensation for material, equipment, labor, work, tools, and incidentals.

Test piling or test shafts that are not part of the permanent structure will not be paid for directly but will be subsidiary to this Item. Test piling or test shafts that are part of the permanent structure will be paid for under the pertinent Items.

Item 409
Prestressed Concrete Piling

1. DESCRIPTION

Furnish and place prestressed concrete piling.

2. MATERIALS

Use materials that meet the requirements of the following Items.

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 425, "Precast Prestressed Concrete Structural Members"
- Item 440, "Reinforcement for Concrete"

Fabricate prestressed concrete piling in accordance with the following Items.

- Item 424, "Precast Concrete Structural Members (Fabrication)"
- Item 425, "Precast Prestressed Concrete Structural Members"

Furnish piling in the lengths indicated on the plans when test or test-loaded piling is not required. When test or test-loaded piling is required, the Engineer will approve lengths based on test driving data or test load data. Cast regular piling only after the Engineer has determined the approved lengths based on the test or test-loaded piling.

3. CONSTRUCTION

Handle and store piling in a way that minimizes the risk of damage by impact or bending stress. Store piling above ground on adequate blocking. Do not use chain slings to handle piling. Immediately review and correct conditions causing the damage to any piling. Drive piling in accordance with Item 404, "Driving Piling." Test-load, when required, in accordance with Item 405, "Foundation Load Test."

3.1. **Defects and Breakage**. Damage to piling due to faulty materials or construction methods may be cause for rejection. Piling damaged in the process of fabrication, handling, storing, hauling, or driving is subject to the acceptance criteria and repair provisions set forth in the *Concrete Repair Manual*.

3.2. **Buildups and Cutoffs**. Construct buildups in accordance with plan details and Item 420, "Concrete Substructures." Make the final cut of the concrete square to the longitudinal axis for cutoffs.

3.3. **Test Piling**. Test piling must meet requirements for prestressed concrete piling. The Engineer may adjust the number of test piles to secure desired information.

4. MEASUREMENT

4.1. **Concrete Piling**. Prestressed concrete piling and prestressed concrete test piling will be measured by the foot of acceptable piling in place after all cutoffs and buildups have been made. When the Contractor elects to drive piling deeper than required to meet the specified length and bearing requirements, no measurement will be made on that portion below the elevation at which length and bearing requirements were first obtained.

4.2. **Buildups**. Buildups will be measured by each authorized, completed buildup made necessary by driving beyond the plan pile length to obtain required bearing resistance. No measurement will be made for a buildup made necessary by improper casting, handling, or driving.

4.3. **Cutoffs**. Cutoffs for both regular and test piling will be measured by the foot of cutoff above required grade.

5. PAYMENT

The price bid is full compensation for jetting, pilot holes, alignment holes, repairs, materials, tools, equipment, labor, and incidentals. Test-loaded piling and associated anchor piling will be paid for as provided in Item 405, "Foundation Load Test." Any test load ordered by the Engineer that is not provided for in the Contract will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

5.1. **Concrete Piling**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Prestressed Concrete Piling" or "Prestressed Concrete Test Piling" of the size specified.

5.2. **Buildups**. An additional payment for each completed authorized buildup splice for both regular and test piling, regardless of buildup length, will be made at a price equal to 10 times the unit price bid for "Prestressed Concrete Piling." Where piling is broken back for constructing buildups, payment for the breakback is included in the payment for buildups.

5.3. **Cutoffs**. Payment for cutoff lengths of both regular piling and test piling will be made at a price equal to 1/2 the unit price bid per foot for "Prestressed Concrete Piling." Payment for cut is included in the payment for cutoffs.

Item 410
Soil Nail Anchors

1. DESCRIPTION

Construct reinforced soil nail anchors.

2. MATERIALS

Provide materials conforming to the following requirements.

2.1. **Hydraulic Cement Concrete**. Use materials that meet the requirements of Item 421, "Hydraulic Cement Concrete." Provide a neat cement or sand-cement mixture for the grout for soil nail anchors with a 7-day compressive strength of 3,000 psi. Determine grout strength by testing the grout used for the test soil nail anchors in cubes in accordance with Tex-307-D or cylinders in accordance with Tex-418-A. Test further as directed or if the grout mixture is modified. Fly ash may be included in the grout.

Do not use grout mixed in a mobile continuous volumetric mixer.

Provide a grout mix with a minimum water-cement ratio of 0.4 and a minimum specific gravity of 1.85. Test for specific gravity in accordance with Tex-130-E.

When a sand-cement mixture is used for grouting soil nail anchors, provide a grout mixture with a minimum slump flow of 20 in. Test the slump flow of the grout in accordance with ASTM C1611.

The need for stiffer grout may arise when the hollow-stem auger drilling method is used or it is desired to control leakage of grout into highly permeable granular soils or highly fractured rock. In these instances, the Engineer may waive the requirements of slump flow testing.

2.2. **Pneumatically Placed Concrete**. Use materials that meet the requirements of Class II concrete in Item 431, "Pneumatically Placed Concrete," unless otherwise shown on the plans.

2.3. **Reinforcing Steel**. Use materials that meet the requirements of Item 440, "Reinforcement for Concrete." Provide epoxy coated reinforcing steel bar of the size and grade shown on the plans for permanent walls. The minimum allowable epoxy coating thickness is 12 mils.

2.4. **Bar Couplers**. Provide bar couplers that develop the full nominal tensile capacity of the soil nail bars as certified by the manufacturer.

2.5. **Nail Centralizers**. Provide expanded slit PVC centralizers with a minimum diameter of 1 in. less than the nail-hole. Wheel type centralizers will not be allowed.

3. EQUIPMENT

Furnish suitable equipment to drill the holes to the specified diameter, depth, and line. Provide a drill rig with an articulating head in the vertical plane and continuous flight augers. If an auger becomes worn to the degree that the drilled hole is less than the required diameter, remove the auger from service until it is repaired and can provide a hole of at least the required diameter.Return the auger to service once it is repaired and can provide a hole of at least the required diameter.

Furnish a hydraulic jack and reaction frame for stressing the test anchors. Furnish a pressure gauge for the jack that is graduated in 75 psi increments or less. Furnish a minimum of 2 dial gauges capable of measuring

to 0.001 in. Calibrate the hydraulic jack and ram used together as a system, and furnish certified copies of load calibration curves for all jacks and ram systems to be used in the work. Calibrate the jack and ram as a unit no more than 6 mo. before starting work. Recalibrate stressing systems when directed or at least every 6 mo.

Furnish a grout mixer and pump of sufficient capacity to place grout properly in the required quantities.

4. CONSTRUCTION

4.1. **Soil Nail Wall Construction Plan**. Submit a soil nail wall construction plan at least 30 days before beginning construction. Begin soil nail wall construction once the construction plan submittal is accepted. Provide detailed project-specific information in the soil nail wall construction plan that includes the following:

- Project start date, an overall description, and sequence of soil nail wall construction;
- List and sizes of excavation equipment, drill rigs (must have an articulating head in a vertical plane), cutting head (auger, rock bit, etc.), tools, tremies, and grouting equipment;
- Procedures for the sequence for the following items of work: excavations; drilling and grouting; soil nail and wall drainage system installation; and, if appropriate, facing construction;
- Details of pneumatically placed concrete equipment and application including mix process, shooting methods, and means for determining the thickness of the concrete applied;
- A nozzleman who is certified as an American Concrete Institute (ACI) Shotcrete Nozzelman;
- Plan and methods for nail testing, both the verification tests and proof tests, with calibration certificates dated within 5 mo. of the submittal date; and
- Other information shown on the plans or requested by the Engineer.

4.2. **Drilling**. Drill the hole so that its diameter is not smaller than the diameter shown on the plans or established by test soil nail anchors. Control hole alignment so that it varies no more than 5 degrees from the line specified on the plans. Furnish suitable drilling equipment and use methods suitable for the ground conditions. The use of drilling mud or other fluids to remove cuttings will not be allowed.

4.3. **Grouting**. Place the soil nail anchor with centralizers that are spaced no more than 8 ft. apart in the hole. Set the centralizers to position the soil nail reinforcing bar within 1 in. of the center of the hole. To grout, advance the grouting pipe to the bottom of the hole, and leave it there until the hole is filled with grout and enough unsegregated grout is expelled at the top of the hole. Withdraw the pipe slowly while grouting continues, filling the void left by the grout pipe. Grout each nail within 8 hr. of the completion of drilling. Holes open longer than 8 hr. will be rejected and backfilled with grout.

Grouting before insertion of the epoxy coated bar into the hole is only allowed with approval. If approved, advance the grout pipe to the bottom of the hole and leave it there until the hole is filled with grout and enough unsegregated grout is expelled at the top of the hole. Withdraw the pipe slowly while grouting continues, filling the void left by the grout pipe. Insert the epoxy coated bar with the centralizers attached and fill any void that is left from the insertion of the bar. Fill the hole completely to face of the cut.

If caving or sloughing of the hole occurs that prevents open-hole grouting, furnish either hollow-stem auger equipment, placing the nail reinforcing bar and grout through the auger, or casing to support the sides of the excavation. Use grouting methods that result in complete filling of the hole at the ground surface. Methods may include placement of grout in multiple stages or other approved methods. Completely remove any device used to dam the front of the hole immediately after the grout takes an initial set.

Record the following information concerning the grouting:

- Type of mixer
- Water-cement ratio
- Types of additives
- Type of cement
- Volume of grout

4.4. **Soil Nail Anchor Test.**

4.4.1. **Verification Tests.** Construct and test the soil nail anchors as indicated on the plans. Test the soil nail anchors before installing any production soil nail anchors. Do not use verification test nails as production soil nail anchors.

Provide an adequate reaction pad large enough to resist the required load without sinking into the soil or shifting laterally during the test. Do not use a reaction pad that sinks into the soil more than 2 in. or that allows the free end of the soil nail reinforcing bar to move laterally more than 2 in. Failure to provide an adequate reaction pad will void the soil nail anchor test. Provide additional test soil nail anchors until an adequate reaction system is achieved. Furnish additional test soil nail anchors, required due to inadequate reaction pads, at no expense to the Department.

Provide a reaction pad with a center opening larger than the hole diameter to ensure that no bridging or interaction occurs between the grout column and the reaction pad. Similarly, remove all pneumatically placed concrete, excess grout, or other foreign material to expose the full face of the grout column. Ensure the reaction system does not contact or interfere with the soil nail anchor reinforcing bar during the test. Conduct the following testing method:

- Apply test loads to soil nail anchors in increments of approximately 10% of the required test load stated on the plans. Hold each load increment long enough to obtain the gauge readings and to ensure that the readings have stabilized. Hold the final maximum test load for 10 min.
- Perform initial tensioning to take the slack out of the testing apparatus at 5% of the required test load unless otherwise directed.
- Provide gauges that extend and retract freely and move smoothly throughout their range. Provide a rigid and secure system to support the gauge independently of the jack or reaction system.
- Verification Test Nail Acceptance Criteria
  Unless otherwise shown on the plans, the verification test nail acceptance criteria is:
  - The total creep movement is less than 0.04 in. during the final 10-min. reading increment. If movement exceeds this value, the Engineer may require an additional hold period of up to 60 min. with a maximum 0.08-in. total creep movement including the movement from the original 10-min. hold.
  - The total measured movement at the maximum test load exceeds 80% of the theoretical elastic elongation of the unbonded length of the test nail.
  - A pullout limit state does not occur for the verification load listed on the plans. Pullout limit state is defined at a load level at which the test load cannot be further increased while there is continued movement of the test nail.

Modify construction methods or procedures if the test soil nail anchors fail to provide the minimum pullout capacity specified on the plans. Install and test additional soil nail test anchors until adequate pullout capacity is achieved. Test soil nail anchors, in addition to the number specified on the plans, are subsidiary to this Item.

Install additional soil nail test anchors following the modified construction procedures and test additional soil nail test anchors if the Contractor chooses to modify construction procedures after test soil nail anchors are completed and approved. This additional testing is subsidiary to this Item.

4.4.2. **Proof Tests.** Conduct Proof Testing of production nails when shown on the plans. The number, length, and target load of nail(s) to be proof loaded must be satisfied and tested according to the following criteria:

- The Engineer will determine the locations of each proof test nail. Completely grout the proof test nails. Proof testing may occur before the placement of pneumatically placed concrete for the temporary face. Leave a sufficiently voided region around the nail head to allow free nail movement if proof testing is to occur after the placement of pneumatically placed concrete for the temporary facing. Provide a minimum 2 in. clear zone around the grouted nail.

- Use a reaction system as outlined in Section 410.4.4.1., "Verification Tests."
- Follow proof nail loading sequence outlined for Section 410.4.4.1., "VerificationTests," except use the required proof load stated on the plans.
- Proof Test Nail Acceptance Criteria
  Unless otherwise shown on the plans, the proof test nail acceptance criteria is:
  - The total creep movement is less than 0.04 in. during the final 10 min. reading increment. If movement exceeds this value, the Engineer may require an additional hold period of up to 60 min. with a maximum 0.08 in. total creep movement including the movement from the original 10 min. hold.
  - The total measured movement at the maximum test load exceeds 80% of the theoretical elastic elongation of the unbonded length of the test nail.
  - A pullout limit state does not occur for the proof load listed on the plans. Pullout limit state is defined at a load level at which the test load cannot be further increased while there is continued movement of the test nail.
- If the proof test nails fail, the Contractor's engineer is responsible for redesigning the wall with supplemental soil nail anchors.

5. MEASUREMENT

Soil nail anchors will be measured by the foot of acceptable soil nail anchor in place. The soil nail anchor length measured is the length of the drilled and grouted hole as specified on the plans or modified by the Engineer. Soil nail anchor tests, both verification tests and proof tests, are subsidiary to this Item.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Soil Nail Anchors." This price is full compensation for materials, equipment, testing, labor, tools, and incidentals.

Item 411
Rock Nail Anchors

1. DESCRIPTION

Construct reinforced rock nail anchors.

2. MATERIALS

Provide materials conforming to the following requirements.

2.1. **Hydraulic Cement Concrete**. Use materials that meet the requirements of Item 421, "Hydraulic Cement Concrete." Provide a neat cement or sand-cement mixture for the grout for rock nail anchors with a 7-day compressive strength of 3,000 psi. Determine grout strength by testing the grout used for the test rock nail anchors in cubes in accordance with Tex-307-D or cylinders in accordance with Tex-418-A. Test further as directed or if the grout mixture is modified. Fly ash may be included in the grout.

Do not use grout mixed in a mobile continuous volumetric mixer.

Provide a grout mix with a minimum water-cement ratio of 0.4 and a minimum specific gravity of 1.85. Test for specific gravity in accordance with Tex-130-E.

When a sand-cement mixture is used for grouting rock nail anchors, provide a grout mixture with a minimum slump flow of 20 in. Test the slump flow of the grout in accordance with ASTM C1611.

The need for stiffer grout may arise when it is desired to control leakage of grout into highly permeable or fractured rock. In these instances, the Engineer may waive the requirements of slump flow testing.

2.2. **Pneumatically Placed Concrete**. Use materials that meet the requirements of Class II concrete in Item 431, "Pneumatically Placed Concrete," unless otherwise shown on the plans.

2.3. **Reinforcing Steel**. Use materials that meet the requirements of Item 440, "Reinforcement for Concrete." Provide epoxy coated reinforcing steel bar of the size and grade shown on the plans for permanent walls. The minimum allowable epoxy coating thickness is 12 mils.

2.4. **Bar Couplers**. Provide bar couplers that develop the full nominal tensile capacity of the rock nail bars, as certified by the manufacturer.

2.5. **Nail Centralizers**. Provide expanded slit PVC centralizers with a minimum diameter of 1 in. less than the nail-hole. Wheel type centralizers will not be allowed.

3. EQUIPMENT

Furnish suitable equipment to drill the holes to the specified diameter, depth, and line. Provide a drill rig with an articulating head in the vertical plane and continuous flight augers.

If the auger becomes worn to the degree that the drilled hole is less than the required diameter, remove the auger from service until it is repaired and can provide a hole of at least the required diameter.

Furnish a hydraulic jack and reaction frame for stressing the test anchors. Furnish a pressure gauge for the jack that is graduated in 75 psi increments or less. Furnish a minimum of 2 dial gauges capable of measuring to within 0.001 in. Calibrate the hydraulic jack and ram used together as a system, and furnish certified

copies of load calibration curves for all jacks and ram systems to be used in the work. Calibrate the jack and ram as a unit no more than 6 mo. before starting work. Recalibrate stressing systems when directed or at least every 6 mo.

Furnish a grout mixer and pump of sufficient capacity to place grout properly in the required quantities.

4. CONSTRUCTION

4.1. **Rock Nail Wall Construction Plan**. Submit a rock nail wall construction plan at least 30 days before beginning construction. Begin rock nail wall construction once the construction plan submittal is accepted. Provide detailed project-specific information in the rock nail wall construction plan that includes the following:

- Project start date, an overall description, and sequence of rock nail wall construction;
- List and sizes of excavation equipment, drill rigs (must have an articulating head in a vertical plane), cutting head (auger, rock bit, etc.), tools, tremies, and grouting equipment;
- Procedures for the sequence for the following items of work: excavations; drilling and grouting; rock nail and wall drainage system installation; and, if appropriate, facing construction;
- Details of pneumatically placed concrete equipment and application including mix process, shooting methods, and means for determining the thickness of the concrete applied;
- A nozzleman that is certified as an American Concrete Institute (ACI) Shotcrete Nozzelman;
- Plan and methods for rock nail testing, both the verification tests and proof tests, with calibration certificates dated within 5 months of the submittal date; and
- Other information shown on the plans or requested by the Engineer.

4.2. **Drilling**. Drill the hole so that its diameter is not smaller than the diameter shown on the plans or established by test rock nail anchors. Control hole alignment so that it varies no more than 5 degrees from the line specified on the plans. Furnish suitable drilling equipment and use methods suitable for the ground conditions. The use of drilling mud or other fluids to remove cuttings will not be allowed.

4.3. **Grouting**. Place the rock nail anchor with centralizers that are spaced no more than 8 ft. apart in the hole. Set the centralizers to position the rock nail reinforcing bar within 1 in. of the center of the hole. To grout, advance the grouting pipe to the bottom of the hole, and leave it there until the hole is filled with grout and enough unsegregated grout is expelled at the top of the hole. Withdraw the pipe slowly while grouting continues, filling the void left by the grout pipe. Grout each nail within 8 hr. of the completion of drilling. Holes open longer than 8 hours will be rejected and backfilled with grout.

Grouting before insertion of the epoxy coated bar into the hole is only allowed with approval. If approved, advance the grout pipe to the bottom of the hole and leave it there until the hole is filled and enough unsegregated grout is expelled at the top of the hole. Withdraw the pipe slowly while grouting continues, filling the void left by the grout pipe. Insert the epoxy coated bar with the centralizers attached and fill any void that is left from the insertion of the bar. Fill the hole completely to face of the cut.

If caving or sloughing of the hole occurs that prevents open-hole grouting, furnish either hollow-stem auger equipment, placing the nail reinforcing bar and grout through the auger, or casing to support the sides. Use grouting methods that result in complete filling of the hole at the ground surface. Methods may include placement of grout in multiple stages or other approved methods. Completely remove any device used to dam the front of the hole immediately after the grout takes an initial set.

Record the following information concerning the grouting:

- Type of mixer
- Water-cement ratio
- Types of additives
- Type of cement
- Volume of grout

4.4. **Rock Nail Anchor Test**.

4.4.1. **Verification Tests**. Construct and test the rock nail anchors as indicated on the plans. Test the rock nail anchors before installing any production rock nail anchors. Do not use verification test nails as production rock nail anchors.

Provide an adequate reaction pad large enough to resist the required load without sinking into the rock or shifting laterally during the test. Do not use a reaction pad that sinks into the rock more than 2 in. or that allows the free end of the rock nail reinforcing bar to move laterally more than 2 in. Failure to provide an adequate reaction pad will void the rock nail anchor test. Provide additional test rock nail anchors until an adequate reaction system is achieved. Furnish additional test rock nail anchors, required due to inadequate reaction pads, at no expense to the Department.

Provide a reaction pad with a center opening larger than the hole diameter to ensure that no bridging or interaction occurs between the grout column and the reaction pad. Similarly, remove all pneumatically placed concrete, excess grout, or other foreign material to expose the full face of the grout column. Ensure the reaction system does not contact or interfere with the rock nail anchor reinforcing bar during the test. Conduct the following testing method:

- Apply test loads to rock nail anchors in increments of approximately 10% of the required test load stated on the plans. Hold each load increment long enough to obtain the gauge readings and ensure that the readings have stabilized. Hold the final maximum test load for 10 min.
- Perform initial tensioning to take the slack out of the testing apparatus at 5% of the required test load unless otherwise directed.
- Provide gauges that extend, retract freely, and move smoothly throughout their range. Provide a rigid and secure system to support the gauge independently of the jack or reaction system.
- Verification Test Nail Acceptance Criteria
  Unless otherwise shown on the plans, the verification test nail acceptance criteria is:
  - The total creep movement is less than 0.04 in. during the final 10-min. reading increment. If movement exceeds this value, the Engineer may require an additional hold period of up to 60 min. with a maximum 0.08-in. total creep movement including the movement from the original 10-min. hold.
  - The total measured movement at the maximum test load exceeds 80% of the theoretical elastic elongation of the unbonded length of the test nail.
  - A pullout limit state does not occur for the verification load listed on the plans. Pullout limit state is defined at a load level at which the test load cannot be further increased while there is continued movement of the test nail.

Modify construction methods or procedures if the test rock nail anchors fail to provide the minimum pullout capacity specified on the plans. Install and test additional rock nail test anchors until adequate pullout capacity is achieved. Test rock nail anchors, in addition to the number specified on the plans, are subsidiary to this Item.

Install additional rock nail test anchors following the modified construction procedures and test additional rock nail test anchors if the Contractor chooses to modify construction procedures after test rock nail anchors are completed and approved. This additional testing is subsidiary to this Item.

4.4.2. **Proof Tests**. Conduct Proof Testing of production rock nails when shown on the plans. The number, length, and target load of nails to be proof loaded must be satisfied and tested according to the following criteria:

- The Engineer will determine the locations of each proof test nail. Completely grout the proof test nails. Proof testing may occur before the placement of pneumatically placed concrete for the temporary face. Leave a sufficiently voided region around the nail head to allow free nail movement if proof testing is to occur after the placement of pneumatically placed concrete for the temporary facing. A minimum of 2 in. clear around the grouted nail is required.

- Use a reaction system as outlined in the Section 411.4.4.1., "Verification Tests."
- Follow proof nail loading sequence outlined in the Section 411.4.4.1., "Verification Tests," except use the required proof load stated on the plans.
- Proof Test Nail Acceptance Criteria
  Unless otherwise shown on the plans, the proof test nail acceptance criteria is:
  - The total creep movement is less than 0.04 in. during the final 10-min. reading increment. If movement exceeds this value, the Engineer may require an additional hold period of up to 60 min. with a 0.08 in. total creep movement maximum including the movement from the original 10-min. hold.
  - The total measured movement at the maximum test load exceeds 80% of the theoretical elastic elongation of the unbonded length of the test nail.
  - A pullout limit state does not occur for the proof load listed on the plans. Pullout limit state is defined at a load level at which the test load cannot be further increased while there is continued movement of the test nail.
- If the proof test nails fail, the Contractor's engineer is responsible for redesigning the wall with supplemental rock nail anchors.

5. MEASUREMENT

Rock nail anchors will be measured by the foot of acceptable rock nail anchor in place. The rock nail anchor length measured is the length of the drilled and grouted hole as specified on the plans or modified by the Engineer. Rock nail anchor tests, both verification tests and proof tests, are subsidiary to this Item.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Rock Nail Anchors." This price is full compensation for materials, equipment, labor, tools, and incidentals.

Item 416
Drilled Shaft Foundations

1. DESCRIPTION

Construct foundations consisting of reinforced or non-reinforced concrete drilled shafts.

2. MATERIALS

Use materials that meet the requirements of the following Items.

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- Item 448, "Structural Field Welding"

Use concrete for drilled shafts that meets the requirements of Table 1 unless otherwise shown on the plans.

Table 1
Concrete for Drilled Shafts

Drilled Shaft Type	Concrete
Non-reinforced	Class A
Reinforced	Class C
Slurry and underwater concrete placement	Class SS

Use coarse aggregate Grade 4, 5, or 6 for drilled shaft concrete in reinforced drilled shafts. Grade 2 or 3 may be used if the shaft is dry and reinforcing steel has a 5 in. minimum clear spacing.

Use a water-reducing, retarding admixture in accordance with DMS-4640, "Chemical Admixtures for Concrete," in all concrete when using casing that will be pulled or when placing shafts underwater or under slurry.

Use concrete with slump that meets the requirements of Table 2 as determined by Tex-415-A.

Table 2
Slump Requirements

Placement Type	Minimum Acceptable Placement Slump, in.	Recommended Design and Placement Slump, in.	Maximum Acceptable Placement Slump, in.
Dry	5-1/2	6-1/2	7-1/2
Underwater and under slurry	7	8	9

Perform a slump loss test in accordance with Tex-430-A before beginning work when casing is to be pulled or concrete is to be placed underwater or under slurry. Provide concrete that will maintain a slump of at least 4 in. throughout the entire anticipated time of concrete placement. Time of concrete placement is described in Section 416.3.6., "Concrete," and Section 416.3.7., "Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods." Note the temperature of the concrete mix at the beginning of the slump loss test. Place the concrete if its temperature at the time of placement into the drilled shaft is no more than 10°F higher than the slump loss test temperature. Use ice or other concrete cooling ingredients to lower concrete temperature, or run additional slump loss tests at the higher temperatures. Slump loss testing will be waived if anticipated time of concrete placement is less than 90 minutes.

Use mineral drilling slurry that meets the requirements of Table 3, as determined by Tex-130-E. Determine pH of slurry by Tex-128-E or pH paper strips.

Table 3
Mineral Slurry Requirements

Before Introduction into the Excavation			Sampled from the Bottom of the Excavation before Concreting		
Specific Gravity	Sand Content	pH	Specific Gravity	Viscosity (sec.)	Sand Content
≤ 1.10	≤ 1%	8–11	≤ 1.15	≤ 45	≤ 4%

Use mineral slurry consisting of processed bentonite or attapulgite clays mixed with clean fresh water. Do not use partially hydrolyzed polyacrylamide (PHPA) polymeric slurry or any blended mineral-polymer slurry.

If approved, water may be used as the drilling fluid. In this case, all of the provisions of Table 3 must be met except that the maximum specific gravity is not to exceed 1.12.

Sample slurry from the bottom of the hole, before placing concrete, and test it in accordance with Tex-130-E. Use a pump or air lift to remove slurry that does not meet the requirements of Table 3 while adding fresh clean slurry to the top of the hole to maintain the slurry level. Continue this operation until the slurry sampled from the bottom of the hole meets the requirements.

3. CONSTRUCTION

Submit Drilled Shaft installation plan for review no later than one month before drilled shaft construction. Include the following in the plan:

- Name and experience record of the drilled shaft superintendent who will be in charge of drilled shaft opertations for this project.
- List of proposed equipment to be used, including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies or concrete pumps, casing, etc.
- Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
- Details of shaft excavation methods.
- When the use of slurry is anticipated, details of the slurry mix design and its suitability for the subsurface conditions at the construction site, mixing and storage methods, maintenance methods and disposal procedures.
- Details of methods to clean the shaft excavation.
- Details of reinforcement placement, including support and centralization methods.
- Details of concrete placement, including proposed operational procedures for free fall, tremie or pumping methods.
- Details of casing installation and removal methods.

The installation plan will be reviewed for conformance with the plans, specifications and special provisions. The Contractor will be notified within 14 days of receipt of the installation plan of any additional information required and/or changes necessary to meet the contract requirements. All procedural approvals given will be subject to trial in the field and will not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the plans and specifications.

Place the shaft to within the following tolerances:

- Vertical plumbness—1 in. per 10 feet of depth.
- Center of shaft located under column—1 in. of horizontal plan position.
- Center of shaft located under footing—3 in. of horizontal plan position.

Complete the embankment at bridge ends before installing drilled shafts that pass through the fill. Refer to Item 423, "Retaining Walls," for provisions for drilled shafts passing through the structural volume of retaining walls.

3.1. **Excavation**. The plans indicate the expected depths and elevations for encountering satisfactory bearing material. Excavate as required for the shafts through all materials encountered to the dimensions and elevations shown on the plans or required by the site conditions. Removal of man-made obstructions not shown on the plans will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Adjust the bottom of the shaft or alter the foundation if satisfactory founding material is not encountered at plan elevation, as approved to satisfactorily comply with design requirements. Blasting is not allowed for excavations.

Stop drilling if caving conditions are encountered, and adopt a construction method that stabilizes the shaft walls.

Do not excavate a shaft within 2 shaft diameters (clear) of an open shaft excavation, or one in which concrete has been placed in the preceding 24 hr.

Dispose of material excavated from shafts and not incorporated into the finished project in accordance with the plans and with federal, state, and local laws.

Provide suitable access, lighting, and equipment for proper inspection of the completed excavation and checking the dimensions and alignment of shafts excavation.

3.2. **Core Holes**. Take cores to determine the character of the supporting materials if directed. Use a method that will result in recovery of an intact sample adequate for judging the character of the founding material. Such cores should be at least 5 ft. deeper than the proposed founding grade or a depth equal to the diameter of the shaft, whichever is greater. Take these cores when the excavation is complete.

3.3. **Casing**. Use casing when necessary to prevent caving of the material, to exclude ground water, when slurry is used for hole stabilization, or when required as part of the Contractor's Safety Plan. Provide casing with an outside diameter not less than the specified diameter of the shaft. The portion of shaft below the casing may be as much as 2 in. smaller than the specified shaft diameter. No extra compensation will be made for concrete required to fill an oversized casing or oversized excavation. Use casing strong enough to withstand handling stresses and pressures of concrete and of the surrounding earth or water, and that is watertight, smooth, clean, and free of accumulations of hardened concrete.

Use construction methods that result in a minimal amount of disturbed soil being trapped outside the casing. This does not apply to temporary undersized casings used to protect workers inside shafts or to drilled shafts designed for point bearing only.

Leave casing in place only if authorized or shown on the plans. Extract casing only after placing the concrete to an appropriate level. Maintain sufficient concrete in the casing at all times to counteract soil and water pressure. Rotate or move the casing up or down a few inches if necessary before and during concrete placement to facilitate extraction of the casing.

3.4. **Requirements for Slurry Displacement Method**. When soil conditions warrant, use the slurry displacement method to construct drilled shafts unless otherwise shown on the plans. Use this method to support the sides of the excavation with processed mineral slurry that is then displaced by concrete to form a continuous concrete shaft.

Install surface casing to a minimum of 10 ft. below existing ground before introducing slurry. Do not use casing other than surface casing. Do not use surface casing longer than 20 ft. without approval. Do not extract the surface casing until after placing the concrete.

Pre-mix slurry in a reservoir with enough capacity to fill the excavation and for recovery of the slurry during concrete placement. Do not mix slurry in the shaft excavation or other hole. Allow adequate time for hydration of the slurry before introduction into the excavation.

Maintain a head of slurry in the shaft excavation at or near ground level or higher, as necessary, to counteract ground water pressure during and after drilling.

Use an air lift or proper size cleanout bucket, just before placing reinforcing steel, to remove any material that may have fallen from the sides of the excavation or accumulated on the bottom after the completion of drilling. Use a cleanout bucket if material is too large to be picked up with an air lift.

Re-process the hole with the auger as directed if concrete placement is not started within 4 hr. of the completion of the shaft excavation. Then clean the bottom with an air lift or cleanout bucket, and check the slurry at the bottom of the hole for compliance with the slurry requirements of Article 416.2., "Materials."

Agitate the congealed slurry to liquefaction if the slurry forms a gel before concrete placement, and whenever directed.

Recover and dispose of all slurry as approved, and in accordance with all federal, state, and local laws. Do not discharge slurry into or in close proximity to streams or other bodies of water.

3.5. **Reinforcing Steel**. Completely assemble the cage of reinforcing steel, and place it as a unit immediately before concrete placement. The cage consists of longitudinal bars and lateral reinforcement (spiral reinforcement, lateral ties, or horizontal bands). Connect individual segments with couplers or by lapping steel as approved if overhead obstacles prevent placement of the cage as a single unit.

Extend the reinforcing steel cage as follows if the shaft is lengthened beyond plan length unless directed otherwise.

- Extend the cage to the bottom for shafts supporting structures other than bridges.
- Extend the cage to 25 ft. or to the bottom, whichever is shorter, for bridge shafts with plan lengths less than 25 ft.
- Do not extend the cage for bridge shafts with plan lengths at least 25 ft. that are lengthened less than 33% of plan length.
- Extend the cage as directed for bridge shafts with plan lengths at least 25 ft. that are lengthened more than 33% of plan length.

If the cage does not reach the bottom of the shaft, it may be suspended, or a portion of the longitudinal steel may be extended to support the cage on the bottom of the shaft. Bars used to extend or support the cage may be lap spliced or welded by a qualified welder. Place the extension at the bottom of the shaft.

Tie spiral reinforcement to the longitudinal bars at a spacing no more than 24 in., or as required for a stable cage. Ensure lateral reinforcement is not welded to longitudinal bars unless otherwise shown on the plans.

Center the reinforcing steel cage in the excavation using approved "roller" type centering devices unless otherwise approved. Use concrete or plastic chairs to keep the reinforcing cage off of the bottom of the hole. Use centering devices starting at 1.5 ft. off from the bottom of the cage and spaced vertically at intervals not exceeding 10 ft. Use a minimum of 3 centering devices per level at a spacing not to exceed 30 in. Flat or crescent-shaped centralizers ("sleds") are not allowed.

Support or hold down the cage to control vertical displacement during concrete placement or extraction of the casing. Use support that is concentric with the cage to prevent racking and distortion of the steel.

Check the elevation of the top of the steel cage before and after concrete placement or after casing extraction when casing is used. Downward movement of the steel up to 6 in. per 20 feet of shaft length and upward movement of the steel up to 6 in. total are acceptable.

Maintain the minimum length of steel required for lap with column steel. Use dowel bars if the proper lap length is provided both into the shaft and into the column. Locate and tie all dowel bars into the cage before placing concrete or insert dowel bars into fresh, workable concrete.

Locate and tie anchor bolts when required before placement of concrete. Use templates or other devices to assure accurate placement of anchor bolts.

3.6. **Concrete**. Perform all work in accordance with Item 420, "Concrete Substructures." Provide concrete with maximum placement temperatures as specified in Table 4. Provide thermal analysis to show and temperature recording devices to verify maximum core temperature requirements are met as specified in Section 420.4.7.14., "Mass Placements," as directed.

Table 4
Maximum Concrete Placing Temperature

Shaft Size	Mix Design Options 1–5	Mix Design Options 6–8
Diameter < 5 ft.	95°F	95°F
5 ft.≤ Diameter ≤ 7 ft.	95°F	85°F
7 ft. < Diameter	85°F	75°F

Form portions of drilled shaft that project above natural ground.

Remove loose material and accumulated seep water from the bottom of the excavation before placing concrete. Place concrete using underwater placement methods if water cannot be removed.

Place concrete as soon as possible after all excavation is complete and reinforcing steel is placed. Provide workable concrete that does not require vibrating or rodding. Vibrate formed portions of drilled shafts.

Place concrete continuously for the entire length of the shaft. Limit free fall of concrete to 25 ft. for dry shafts of 24 in. or smaller diameter. Use a suitable tube or tremie to prevent segregation of materials. Use a tube or tremie in sections to provide proper discharge and permit raising as the placement progresses. For dry shafts over 24 in. diameter, concrete can be allowed to free fall an unlimited distance if it does not strike the reinforcing cage or sides of the hole during placement. Provide a hopper with a minimum 3-ft.long drop-tube at the top of the shaft to direct concrete vertically down the center of the shaft when free fall is used. Do not use a shovel or other means to simply deflect the concrete discharge from the truck.

Maintain a sufficient head of concrete for cased shafts at all times above the bottom of the casing to overcome hydrostatic pressure. Extract casing at a slow, uniform rate with the pull in line with the axis of the shaft. Monitor the concrete level in the casing during extraction. Stop the extraction and add concrete to the casing as required to ensure a completely full hole upon casing removal. The elapsed time from the mixing of the first concrete placed into the cased portion of the shaft until the completion of extraction of the casing must not exceed the time for which the concrete maintains a slump of over 4 in. in accordance with Article 416.2., "Materials." Modify the concrete mix, the construction procedures, or both for subsequent shafts if the elapsed time is exceeded.

Cure the top surface and treat any construction joint area in accordance with Item 420, "Concrete Substructures."

3.7. **Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods**. Place concrete on the same day the shaft is excavated and as soon as possible after all excavation is complete and reinforcing steel is placed. Use an air lift or cleanout bucket of the proper size to clean the bottom of the excavation before placing the reinforcing steel cage and concrete. Place concrete through a closed tremie or pump it to the bottom of the excavation. The minimum tremie diameter will be at least 6 times the maximum size of aggregate used in the concrete mix but not less than 10 in. Initially seal the tremie or pump line to positively separate the concrete from the slurry or water. Place concrete continuously from the beginning of placement until the shaft is completed. Keep the tremie full of concrete and well submerged in the previously placed concrete at all times if using a tremie. Raise the tremie as necessary to maintain the free flow of concrete and the stability of any casing used. Keep the discharge tube submerged in the previously placed concrete at all times if using a pump. Place additional concrete to ensure the removal of any contaminated concrete at the top of the shaft. Allow the top portion of concrete to flush completely from the hole at the completion of the pour until there is no evidence of slurry or water contamination. Do not attempt to remove this concrete with shovels, pumps, or other means. Level the top of shaft with hand tools as necessary.

Use a sump or other approved method to channel displaced fluid and concrete away from the shaft excavation. Recover slurry and dispose of it as approved. Do not discharge displaced fluids into or near

streams or other bodies of water. Provide a collar or other means of capturing slurry and the top portion of concrete flushed from the shaft for pours over water.

Remove the tube, reseal it at the bottom, penetrate with the tube into the concrete already placed by at least 5 ft., and recharge it before continuing if concrete placement is interrupted due to withdrawal of the submerged end of the tremie or pump discharge tube before completion. If this condition exists, notify the Engineer and note the elevation and circumstances related to the loss of seal on the drilled shaft log.

The elapsed time from the mixing of the first concrete placed until the completion of concrete placement, including extraction of the casing, must not exceed the time for which the concrete maintains a slump of over 4 in. in accordance with Article 416.2., "Materials." Modify the concrete mix, the construction procedures, or both for subsequent shafts if the elapsed time is exceeded.

3.8. **Test Load**. Load test shafts, if required, in accordance with Item 405, "Foundation Load Test."

3.9. **Trial Shaft**. When required on the plans, construct trial shafts to the depth and diameter specified on the plans. Trial shafts include: drilling the hole, placement of the rebar cage (unless otherwise stated), and placement of the concrete. When trial shafts are required, delay start of production shafts until successful completion of trial shafts.

4. MEASUREMENT

4.1. **Drilled Shaft**. Drilled shaft foundations will be measured by the foot to the bottom of the shaft.

4.1.1. **Interior Bents and Piers**. Shafts will be measured from a point approximately 6 in. below the finished earthwork elevation at the center of each shaft, unless specific elevations or dimensions are indicated on the plans or unless otherwise directed to meet unusual conditions. The bent height shown on the plans is for estimating purposes only and does not control the top-of-shaft measurement.

4.1.2. **Abutment Bents and Retaining Walls**. Shafts will be measured from the bottom of footing or cap elevation.

4.1.3. **Other Non-Bridge Structures**. Shafts, including trial shafts, will be measured from the top of the shaft.

4.2. **Core Hole**. Core holes will be measured by each core hole drilled.

5. PAYMENT

The unit prices bid for the various classifications of drilled shafts will be full compensation for excavation; furnishing, placing, and removing casing; furnishing, processing, and recovering slurry; furnishing, and placing reinforcing steel; pumping; furnishing and placing concrete, including additional concrete required to fill an oversize casing or oversize excavation; conducting slump loss tests; backfilling; disposing of cuttings and slurry; and materials, tools, equipment, labor, and incidentals.

When the bottom of a drilled shaft is placed at an elevation below plan grade, no direct payment will be made for extra reinforcement placed to support the cage. The extra reinforcement will be considered subsidiary to the price bid per foot of shaft. No extra payment will be made for casings left in place.

No payment will be made for "Drilled Shaft" until the concrete has been placed.

5.1. **Drilled Shaft**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Drilled Shaft," "Drilled Shaft (Non-reinforced)," "Drilled Shaft (Sign Mounts)," "Drilled Shaft (High Mast Pole)," "Drilled Shaft (Roadway Illumination Pole)," or "Drilled Shaft (Traffic Signal Pole)" of the specified diameter, subject to the limitations for overruns authorized by the Engineer given in Section 416.5.1.1., "Overrun."

5.1.1. **Overrun**. Payment for individual completed shaft lengths up to and including 5 ft. in excess of the maximum plan length shaft, as defined in Section 416.5.1.2., "Maximum Plan Length Shaft," will be made at the unit price bid per foot of the specified diameter.

Payment for the portion of individual completed shaft length in excess of 5 ft. and up to and including 15 ft. more than the maximum plan length shaft, as defined in this Item, will be made at a unit price equal to 115% of the unit price bid per foot of the specified diameter.

Payment for the portion of individual completed shaft length in excess of 15 ft. more than the maximum plan length shaft, as defined in Section 416.5.1.2., "Maximum Plan Length Shaft," will be made at a unit price equal to 125% of the unit price bid per foot of the specified diameter.

5.1.2. **Maximum Plan Length Shaft**. Payment described above is subject to the following provisions for extra depth drilling:

- For bridge structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific bridge.
- For retaining walls, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific retaining wall.
- For overhead sign structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any overhead sign structures included in the Contract.
- For high mast illumination poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any high mast illumination pole included in the Contract.
- For roadway illumination poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any roadway illumination pole included in the Contract.
- For traffic signal poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any traffic signal pole included in the Contract.

5.2. **Core Hole**. Core holes will be paid at $200 each.

Item 420
Concrete Substructures

1. DESCRIPTION

Construct concrete substructures including footings, columns, caps, abutments, piers, culverts, other bridge substructure elements, and other concrete structures as indicated.

2. MATERIALS

2.1. **Concrete**. Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." Provide the class of concrete for each type of structure or unit as shown on the plans or in pertinent governing specifications.

2.2. **Grout or Mortar**. Provide grout for dowelling anchors or precast connections in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications."

2.3. **Latex Curing Materials**. Provide an acrylic-polymer latex admixture (acrylic resin emulsion per DMS-4640, "Chemical Admixtures for Concrete") suitable for producing polymer-modified concrete or mortar. Do not allow latex to freeze.

2.4. **Reinforcing Steel**. Provide reinforcing steel in accordance with Item 440, "Reinforcement for Concrete."

2.5. **Expansion Joint Material**. Provide materials in accordance with DMS-6310, "Joint Sealants and Fillers."

- Provide preformed fiber expansion joint material that conforms to the dimensions shown on the plans.
- Provide preformed bituminous fiber material unless otherwise specified.
- Provide asphalt board that conforms to dimensions shown on the plans.
- Provide re-bonded neoprene filler that conforms to the dimensions shown on the plans.

2.6. **Waterstop**. Provide rubber or polyvinyl chloride (PVC) waterstops in accordance with DMS-6160, "Water Stops, Nylon Reinforced Neoprene Sheet, and Elastomeric Pads," unless otherwise shown on the plans.

2.7. **Curing Materials**. Provide membrane curing compounds in accordance with DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

Provide cotton mats that consist of a filling material of cotton "bat" or "bats" (at least 12 oz. per square yard) completely covered with unsized cloth (at least 6 oz. per square yard) stitched longitudinally with continuous parallel rows of stitching spaced at less than 4 in., or tuft both longitudinally and transversely at intervals less than 3 in. Provide cotton mats that are free from tears and in good general condition. Provide a flap at least 6 in. wide consisting of 2 thicknesses of the covering and extending along 1 side of the mat.

Provide polyethylene sheeting that is at least 4 mils thick and free from visible defects. Provide only clear or opaque white sheeting when the ambient temperature during curing exceeds 90°F or when applicable to control temperature during mass pours.

Provide burlap-polyethylene mats made from burlap impregnated on 1 side with a film of opaque white pigmented polyethylene, free from visible defects. Provide laminated mats that have at least 1 layer of an impervious material such as polyethylene, vinyl plastic, or other acceptable material (either as a solid sheet or impregnated into another fabric) and are free of visible defects.

Provide burlap material which complies with AASHTO M 182, Class 3 (10 oz. per square yard) with the following additions:

- Manila hemp may also be used to make burlap.
- Do not use burlap fabricated from bags.
- Do not use burlap containing any water soluble ingredient which will retard the setting time of concrete.

Provide used burlap complying with the requirements stated above and that has only been used previously for curing concrete. "Like new" cleanliness is not expected, but contamination with any substance foreign to the concrete curing process, such as grease or oil, will be cause for rejection.

2.8. **Epoxy**. Provide epoxy materials in accordance with DMS-6100, "Epoxies and Adhesives," unless otherwise specified.

3. EQUIPMENT

3.1. **Transporting and Placing Equipment**. Use appropriate transporting and placing equipment such as buckets, chutes, buggies, belt conveyors, pumps, or other equipment as necessary. Ensure concrete is not transported or conveyed through equipment made of aluminum.

Use tremies to control the fall of concrete or for underwater placement. Use tremies that are watertight and of large enough diameter to allow the placement of the concrete but less than 14 in. in diameter. Construct the tremie so the bottom can be sealed and opened once the tremie has been fully charged with concrete for underwater placements.

Use pumps with lines at least 5 in. inside diameter (I.D.) where Grade 2 or smaller coarse aggregate is used, and at least 8 in. I.D. for Grade 1 coarse aggregate.

3.2. **Vibrators**. Use immersion-type vibrators for consolidation of concrete. Provide at least 1 standby vibrator for emergency use. Furnish vibrator head covered by a rubberized or elastomeric cover when used near epoxy coated reinforcing steel.

3.3. **Temperature Recording Equipment**. Use strip chart temperature recording devices, recording maturity meters in accordance with Tex-426-A, or other approved devices that are accurate to within ±2°F within the range of 32°F to 212°F for mass concrete operations, cold weather placements, and as otherwise specified.

3.4. **Artificial Heating Equipment**. Use artificial heating equipment as necessary for maintaining the concrete temperatures as specified in Section 420.4.7.11., "Placing Concrete in Cold Weather."

3.5. **Spraying Equipment**. Use mechanically powered pressure sprayers, either air or airless, with appropriate atomizing nozzles for the application of membrane curing. Use hand-pressurized spray equipment with 2 or 3 fan-spray nozzles if approved. Ensure the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.

3.6. **Concrete Testing Equipment**. Provide testing equipment for use by the Engineer in accordance with Section 421.3.3., "Testing Equipment."

4. CONSTRUCTION

Obtain approval for proposed construction methods before starting work. Approval of construction methods and equipment does not relieve the Contractor's responsibility for safety or correctness of methods, adequacy of equipment, or completion of work in full accordance with the Contract.

Unless otherwise shown on the plans, it is the Contractor's option to perform testing on structural concrete (structural classes of concrete are identified in Table 8 of Section 421.4.1., "Classification of Concrete Mix Designs,") to determine the in-situ strength to address the schedule restrictions in Section 420.4.1., "Schedule Restrictions." The Engineer may require the Contractor to perform this testing for concrete placed in cold weather. Make enough test specimens for Contractor-performed testing to ensure strength

requirements are met for the operations listed in Section 420.4.1., "Schedule Restrictions." Make at least 1 set of test specimens for each element cast each day. Cure these specimens under the same conditions as the portion of the structure involved for all stages of construction. Ensure safe handling, curing, and storage of all test specimens. Provide testing personnel, and sample and test the hardened concrete in accordance with Section 421.4.8., "Sampling and Testing of Concrete." The maturity method, Tex-426-A, may be used for in-situ strength determination for schedule restrictions if approved. Coring will not be allowed for in-situ strength determination for schedule restrictions. Provide the Engineer the opportunity to witness all testing operations. Report all test results to the Engineer.

If the Contractor does not wish to perform schedule restriction testing, the Engineer's 7-day lab-cured tests, performed in accordance with Article 421.5., "Acceptance of Concrete," will be used for schedule restriction determinations. The Engineer may require additional time for strength gain to account for field curing conditions such as cold weather.

4.1. **Schedule Restrictions**. Construct and open completed structures to traffic with the following limitations unless otherwise shown on the plans:

4.1.1. **Setting Forms**. Attain at least 2,500 psi compressive strength before erecting forms on concrete footings supported by piling or drilled shafts, or on individual drilled shafts. Erect forms on spread footings and culvert footings after the footing concrete has aged at least 2 curing days as defined in Section 420.4.10., "Curing Concrete." Place concrete only after the forms and reinforcing steel have been inspected by the Engineer.

Support tie beam or cap forms by falsework on previously placed tie beams only if the tie beam concrete has attained a compressive strength of 2,500 psi and the member is properly supported to eliminate stresses not provided for in the design. Maintain curing as required until completion of the curing period.

Place superstructure forms or falsework on the substructure only if the substructure concrete has attained a compressive strength of 3,000 psi.

4.1.2. **Removal of Forms and Falsework**. Keep in place weight-supporting forms and falsework for bridge components and culvert slabs until the concrete has attained a compressive strength of 2,500 psi in accordance with Section 420.4.11., "Removal of Forms and Falsework." Keep all forms for mass placements in place for 4 days following concrete placement unless otherwise approved based on the outcome of the heat control plan outlined in Section 420.4.7.14., "Mass Placements."

4.1.3. **Placement of Superstructure Members**. Erect or place superstructure members or precast substructure members only after the substructure concrete has attained a compressive strength of 3,000 psi.

4.1.4. **Opening to Traffic**. Direct traffic culverts may be opened to construction traffic when the design strength specified in Section 421.4.1., "Classification of Concrete Mix Design," has been attained if curing is maintained. Obtain approval before opening direct traffic culverts to the traveling public. Open other noncritical structural and nonstructural concrete for service upon the completion of curing unless otherwise specified or directed.

4.1.5. **Post-Tensioned Construction**. Ensure strength requirements on the plans for structural elements designed to be post-tensioned are met for stressing and staged loading of structural elements.

4.1.6. **Backfilling**. Backfill in accordance with Section 400.3.3., "Backfill."

4.2. **Plans for Falsework and Forms**. Submit plans for falsework and forms for the following items: vertical forms for piers and single column bents; load supporting forms for caps and tie-beams; form attachments for bridges to be widened; and other items as indicated or directed. Provide design calculations when requested. Show all essential details of proposed forms, falsework, and bracing. Have a licensed professional engineer design, seal, and sign these plans. Department approval is not required, except as noted in Table 1 of Item 5, "Control of the Work," when forms or falsework are located such that public safety can be affected, but the Department reserves the right to request modifications to the plans. The Contractor is responsible for the adequacy of these plans. Design job-fabricated formwork assuming a weight of 150 pcf for concrete, and

include a liveload allowance of 50 psf of horizontal surface of the form. Do not exceed 125% of the allowable stresses used by the Department for the design of structures.

4.3. **Falsework**. Design and construct falsework to safely carry the maximum anticipated loads, including wind loads, and to provide the necessary rigidity. Consult AASHTO's *Guide Design Specifications for Bridge Temporary Works* and *Construction Handbook for Bridge Temporary Works* for falsework and shoring information not indicated below. Submit details in accordance with Section 420.4.2., "Plans for Falsework and Forms."

Design job-fabricated falsework assuming a weight of 150 pcf for concrete, and include a minimum liveload allowance of 50 psf of horizontal surface of the form. Do not exceed 125% of the allowable stresses used by the Department for the design of structures.

Do not exceed the manufacturer's maximum allowable working loads for moment and shear or end reaction for commercially produced structural units used in falsework. Include a minimum liveload allowance of 35 psf of horizontal form surface in determining the maximum allowable working load for commercially produced structural units.

Provide timber that is sound, in good condition, and free from defects that would impair its strength. Provide timber that meets or exceeds the species, size, and grade requirements in the submitted falsework plans.

Provide wedges made of hardwood or metal in pairs to adjust falsework to desired elevations to ensure even bearing. Do not use wedges to compensate for incorrectly cut bearing surfaces.

Use sills or grillages large enough to support the superimposed load without settlement. Take precautions to prevent settling of the supporting material unless the sills or grillages are founded on solid rock, shale, or other hard materials.

Place falsework that cannot be founded on a satisfactory spread footing on piling or drilled shafts with enough bearing capacity to support the superimposed load without settlement. Drive falsework piling to the required resistance determined by the applicable formula in Item 404, "Driving Piling." Design drilled shafts for falsework to carry the superimposed load using both skin friction and point bearing.

Weld in conformance with Item 448, "Structural Field Welding." Securely brace each falsework bent to provide the stiffness required, and securely fasten the bracing to each pile or column it crosses.

Remove falsework when it is no longer required or as indicated on the submitted falsework plan. Pull or cut off foundations for falsework at least 2 ft. below finished ground level. Completely remove falsework, piling, or drilled shafts in a stream, lake, or bay to the approved limits to prevent obstruction to the waterway.

4.4. **Forms**. Submit formwork plans in accordance with Section 420.4.2., "Plans for Falsework and Forms."

4.4.1. **General**. Provide forms of either timber or metal except where otherwise specified or permitted.

Design forms for the pressure exerted by a liquid weighing 150 pcf. Take the rate of concrete placement into consideration in determining the depth of the equivalent liquid. Include a minimum liveload allowance of 50 psf of horizontal surface for job-fabricated forms. Do not exceed 125% of the Department's allowable stresses for the design of structures.

Do not exceed the manufacturer's maximum allowable working loads for moment and shear or end reaction for commercially produced structural units used for forms. Include a minimum liveload allowance of 35 psf of horizontal form surface in determining the maximum allowable working load for commercially produced structural units.

Provide steel forms for round columns unless otherwise approved. Refer to Item 427, "Surface Finishes for Concrete," for additional requirements for off-the-form finishes.

Provide commercial form liners for imprinting a pattern or texture on the concrete surface as shown on the plans and specified in Section 427.4.3.5., "Form Liner Finish."

Provide forming systems that are practically mortar-tight, rigidly braced, and strong enough to prevent bulging between supports, and maintain them to the proper line and grade during concrete placement. Maintain forms in a manner that prevents warping and shrinkage. Do not allow offsets at form joints to exceed 1/16 in.

Use only material that is inert, non-biodegradable, and nonabsorptive for forms to be left in place.

Construct all forms to permit their removal without marring or damaging the concrete. Clean all forms and footing areas of any extraneous matter before placing concrete. Provide openings in forms if needed for the removal of laitance or foreign matter.

Treat the facing of all forms with bond-breaking coating of composition that will not discolor or injuriously affect the concrete surface. Take care to prevent coating of the reinforcing steel.

Complete all preparatory work before requesting permission to place concrete.

Cease placement if the forms show signs of bulging or sagging at any stage of the placement, and remove the portion of the concrete causing this condition immediately as directed. Reset the forms and securely brace them against further movement before continuing the placement.

4.4.2. **Timber Forms**. Provide properly seasoned, good-quality lumber that is free from imperfections that would affect its strength or impair the finished surface of the concrete. Provide timber or lumber that meets or exceeds the requirements for species and grade in the submitted formwork plans.

Maintain forms or form lumber that will be reused so it stays clean and in good condition. Do not use any lumber that is split, warped, bulged, or marred, or that has defects in any way that will produce inferior work. Promptly remove such lumber from the work.

Provide form lining for all formed surfaces except:

- the inside of culvert barrels, inlets, manholes, and box girders;
- surfaces that are subsequently covered by backfill material or are completely enclosed; and
- any surface formed by a single finished board or by plywood.

Provide form lining of an approved type such as masonite or plywood. Do not provide thin membrane sheeting such as polyethylene sheets for form lining.

Use plywood at least 3/4 in. thick. Place the grain of the face plies on plywood forms parallel to the span between the supporting studs or joists unless otherwise indicated on the submitted form drawings.

Use plywood for forming surfaces that remain exposed that meets the requirements for B-B Plyform Class I or Class II Exterior of the U.S. Department of Commerce Voluntary Product Standard PS 1.

Space studs and joists so the facing form material remains in true alignment under the imposed loads.

Space wales closely enough to hold forms securely to the designated lines, scabbed at least 4 ft. on each side of joints to provide continuity. Place a row of wales near the bottom of each placement.

Place facing material with parallel and square joints, securely fastened to supporting studs.

Place forms with the form panels symmetrical (long dimensions set in the same direction) for surfaces exposed to view and receiving only an ordinary surface finish as defined in Section 420.4.13., "Ordinary Surface Finish." Make horizontal joints continuous.

Make molding for chamfer strips or other uses of materials of a grade that will not split when nailed and can be maintained to a true line without warping. Dress wood molding on all faces. Fill forms at all sharp corners and edges with triangular chamfer strips measuring 3/4 in. on the sides unless otherwise shown on the plans.

Use metal form ties of an approved type or a satisfactory substitute of a type that permits ease of removal of the metal to hold forms in place. Cut back wire ties at least 1/2 in. from the face of the concrete.

Use devices to hold metal ties in place that are able to develop the strength of the tie and adjust to allow for proper alignment.

Entirely remove metal and wooden spreaders that separate the forms as the concrete is being placed.

Provide adequate clean-out openings for narrow walls and other locations where access to the bottom of the forms is not readily attainable.

4.4.3. **Metal Forms**. Requirements for timber forms regarding design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and wetting also apply to metal forms except metal forms do not require lining unless specifically noted on the plans.

Use form metal thick enough to maintain the true shape without warping or bulging. Countersink all bolt and rivet heads on the facing sides. Design clamps, pins, or other connecting devices to hold the forms rigidly together and to allow removal without damage to the concrete. Use metal forms that present a smooth surface and line up properly. Keep metal free from rust, grease, and other foreign materials.

4.5. **Drains**. Install and construct weep holes and roadway drains as shown on the plans.

4.6. **Placing Reinforcement and Post-Tensioning**. Place reinforcement as provided in Item 440, "Reinforcement for Concrete." Do not weld reinforcing steel supports to other reinforcing steel except where shown on the plans.

Place post-tensioning ducts, anchorages, and other hardware in accordance with the approved prestressing details and Item 426, "Post-Tensioning." Keep ducts free of obstructions until all post-tensioning operations are complete.

4.7. **Placing Concrete**. Give the Engineer sufficient advance notice before placing concrete in any unit of the structure to permit the inspection of forms, reinforcing steel placement, and other preparations.

Do not place concrete when impending weather conditions would impair the quality of the finished work. Place concrete in early morning or at night or adjust the placement schedule for more favorable weather when conditions of wind, humidity, and temperature are such that concrete cannot be placed without the potential for weather-related distress.

Adequately illuminate the entire placement site as approved when mixing, placing, and finishing concrete in non-daylight hours.

Furnish adequate shelter to protect the concrete against damage from rainfall or freezing temperatures as outlined in this Item if changes in weather conditions require protective measures after work starts. Continue operations during rainfall only if approved. Use protective coverings for the material stockpiles. Cover aggregate stockpiles only to the extent necessary to control the moisture conditions in the aggregates.

Allow at least 1 curing day after the concrete has achieved initial set before placing strain on projecting reinforcement to prevent damage to the concrete.

4.7.1. **Placing Temperature**. Place concrete according to the following temperature limits for the classes of concrete defined in Section 421.4.1., "Classification of Concrete Mix Designs."

- Place Class C, F, H, K, or SS concrete only when its temperature at time of placement is between 50°F and 95°F. Increase the minimum placement temperature to 60°F if ground-granulated blast furnace (GGBF) slag is used in the concrete.
- Place Class S concrete, used in this Item only as indicated for culvert top slabs, only when its temperature is between 50°F and 85°F. Increase the minimum placement temperature to 60°F if ground-granulated blast furnace (GGBF) slag is used in the concrete.
- Place Class A, B, and D concrete only when its temperature at the time of placement is greater than 50°F.
- Place mass concrete in accordance with Section 420.4.7.14., "Mass Placements," only when its temperature at the time of placement is between 50°F and 75°F.

4.7.2. **Transporting Time**. Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14 of Item 421, "Hydraulic Cement Concrete."

4.7.3. **Workability of Concrete**. Place concrete with a slump as specified in Section 421.4.2.5., "Slump." Water may be added to the concrete before discharging any concrete from the truck to adjust for low slump provided that the maximum mix design water–cement ratio is not exceeded. Mix concrete in accordance with Section 421.4.6., "Mixing and Delivering Concrete," after introduction of any additional water or chemical admixtures. Do not add water or chemical admixtures after any concrete has been discharged.

4.7.4. **Transporting Concrete**. Transport concrete by buckets, chutes, buggies, belt conveyors, pumps, or other methods.

Protect concrete transported by conveyors from sun and wind to prevent loss of slump and workability. Shade or wrap with wet burlap pipes through which concrete is pumped as necessary to prevent loss of slump and workability.

Arrange and use chutes, troughs, conveyors, or pipes so the concrete ingredients will not be separated. Terminate such equipment in vertical downspouts when necessary to prevent segregation. Extend open troughs and chutes, if necessary, down inside the forms or through holes left in the forms.

Keep all transporting equipment clean and free from hardened concrete coatings. Discharge water used for cleaning clear of the concrete.

4.7.5. **Preparation of Surfaces**. Thoroughly wet all forms and hardened concrete on which concrete is to be placed before placing concrete on them. Remove any remaining puddles of excess water before placing concrete. Provide surfaces that are in a moist, saturated surface-dry condition when concrete is placed on them.

Ensure the subgrade or foundation is moist before placing concrete on grade. Lightly sprinkle the subgrade if dry.

4.7.6. **Expansion Joints**. Construct joints and devices to provide for expansion and contraction in accordance with plan details.

Use light wire or nails to anchor any preformed fiber joint material to the concrete on 1 side of the joint.

Ensure finished joints conform to the plan details with the concrete sections completely separated by the specified opening or joint material.

Remove all concrete within the joint opening soon after form removal and again where necessary after surface finishing to ensure full effectiveness of the joint.

4.7.7. **Construction Joints**. A construction joint is the joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set. Monolithic placement means the manner and sequence of concrete placing does not create a construction joint.

Make construction joints of the type and at the locations shown on the plans. Additional joints in other members are not permitted without approval. Place authorized additional joints using details equivalent to those shown on the plans for joints in similar locations.

Make construction joints square and normal to the forms unless otherwise required. Use bulkheads in the forms for all vertical joints.

Thoroughly roughen the top surface of a concrete placement terminating at a horizontal construction joint as soon as practical after initial set is attained.

Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter, and saturate it with water. Remove all free water and moisten the surface before concrete or bonding grout is placed against it. Ensure the surface of the existing concrete is in a saturated surface-dry condition (SSD) just before placing subsequent concrete. Wet the existing concrete by ponding water on the surface for 24 hr. before placing subsequent concrete. Use high-pressure water blasting if ponding is not possible to achieve SSD conditions 15 to 30 min. before placing the concrete. An SSD condition is achieved when the surface remains damp when exposed to sunlight for 15 min.

Draw forms tight against the existing concrete to avoid mortar loss and offsets at joints.

Bonding agents are not required unless indicated otherwise. Coat the joint surface with bonding mortar, grout, epoxy, or other material if a bonding agent is required as indicated on the plans. Provide Type V epoxy per DMS-6100, "Epoxies and Adhesives," for bonding fresh concrete to hardened concrete. Place the bonding epoxy on a clean, dry surface, and place the fresh concrete while the epoxy is still tacky. Place bonding mortar or grout on a surface that is SSD, and place the concrete before the bonding mortar or grout dries. Place other bonding agents in accordance with the manufacturer's recommendations.

4.7.8. **Handling and Placing**. Minimize segregation of the concrete and displacement of the reinforcement when handling and placing concrete. Produce a uniform, dense compact mass.

Ensure concrete free-falls no more than 5 ft. except in the case of drilled shafts, thin walls such as in culverts, or as allowed by other Items. Remove any hardened concrete splatter ahead of the plastic concrete.

Fill each part of the forms by depositing concrete as near its final position as possible. Do not deposit large quantities of concrete at 1 point and run or move the concrete along to fill the forms.

Deposit concrete in the forms in layers of suitable depth but no more than 36 in. deep unless otherwise permitted.

Avoid cold joints in a monolithic placement. Sequence successive layers or adjacent portions of concrete so they can be vibrated into a homogeneous mass with the previously placed concrete before it sets. Allow no more than 1 hr. to elapse between adjacent or successive placements of concrete when re-vibration of the concrete is shown on the plans except as otherwise allowed by an approved placing procedure. This time limit may be extended by 1/2 hr. if the concrete contains at least the minimum recommended dosage of a Type B or D admixture.

4.7.9. **Consolidation**. Carefully consolidate concrete and flush mortar to the form surfaces with immersion type vibrators. Do not use vibrators that operate by attachment to forms or reinforcement except where approved on steel forms.

Vibrate the concrete immediately after deposit. Systematically space points of vibration to ensure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Insert the vibrators vertically where possible. Vibrate the entire depth of

each lift, allowing the vibrator to penetrate several inches into the preceding lift. Do not use the vibrator to move the concrete to other locations in the forms. Do not drag the vibrator through the concrete. Thoroughly consolidate concrete along construction joints by operating the vibrator along and close to but not against the joint surface. Continue the vibration until the concrete surrounding reinforcements and fixtures is completely consolidated. Hand-spade or rod the concrete if necessary to ensure flushing of mortar to the surface of all forms.

4.7.10. **Installation of Dowels and Anchor Bolts**. Install dowels and anchor bolts by casting them in-place or by grouting with grout, epoxy, or epoxy mortar unless noted otherwise. Form or drill holes for grouting. Follow the manufacturer's recommended installation procedures for pre-packaged grout or epoxy anchor systems. Test anchors if required on the plans or by other Items.

Drill holes for anchor bolts to accommodate the bolt embedment required by the plans. Make holes for dowels at least 12 in. deep unless otherwise shown on the plans. Make the hole diameter at least twice the dowel or bolt diameter, but not exceeding the dowel or bolt diameter plus 1-1/2 in. when using cementitious grout or epoxy mortar. Make the hole diameter 1/16 to 1/4 in. greater than the dowel or bolt diameter when using neat epoxy unless indicated otherwise by the epoxy manufacturer.

Thoroughly clean holes of all loose material, oil, grease, or other bond-breaking substance, and blow them clean with filtered compressed air. Use a wire brush followed by oil-free compressed air to remove all loose material from the holes, repeating as necessary until no more material is removed. Ensure holes are in a surface-dry condition when epoxy type materials are used and in a surface-moist condition when cementitious grout is used. Develop and demonstrate for approval a procedure for cleaning and preparing the holes for installation of the dowels and anchor bolts. Completely fill the void between the hole and dowel or bolt with grouting material. Follow exactly the requirements for cleaning outlined in the product specifications for pre-packaged systems.

Provide hydraulic cement grout for cast-in-place or grouted systems in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications." Provide a Type III epoxy per DMS-6100, "Epoxies and Adhesives," when neat epoxy is used for anchor bolts or dowels. Provide Type VIII epoxy per DMS-6100, "Epoxies and Adhesives," when an epoxy grout is used. Provide grout, epoxy, or epoxy mortar as the binding agent unless otherwise indicated on the plans.

Provide other anchor systems as required on the plans.

4.7.11. **Placing Concrete in Cold Weather**. Protect concrete placed under weather conditions where weather may adversely affect results. Permission given by the Engineer for placing during cold weather does not relieve the Contractor of responsibility for producing concrete equal in quality to that placed under normal conditions. Remove and replace concrete as directed at the Contractor's expense if it is determined unsatisfactory due to poor conditions.

Do not place concrete in contact with any material coated with frost or with a temperature of 32°F or lower. Do not place concrete when the ambient temperature in the shade is below 40°F and falling unless approved. Place concrete when the ambient temperature in the shade is at least 35°F and rising or above 40°F.

Provide and install recording thermometers, maturity meters, or other suitable temperature measuring devices to verify all concrete is effectively protected as follows:

- Maintain the temperature at all surfaces of concrete in bents, piers, culvert walls, retaining walls, parapets, wingwalls, top slabs of non-direct traffic culverts, and other similar formed concrete at or above 40°F for 72 hr. from the time of placement.
- Maintain the temperature of all other concrete, including the bottom slabs (footings) of culverts, placed on or in the ground above 32°F for 72 hr. from the time of placement.

Use additional covering, insulated forms, or other means and, if necessary, supplement the covering with artificial heating. Avoid applying heat directly to concrete surfaces. Cure as specified in Section 420.4.10., "Curing Concrete," during this period until all requirements for curing have been satisfied.

Have all necessary heating and covering material ready for use before permission is granted to begin placement when impending weather conditions indicate the possible need for temperature protection.

4.7.12. **Placing Concrete in Hot Weather**. Keep the concrete at or below the maximum temperature at time of placement as specified in Section 420.4.7.1., "Placing Temperature." Sprinkle and shade aggregate stockpiles or use ice, liquid nitrogen systems, or other approved methods as necessary to control the concrete temperature.

4.7.13. **Placing Concrete in Water**. Deposit concrete in water only when shown on the plans or with approval. Make forms or cofferdams tight enough to prevent any water current passing through the space in which the concrete is being deposited. Do not pump water during the concrete placing or until the concrete has set for at least 36 hr.

Place the concrete with a tremie or pump, or use another approved method, and do not allow it to fall freely through the water or disturb it after it is placed. Keep the concrete surface level during placement.

Support the tremie or operate the pump so it can be easily moved horizontally to cover all the work area and vertically to control the concrete flow. Submerge the lower end of the tremie or pump hose in the concrete at all times. Use continuous placing operations until the work is complete.

Design the concrete mix in accordance with Item 421, "Hydraulic Cement Concrete," with a minimum cement content of 650 lb. per cubic yard for concrete to be placed under water. Include an anti-washout admixture in the mix design as necessary to produce a satisfactory finished product.

4.7.14. **Mass Placements**. Develop and obtain approval for a heat control plan for monolithic placements designated on the plans as mass concrete to ensure the following during the heat dissipation period:

- the temperature differential between the central core of the placement and the exposed concrete surface does not exceed 35°F and
- the temperature at the central core of the placement does not exceed 160°F.

Use the ConcreteWorks© software available from the Department, or another approved method based on the guidelines in ACI 207, "Mass Concrete," to develop the heat control plan. The Department will make available technical assistance on the use of ConcreteWorks©. Develop the heat control plan using historical temperature ranges for the anticipated time of the mass placement. Re-create the plan if the work schedule shifts by more than one month.

The heat control plan may include a combination of the following elements:

- selection of concrete ingredients including aggregates, gradation, and cement types, to minimize heat of hydration;
- use of ice or other concrete cooling ingredients;
- use of liquid nitrogen dosing systems;
- controlling rate or time of concrete placement;
- use of insulation or supplemental external heat to control heat loss;
- use of supplementary cementing materials;
- use of a cooling system to control the core temperature; or
- vary the duration formwork remains in place.

Furnish and install 2 pairs of temperature recording devices, maturity meters, or other approved equivalent devices. Install devices to measure the surface temperature no more than 3 in. from the surface. Install devices to measure the core temperature a distance of half the least dimension from the nearest surface near the point of maximum predicted heat. Use these devices to simultaneously measure the temperature of

the concrete at the core and the surface. Maintain temperature control methods for 4 days unless otherwise approved based on the submitted heat control plan. Do not use maturity meters to predict strength of mass concrete. Revise the heat control plan as necessary to maintain the temperature limitations shown above.

If the core temperature exceeds 160°F, the mass concrete element will be subject to review and acceptance by the Engineer using forensic analyses to determine its potential reduction in service life or performance. Proceed with subsequent construction on the affected element only when notified regarding acceptance. Repair any resulting cracking if the temperature differential between the central core of the placement and the nearest concrete surface exceeds 35°F at no expense to the Department and revise the heat control plan as necessary to prevent further occurrences.

4.7.15. **Placing Concrete in Foundation and Substructure**. Do not place concrete in footings until the depth and character of the foundation has been inspected and permission has been given to proceed.

Place concrete footings upon seal concrete after the cofferdams are free from water and the seal concrete is cleaned. Perform any necessary pumping or bailing during the concreting from a suitable sump located outside the forms.

Construct or adjust all temporary wales or braces inside cofferdams as the work proceeds to prevent unauthorized construction joints.

Omit forms when footings can be placed in a dry excavation without the use of cofferdams, if approved, and fill the entire excavation with concrete to the elevation of the top of footing.

Place concrete in columns monolithically between construction joints unless otherwise directed. Columns and caps or tie beams supported on them may be placed in the same operation or separately. Allow for settlement and shrinkage of the column concrete, if placed in the same operation, by placing it to the lower level of the cap or tie beam, and delay placement between 1 and 2 hr. before proceeding with the cap or tie beam placement.

4.7.16. **Placing Concrete in Box Culverts**. Allow between 1 and 2 hr. to elapse where the top slab and walls are placed monolithically in culverts more than 4 ft. in clear height before placing the top slab to allow for settlement and shrinkage in the wall concrete.

Accurately finish the footing slab at the proper time to provide a smooth uniform surface. Finish top slabs that carry direct traffic as specified in Item 422, "Concrete Superstructures." Give top slabs of fill type culverts a float finish.

4.8. **Extending Existing Substructures**. Verify pertinent dimensions and elevations of the existing structure before ordering any required materials.

4.8.1. **Removal**. Remove portions of the existing structure to the lines and dimensions shown on the plans or as directed. Dispose of these materials as shown on the plans or as directed. Repair any portion of the remaining structure damaged as a result of the construction.

Do not use explosives to remove portions of the existing structure unless approved in writing. Do not use a demolition ball, other swinging weight, or impact equipment unless shown on the plans. Use pneumatic or hydraulic tools for final removal of concrete at the "break" line. Use removal equipment, as approved, that will not damage the remaining concrete.

4.8.2. **Reuse of Removed Portions of Structure**. Detach and remove all portions of the old structure that are to be incorporated into the extended structure to the lines and details as specified on the plans or as directed. Move the unit to be reused to the new location specified using approved methods. Place the reinforcement and extension concrete according to the plan details.

4.8.3. **Splicing Reinforcing Steel**. Splice new reinforcing bars to exposed bars in the existing structure using lap splices in accordance with Item 440, "Reinforcement for Concrete," unless otherwise shown on the plans. The new reinforcing steel does not need to be tied to the existing steel where spacing or elevation does not

match that of the existing steel provided the lap length is attained. Weld in accordance with Item 448, when welded splices are permitted. Install any required dowels in accordance with Section 420.4.7.10., "Installation of Dowels and Anchor Bolts."

4.8.4. **Concrete Preparation**. Roughen and clean concrete surfaces that are in contact with new construction before placing forms. Prepare these construction joint surfaces in accordance with Section 420.4.7.7., "Construction Joints."

4.9. **Treatment and Finishing of Horizontal Surfaces**. Strike off to grade and finish all unformed upper surfaces. Do not use mortar topping for surfaces constructed under this Section.

Float the surface with a suitable float after the concrete has been struck off.

Slope the tops of caps and piers between bearing areas from the center slightly toward the edge, and slope the tops of abutment and transition bent caps from the backwall to the edge, as directed, so water drains from the surface. Give the concrete a smooth trowel finish. Construct bearing areas for steel units in accordance with Section 441.3.11.6., "Bearing and Anchorage Devices." Give the bearing area under the expansion ends of concrete slabs and slab and girder spans a steel-trowel finish to the exact grades required. Give bearing areas under elastomeric bearing pads or nonreinforced bearing seat buildups a textured, wood float finish. Do not allow the bearing area to vary from a level plane more than 1/16 in. in all directions.

Cast bearing seat buildups or pedestals for concrete units integrally with the cap or a construction joint. Provide a latex-based mortar, an epoxy mortar, or an approved proprietary bearing mortar for bearing seat buildups cast with a construction joint. Mix mortars in accordance with the manufacturer's recommendations. Construct pedestals of Class C concrete, reinforced as shown on the plans or as indicated in Figure 1 and Figure 2. The Engineer of Record will design pedestals higher than 12 in.

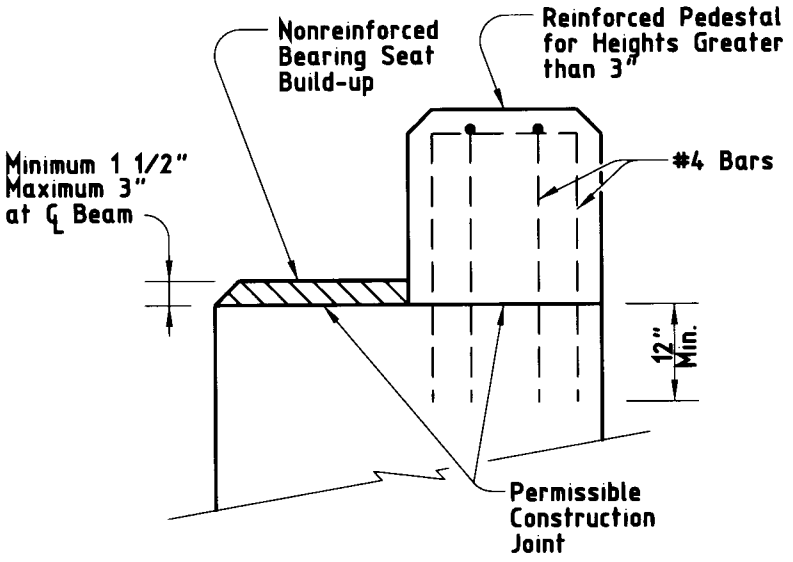


Figure 1
Section through Bearing Seat Buildups

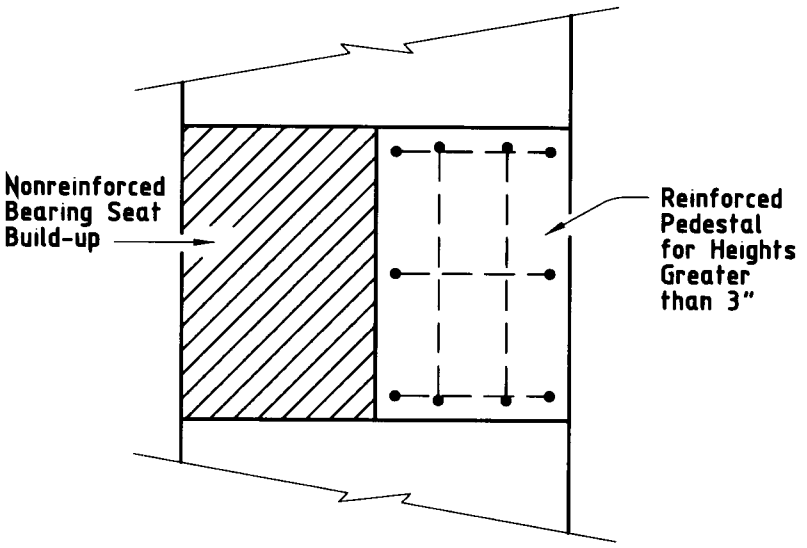


Figure 2
Plan View of Bearing Seat Buildups

4.10. **Curing Concrete**. Obtain approval of the proposed curing methods, equipment, and materials before placing concrete. The Engineer may require the same curing methods for like portions of a single structure. Inadequate curing or facilities may delay all concrete placements on the job until remedial action is taken.

A curing day is a calendar day when the temperature, taken in the shade away from artificial heat, is above 50°F for at least 19 hr. or, on colder days if the temperature of all surfaces of the concrete is maintained above 40°F, for the entire 24 hr. The required curing period begins when all concrete has attained its initial set unless indicated otherwise. Tex-440-A may be used to determine when the concrete has attained its initial set.

Cure all concrete for 4 consecutive days except as allowed for the curing options listed below. Use form or membrane curing for vertical surfaces unless otherwise approved. Use only water curing for horizontal surfaces of HPC or mass concrete. Use water or membrane curing for horizontal or unformed surfaces for all other concrete.

Use one of the following curing options for vertical surfaces, unless indicated otherwise.

- Form cure for 48 hr. after placement.
- Form cure for 12 hr. after placement followed by membrane curing.
- For HPC Concrete, form cure for 48 hr. after placement followed by membrane curing.
- For mass concrete, form cure as required by the heat control plan followed by membrane curing if forms are removed before 4 days.

Apply membrane curing, if used, within 2 hr. of form removal.

Use only water curing in accordance with this Section for the top surface of any concrete unit upon which concrete is to be placed and bonded at a later interval (stub walls, caps with backwalls, risers, etc.).

Cure all other concrete as specified in the pertinent Items. Use the following methods for curing concrete, subject to the requirements of this Item.

4.10.1. **Form Curing**. When forms are left in intimate contact with the concrete, other curing methods are not required except for exposed surfaces and for cold weather protection. Use another approved curing method if forms are removed before the 4-day required curing period.

4.10.2. **Water Curing**. Keep all exposed surfaces of the concrete wet continuously for the required curing time. Use water curing in accordance with concrete mixing water in Section 421.2.5., "Water." Do not use seawater or water that stains or leaves an unsightly residue.

4.10.2.1. **Blankets**. Keep the concrete continuously wet by maintaining wet cotton or burlap mats in direct contact with the concrete for the required curing time. Weight the mats adequately to provide continuous contact with all concrete. Cover surfaces that cannot be cured by direct contact with mats, forming an enclosure well anchored to the forms or ground so outside air cannot enter the enclosure. Provide sufficient moisture inside the enclosure to keep all surfaces of the concrete wet.

4.10.2.2. **Water Spray**. Overlap sprays or sprinklers to keep all unformed surfaces continuously wet.

4.10.2.3. **Ponding**. Cover the surfaces with at least 2 in. of clean granular material, kept wet at all times, or at least 1 in. deep water. Use a dam to retain the water or saturated granular material.

4.10.3. **Membrane Curing**. Choose either Type 1-D or Type 2 membrane-curing compound unless otherwise shown on the plans. Use the same type of curing compound on an individual member.

Apply membrane curing just after free moisture has disappeared at a rate of approximately 180 sq. ft. per gallon. Do not spray curing compound on projecting reinforcing steel or concrete that will later form a construction joint. Do not apply membrane curing to dry surfaces. Dampen formed surfaces and surfaces that have been given a first rub so they are moist at the time of application of the membrane.

Leave the film unbroken for the minimum curing period specified when membrane is used for complete curing. Correct damaged membrane immediately by reapplication of membrane. Polyethylene sheeting, burlap-polyethylene mats, or laminated mats in close contact with the concrete surfaces are equivalent to membrane curing.

4.11. **Removal of Forms and Falsework**. Remove forms for vertical surfaces after the concrete has aged a minimum of 12 hr. after initial set provided the removal can be done without damage to the concrete unless otherwise directed. Keep forms for mass placements in place for 4 days following concrete placement unless otherwise approved based on the outcome of the heat control plan outlined in Section 420.4.7.14., "Mass Placements."

Leave in place weight-supporting forms and falsework spanning more than 1 ft. for all bridge components and culvert slabs except as directed otherwise until the concrete has attained a compressive strength of 2,500 psi. Remove forms for other structural components as necessary.

Remove inside forms (walls and top slabs) for box culverts and sewers after concrete has attained a compressive strength of 1,800 psi if an approved overhead support system is used to transfer the weight of the top slab to the walls of the box culvert or sewer before removal of the support provided by the forms.

Forms or parts of forms may be removed only if constructed to permit removal without disturbing forms or falsework required to be left in place for a longer period on other portions of the structure.

Remove all metal appliances used inside forms for alignment to a depth of at least 1/2 in. from the concrete surface. Make the appliances so metal may be removed without undue chipping or spalling of the concrete, and so it leaves a smooth opening in the concrete surface when removed. Do not burn off rods, bolts, or ties.

Remove all forms and falsework unless otherwise directed.

4.12. **Defective Work**. Repair defective work as soon as possible. Remove and replace at the expense of the Contractor any defect that cannot be repaired to the satisfaction of the Engineer.

4.13. **Ordinary Surface Finish**. Apply an ordinary surface finish to all concrete surfaces. Provide flat or textured surfaces as specified with uniform appearance. Address defects and surface irregularities not consistent with the intent of the expected finish by the following:

- Chip away all loose or broken material to sound concrete where porous, spalled, or honeycombed areas are visible after form removal.
- Repair spalls in accordance with the procedures outlined in the *Concrete Repair Manual* available on the Department's website.
- Clean and fill holes or spalls caused by the removal of form ties, etc., with latex grout, cement grout, or epoxy grout as approved. Fill only the holes. Do not blend the patch with the surrounding concrete. On surfaces to receive a rub finish in accordance with Item 427, "Surface Finishes for Concrete," chip out exposed parts of metals chairs to a depth of 1/2 in. and repair the surface.
- Remove all fins, rust staining, runs, drips, or mortar from surfaces that will be exposed. Smooth all form marks and chamfer edges by grinding or dry-rubbing.
- Ensure all repairs are dense, well-bonded, and properly cured. Finish exposed large repairs to blend with the surrounding concrete where a higher class of finish is not specified.

Apply an ordinary surface finish as the final finish to the following exposed surfaces unless noted otherwise:

- inside and top of inlets,
- inside and top of manholes,
- inside of sewer appurtenances, and
- inside of culvert barrels.

Form marks and chamfer edges do not need to be smoothed for the inside of culvert barrels.

5. MEASUREMENT

This Item will be measured by the cubic yard, square yard, foot, square foot, or by each structure.

5.1. **General**. Concrete quantities will be based on the dimensions shown on the plans or those established in writing by the Engineer.

In determining quantities, no deductions will be made for chamfers less than 2 in. or for embedded portions of steel or prestressed concrete beams, piling, anchor bolts, reinforcing steel, drains, weep holes, junction boxes, electrical or telephone conduit, ducts and voids for prestressed tendons, or embedded portions of light fixtures.

Variation in concrete headwall quantity incurred when an alternate bid for pipe is permitted will not be cause for payment adjustment.

Quantities revised by a change in design, measured as specified, will be increased or decreased and included for payment.

5.2. **Plans Quantity**. Structure elements designated in Table 1 and measured by the cubic yard are plans quantity measurement items. The quantity to be paid for plans quantity items is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

No adjustment will be made for footings or other in-ground elements where the Contractor has been allowed to place concrete in an excavation without forms.

Table 1
Plans Quantity Payment
(Cubic Yard Measurement Only)

Culverts and culvert wing walls	Abutments
Headwalls for pipe	Footings
Retaining walls	Pile bent caps
Inlets and manholes	Post-tensioned elements

Note—Other elements, including pier and bent concrete, may be paid for as "plans quantity" when shown on the plans.

5.3. **Measured in Place**. Items not paid for as "plans quantity" will be measured in place.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the class of concrete and element identified and by the special designation when appropriate. This price is full compensation for furnishing, hauling, and mixing concrete materials; furnishing, bending, fabricating, splicing, welding and placing the required reinforcement; clips, blocks, metal spacers, ties, wire, or other materials used for fastening reinforcement in place; furnishing, placing, and stressing post-tensioning system; placing, finishing, and curing concrete; mass placement controls; applying ordinary surface finish; furnishing and placing drains, metal flashing strips, and expansion-joint material; excavation, subgrade preparation; and forms and falsework, equipment, labor, tools, and incidentals.

Price will be adjusted in accordance with Section 421.6., "Measurement and Payment" when required to address non-compliance of project acceptance testing

Design and installation of foundations for falsework is at the Contractor's expense.

In addition to the work described above, for extending structures the unit prices bid for the various classifications of concrete shown are full compensation for removing and disposing of, if necessary, the designated portion of the existing structure; removing, stockpiling if necessary, and replacing headwall units for reuse; cleaning, bending, and cutting of exposed reinforcing steel; splicing of new reinforcing steel to existing reinforcing steel; installation of dowels; and cleaning and preparing existing concrete surfaces.

Item 421
Hydraulic Cement Concrete

1. DESCRIPTION

Furnish hydraulic cement concrete for concrete pavements, concrete structures, and other concrete construction.

2. MATERIALS

Use materials from prequalified sources listed on the Department website. Provide coarse and fine aggregates from sources listed in the Department's *Concrete Rated Source Quality Catalog* (CRSQC). Use materials from non-listed sources only when tested and approved by the Engineer before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources. Do not combine approved material with unapproved material.

2.1. **Cement**. Furnish cement conforming to DMS-4600, "Hydraulic Cement."

2.2. **Supplementary Cementing Materials (SCM)**.

- **Fly Ash**. Furnish fly ash, ultra-fine fly ash (UFFA), and modified Class F fly ash (MFFA) conforming to DMS-4610, "Fly Ash."
- **Slag Cement**. Furnish Slag Cement conforming to DMS-4620, "Ground Granulated Blast Furnace Slag."
- **Silica Fume**. Furnish silica fume conforming to DMS-4630, "Silica Fume."
- **Metakaolin**. Furnish metakaolin conforming to DMS-4635, "Metakaolin."

2.3. **Cementitious Material**. Cementitious materials are the cement and supplementary cementing materials used in concrete.

2.4. **Chemical Admixtures**. Furnish admixtures conforming to DMS-4640, "Chemical Admixtures for Concrete."

2.5. **Water**. Furnish mixing and curing water that is free from oils, acids, organic matter, or other deleterious substances. Water from municipal supplies approved by the Texas Department of Health will not require testing. Provide test reports showing compliance with Table 1 before use when using water from other sources.

Water that is a blend of concrete wash water and other acceptable water sources, certified by the concrete producer as complying with the requirements of both Table 1 and Table 2, may be used as mix water. Test the blended water weekly for 4 weeks for compliance with Table 1 and Table 2 or provide previous test results. Then test every month for compliance. Provide water test results upon request.

Table 1
Chemical Limits for Mix Water

Contaminant	Test Method	Maximum Concentration (ppm or mg\L)
Chloride (Cl)	ASTM C114	
Prestressed concrete		500
Bridge decks & superstructure		500
All other concrete		1,000
Sulfate (SO4)	ASTM C114	2,000
Alkalies (Na2O + 0.658K2O)	ASTM C114	600
Total solids	ASTM C1603	50,000

Table 2
Acceptance Criteria for Questionable Water Supplies

Property	Test Method	Limits
Compressive strength, min % control at 7 days	ASTM C31, ASTM C39[1,2]	90
Time of set, deviation from control, h:min.	ASTM C403	From 1:00 early to 1:30 later

1. Base comparisons on fixed proportions and the same volume of test water compared to the control mix using 100% potable water or distilled water.
2. Base comparisons on sets consisting of at least 2 standard specimens made from a composite sample.

Do not use mix water that has an adverse effect on the air-entraining agent, on any other chemical admixture, or on strength or time of set of the concrete. Use mixing and curing water free of iron and other impurities that may cause staining or discoloration when using white hydraulic cement.

2.6. **Aggregate**.

2.6.1. **Coarse Aggregate**. Provide coarse aggregate consisting of durable particles of gravel, crushed blast furnace slag, recycled crushed hydraulic cement concrete, crushed stone, or combinations which are free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material, either free or as an adherent coating. Provide coarse aggregate of uniform quality throughout.

Provide coarse aggregate with the requirements listed in Table 3 unless otherwise shown on the plan.

Table 3
Coarse Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.25
Weight of Shale, % Max		1.0
Weight of Laminate and Friable Particle, % Max		5.0
L.A. Abrasion Wear, % Max	Tex-410-A	40
5-Cycle Magnesium Sulfate Soundness,[1,2] non-air-entrained concrete, % Max	Tex-411-A	25
5-Cycle Magnesium Sulfate Soundness,[1,3] air-entrained concrete, % Max		18
Loss by Decantation, % Max	Tex-406-A	1.5

1. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
2. Allowed when air-entrained concrete is used at the Contractor's option.
3. Only when air-entrained concrete is required by the plans.

Increase the loss by decantation limit to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III, in the case of coarse aggregates made primarily from crushing stone unless otherwise shown on the plans. Provide test results upon request.

Provide coarse aggregate conforming to the gradation requirements shown in Table 4 when tested in accordance with Tex-401-A unless otherwise specified.

Table 4
Coarse Aggregate Gradation Chart

Aggregate Grade No.[1]	Maximum Nominal Size	Percent Passing on Each Sieve								
		2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	#4	#8
1	2"	100	80–100	50–85		20–40			0–10	
2	1-1/2"		100	95–100		35–70		10–30	0–10	
3	1-1/2"		100	95–100		60–90	25–60		0–10	
4 (57)	1"			100	95–100		25–60		0–10	0–5
5 (67)	3/4"				100	90–100		20–55	0–10	0–5
6 (7)	1/2"					100	90–100	40–70	0–15	0–5
7	3/8"						100	70–95	0–25	
8	3/8"						100	95–100	20–65	0–10

1. Corresponding ASTM C33 gradation shown in parentheses.

2.6.2. **Fine Aggregate**. Provide fine aggregate consisting of clean, hard, durable particles of natural, manufactured sand, recycled crushed hydraulic cement concrete, slag, lightweight aggregate, or a combination thereof. Provide fine aggregate free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide fine aggregates with the requirements in Table 5 unless otherwise shown on the plans.

Table 5
Fine Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.50
Organic Impurities[1]	Tex-408-A	Color not darker than standard
Sand Equivalent	Tex-203-F	80
Fineness Modulus	Tex-402-A	2.3 to 3.1

1. Only when air-entrained concrete is specified.

Provide fine aggregate or combinations of aggregates conforming to the gradation requirements shown in Table 6 when tested in accordance with Tex-401-A unless otherwise specified.

Table 6
Fine Aggregate Gradation Chart (Grade 1)

Sieve Size	Percent Passing
3/8"	100
#4	95–100
#8	80–100
#16	50–85
#30	25–65
#50	10–35[1]
#100	0–10
#200	0–3[2]

1. 6–35 when sand equivalent value is greater than 85.
2. 0–6 for manufactured sand.

2.6.3. **Intermediate Aggregate**. Provide intermediate aggregate consisting of clean, hard, durable particles of natural, manufactured sand, slag, recycled crushed hydraulic cement concrete, lightweight aggregate, or a combination thereof when optimized aggregate gradation (OAG) concrete is specified or when used at the Contractor's option. Provide intermediate aggregate free from frozen material and injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide intermediate aggregate with the requirements in Table 7.

Table 7
Intermediate Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.50
L.A. Abrasion Wear,[1] % Max	Tex-410-A	40
5-Cycle Magnesium Sulfate Soundness,[1,2,3] non-air-entrained concrete, % Max	Tex-411-A	25
5-Cycle Magnesium Sulfate Soundness,[1,2,4] air-entrained concrete, % Max		18
Organic Impurities[5]	Tex-408-A	Color not darker than standard
Loss by Decantation,[1] % Max	Tex-406-A	1.5

1. Only applies to the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve.
2. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
3. Allowed when air-entrained concrete is used at the Contractor's option.
4. Only when air-entrained concrete is required by the plans.
5. Only applies to the portion passing the 3/8 in. sieve, if more than 30% of the intermediate aggregate is passing the 3/8 in. sieve.

For the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve, and in the case of aggregates made primarily from crushing stone, unless otherwise shown on the plans, the loss by decantation may be increased to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III. Provide test results upon request.

2.7. **Mortar and Grout**. Furnish pre-packaged grouts conforming to DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications," when specified for applications other than post-tension grouting.

Section 421.4.2.6., "Mix Design Options," does not apply for mortar and grout.

2.8. **Storage of Materials**.

2.8.1. **Cement and Supplementary Cementing Materials**. Store all cement and supplementary cementing materials in weatherproof enclosures that will protect them from dampness or absorption of moisture.

When permitted, small quantities of packaged cementitious material may be stored in the open, on a raised platform, and under waterproof covering for up to 48 hr.

2.8.2. **Aggregates**. Handle and store concrete aggregates in a manner that prevents contamination with foreign materials. Clear and level the sites for the stockpiles of all vegetation if the aggregates are stored on the ground and do not use the bottom 6-in. layer of aggregate without cleaning the aggregate before use.

Maintain separate stockpiles and prevent intermixing when conditions require the use of 2 or more grades of coarse aggregates. Separate the stockpiles using physical barriers where space is limited. Store aggregates from different sources in different stockpiles unless the Engineer authorizes pre-blending of the aggregates. Minimize segregation in stockpiles. Remix and test stockpiles when segregation is apparent.

Sprinkle stockpiles to control moisture and temperature as necessary. Maintain reasonably uniform moisture content in aggregate stockpiles.

2.8.3. **Chemical Admixtures**. Store admixtures in accordance with manufacturer's recommendations and prevent admixtures from freezing.

3. EQUIPMENT

3.1. **Concrete Plants and Mixing Equipment**. Except for volumetric stationary plant or truck (auger) mixers, each plant and truck mixer must be currently certified by the National Ready Mixed Concrete Association (NRMCA) or have an inspection report signed and sealed by a licensed professional engineer showing concrete measuring, mixing, and delivery equipment meets all requirements of ASTM C94. A new certification or signed and sealed report is required every time a plant is moved. Plants with a licensed professional engineer's inspection require re-inspection every 2 yr. Provide a copy of the certification or the

signed and sealed inspection report to the Engineer. Remove equipment or facilities from service until corrected when they fail to meet specification requirements.

When allowed on the plans or by the Engineer, for concrete classes not identified as structural concrete in Table 8 or for Class C concrete not used for bridge-class structures, the Engineer may inspect and approve all plants and trucks instead of the NRMCA or non-Department engineer-sealed certifications. The criteria and frequency of Engineer approval of plants and trucks is the same used for NRMCA certification.

Inspect and furnish inspection reports on the condition of blades and fins and their percent wear from the original manufacturer's design for truck mixers and agitators annually. Repair mixing equipment exhibiting 10% or more wear before use. If an inspection within 12 mo. is not practical, a 2-mo. grace period (for a maximum of 14 mo. between inspections) is permitted.

3.1.1. **Scales**. Check all scales before beginning of operations, after each move, or whenever their accuracy or adequacy is questioned, and at least once every 6 mo. Immediately correct deficiencies, and recalibrate. Provide a record of calibration showing scales in compliance with ASTM C94 requirements. Check batching accuracy of volumetric water batching devices at least every 90 days. Check batching accuracy of chemical admixture dispensing devices at least every 6 mo. Perform daily checks as necessary to ensure measuring accuracy.

3.1.2. **Volumetric Mixers**. Provide volumetric mixers with rating plates defining the capacity and the performance of the mixer in accordance with the Volumetric Mixer Manufacturers Bureau or equivalent. Provide volumetric mixers that comply with ASTM C685. Provide test data showing mixers meet the uniformity test requirements of Tex-472-A.

Unless allowed on the plans or by the Engineer, volumetric truck (auger) mixers may not supply classes of concrete identified as structural concrete in Table 8.

3.1.3. **Agitators and Truck and Stationary Mixers**. Provide stationary and truck mixers capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and capable of discharging the concrete so at least 5 of the 6 requirements of Tex-472-A are met.

Perform concrete uniformity tests on mixers or agitators in accordance with Tex-472-A as directed, to resolve issues of mix uniformity and mixer performance.

Perform the mixer or agitator uniformity test at the full rated capacity of the equipment. Remove all equipment that fails the uniformity test from service.

Inspect and maintain mixers and agitators. Keep them free of concrete buildup, and repair or replace worn or damaged blades or fins.

Ensure all mixers have a plate affixed showing manufacturer's recommended operating speed and rated capacity for mixing and agitating.

3.2. **Hauling Equipment**. Provide hauling equipment capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass, and discharging the concrete with a satisfactory degree of uniformity.

Provide equipment with smooth, mortar-tight metal containers equipped with gates that prevent accidental discharge of the concrete when using non-agitating equipment for transporting concrete.

Maintain hauling equipment clean and free of built-up concrete.

3.3. **Testing Equipment**. Furnish and maintain the following in accordance with the pertinent test procedure unless otherwise shown on the plans or specified:

- sieves necessary to perform aggregate gradation analysis when optimized aggregate gradation is specified,

- equipment necessary to perform Tex-415-A and Tex-422-A,
- equipment necessary to perform Tex-409-A or Tex-425-A,
- test molds,
- curing facilities,
- maturity meters if used, and
- wheelbarrow or other container acceptable for the sampling of the concrete.

Provide strength-testing equipment when required in accordance with the Contract-controlling test unless shown otherwise.

4. CONSTRUCTION

4.1. **Classification of Concrete Mix Designs**. Provide classes of concrete meeting the requirements shown in Table 8.

A higher-strength class of concrete with equal or lower water-to-cementitious material (w/cm) ratio may be substituted for the specified class of concrete when approved.

4.2. **Mix Design Proportioning**. Furnish mix designs using ACI 211, Tex-470-A, or other approved procedures for the classes of concrete listed in Table 8 unless a design method is indicated on the plans. Perform mix design proportioning by absolute volume method unless otherwise approved. Perform cement replacement using equivalent weight method unless otherwise approved.

Do not exceed the maximum w/cm ratio listed in Table 8 when designing the mixture.

4.2.1. **Cementitious Materials**. Do not exceed 700 lb. of cementitious material per cubic yard of concrete unless otherwise specified or approved.

- Use cement of the same type and from the same source for monolithic placements.
- Do not use supplementary cementing materials when white hydraulic cement is specified.

Table 8
Concrete Classes

Class of Concrete	Design Strength,[1] Min f'_c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]
A	3,000	0.60	1–4, 8	I, II, I/II, IL, IP, IS, IT, V	1, 2, 4, & 7	When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.	Curb, gutter, curb & gutter, conc. retards, sidewalks, driveways, back-up walls, anchors, non-reinforced drilled shafts
B	2,000	0.60	2–7				Riprap, traffic signal controller foundations, small roadside signs, and anchors
C[6]	3,600	0.45	1–6	I, II, I/II, IP, IS, IT,[7] V	1–8		Drilled shafts, bridge substructure, bridge railing, culverts except top slab of direct traffic culverts, headwalls, wing walls, approach slabs, inlets, manholes, concrete traffic barrier (cast-in-place)
E	3,000	0.50	2–5	I, II, I/II, IL, IP, IS, IT,[7] V	1–8	When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.	Seal concrete
F[6]	Note[8]	0.45	2–5	I, II, I/II, IP, IS, IT,[7] V			Railroad structures; occasionally for bridge piers, columns, or bents

Table 8 (continued)
Concrete Classes

Class of Concrete	Design Strength,[1] Min f'_c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]
H[6]	Note[8]	0.45	3–6	I, II, I/II, III, IP, IS, IT,[7] V	1–5	Do not use Type III cement in mass placement concrete. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete.	Precast concrete, post-tension members
S[6]	4,000	0.45	2–5	I, II, I/II, IP, IS, IT,[7] V	1–8		Bridge slabs, top slabs of direct traffic culverts
P	See Item 360, "Concrete Pavement."	0.50	2–3	I, II, I/II, IL, IP, IS, IT, V	1–8	When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.	Concrete pavement
CO[6]	4,600	0.40	6	I, II, I/II, IP, IS, IT,[7] V	1–8		Bridge deck concrete overlay
LMC[6]	4,000	0.40	6–8				Latex-modified concrete overlay
SS[6]	3,600	0.45	4–6			Use a minimum cementitious material content of 658 lb./cu. yd. of concrete.	Slurry displacement shafts, underwater drilled shafts
K[6]	Note[8]	0.40	Note[8]	I, II, I/II, III IP, IS, IT,[7] V			Note[8]
HES	Note[8]	0.45	Note[8]	I, IL, II, I/II, III		Mix design options do not apply. 700 lb. of cementitious material per cubic yard limit does not apply.	Concrete pavement, concrete pavement repair
"X" (HPC) 6,9,10	Note[11]	0.45	Note[11]	I, II, I/II, III IP, IS, IT,[7] V	1–5, & 8	Maximum fly ash replacement for Options 1 and 3 may be increased to 45%. Up to 20% of a blended cement may be replaced with listed SCMs for Option 4. Do not use Option 8 for precast concrete.	
"X" (SRC) 6,9,10	Note[11]	0.45	Note[11]	I/II, II, IP, IS, IT,[7] V	1–4 , & 7	Do not use Class C Fly Ash Type III-MS may be used where allowed. Type I and Type III cements may be used with Options 1–3, with a maximum w/cm of 0.40. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete. Do not use Option 7 for precast concrete.	

1. Design strength must be attained within 56 days.
2. Do not use Grade 1 coarse aggregate except in massive foundations with 4 in. minimum clear spacing between reinforcing steel bars, unless otherwise permitted. Do not use Grade 1 aggregate in drilled shafts.
3. Use Grade 8 aggregate in extruded curbs unless otherwise approved.
4. Other grades of coarse aggregate maybe used in non-structural concrete classes when allowed by the Engineer.
5. For information only.
6. Structural concrete classes.
7. Do not use Type IT cements containing > 5% limestone.
8. As shown on the plans or specified.
9. "X" denotes class of concrete shown on the plans or specified.
10. (HPC): High Performance Concrete, (SRC): Sulfate Resistant Concrete.
11. Same as class of concrete shown on the plans.

4.2.2. **Aggregates**. Recycled crushed hydraulic cement concrete may be used as a coarse or fine aggregate in Class A, B, D, E, and P concrete. Limit recycled crushed concrete fine aggregate to a maximum of 20% of the fine aggregate.

Use light-colored aggregates when white hydraulic cement is specified.

Use fine aggregate with an acid insoluble residue of at least 60% by weight when tested in accordance with Tex-612-J in all concrete subject to direct traffic.

Use the following equation to determine if the aggregate combination meets the acid insoluble residue requirement when blending fine aggregate or using an intermediate aggregate:

$$\frac{(A_1 \times P_1)+(A_2 \times P_2)+(A_{ia} \times P_{ia})}{100} \geq 60\%$$

where:
A_1 = acid insoluble (%) of fine aggregate 1
A_2 = acid insoluble (%) of fine aggregate 2
A_{ia} = acid insoluble (%) of intermediate aggregate passing the 3/8 in. sieve
P_1 = percent by weight of fine aggregate 1 of the fine aggregate blend
P_2 = percent by weight of fine aggregate 2 of the fine aggregate blend
P_{ia} = percent by weight of intermediate aggregate passing the 3/8 in. sieve

Alternatively to the above equation, blend fine aggregate with a micro-deval loss of less than 12%, when tested in accordance with Tex-461-A, with at least 40% of a fine aggregate with an acid insoluble residue of at least 60%.

4.2.3. **Chemical Admixtures**. Do not use Type C, Type E, Type F, or Type G admixtures in Class S bridge deck concrete. Do not use chemical admixtures containing calcium chloride in any concrete.

Use a 30% calcium nitrite solution when a corrosion-inhibiting admixture is required. The corrosion-inhibiting admixture must be set neutral unless otherwise approved. Dose the admixture at the rate of gallons of admixture per cubic yard of concrete shown on the plans.

4.2.4. **Air Entrainment**. Use an approved air-entraining admixture when air-entrained concrete is specified, or when an air-entraining admixture is used at the Contractor's option, and do not exceed the manufacturer's recommended dosage. Ensure the minimum entrained air content is at least 3.0% for all classes of concrete except Class P when air-entrained concrete is specified, during trial batch, or when providing previous field data.

4.2.5. **Slump**. Provide concrete with a slump in accordance with Table 9 unless otherwise specified. When approved, the slump of a given concrete mix may be increased above the values shown in Table 9 using chemical admixtures, provided the admixture-treated concrete has the same or lower water-to-cementitious material ratio and does not exhibit segregation or excessive bleeding. Request approval to exceed the slump limits in Table 9 sufficiently in advance for proper evaluation by the Engineer.

Perform job-control testing of slump in accordance with Section 421.4.8.3.1., "Job-Control Testing."

Table 9
Placement Slump Requirements

General Usage[1]	Placement Slump Range,[2] in.
Walls (over 9 in. thick), caps, columns, piers, approach slabs, concrete overlays	3 to 5
Bridge slabs, top slabs of direct traffic culverts, latex-modified concrete for bridge deck overlays	3 to 5-1/2
Inlets, manholes, walls (less than 9 in. thick), bridge railing, culverts, concrete traffic barrier, concrete pavement (formed), seal concrete	4 to 5-1/2
Precast concrete	4 to 9
Underwater concrete placements	6 to 8-1/2
Drilled shafts, slurry displaced and underwater drilled shafts	See Item 416, "Drilled Shaft Foundations."
Curb, gutter, curb and gutter, concrete retards, sidewalk, driveways, anchors, riprap, small roadside sign foundations, concrete pavement repair, concrete repair	As approved

1. For information only.
2. For fiber reinforced concrete, perform slump before addition of fibers.

4.2.6. **Mix Design Options.**

4.2.6.1. **Option 1**. Replace 20% to 35% of the cement with Class F fly ash.

4.2.6.2. **Option 2**. Replace 35% to 50% of the cement with slag cement or MFFA.

4.2.6.3. **Option 3**. Replace 35% to 50% of the cement with a combination of Class F fly ash, slag cement, MFFA, UFFA, metakaolin, or silica fume; however, no more than 35% may be fly ash, and no more than 10% may be silica fume.

4.2.6.4. **Option 4**. Use Type IP, Type IS, or Type IT cement as allowed in Table 5 for each class of concrete. Up to 10% of a Type IP, Type IS, or Type IT cement may be replaced with Class F fly ash, slag cement, or silica fume. Use no more than 10% silica fume in the final cementitious material mixture if the Type IT cement contains silica fume, and silica fume is used to replace the cement.

4.2.6.5. **Option 5**. Replace 35% to 50% of the cement with a combination of Class C fly ash and at least 6% of silica fume, UFFA, or metakaolin. However, no more than 35% may be Class C fly ash, and no more than 10% may be silica fume.

4.2.6.6. **Option 6**. Use a lithium nitrate admixture at a minimum dosage determined by testing conducted in accordance with Tex-471-A, "Lithium Dosage Determination Using Accelerated Mortar Bar Testing." Before use of the mix, provide an annual certified test report signed and sealed by a licensed professional engineer, from a laboratory on the Department's MPL, certified by the Construction Division as being capable of testing according to Tex-471-A, "Lithium Dosage Determination Using Accelerated Mortar Bar Testing."

4.2.6.7. **Option 7**. Ensure the total alkali contribution from the cement in the concrete does not exceed 3.5 lb. per cubic yard of concrete when using hydraulic cement not containing SCMs calculated as follows:

$$\text{lb. alkali per cu. yd.} = \frac{(\text{lb. cement per cu. yd.}) \times (\%\ \text{Na}_2\text{O equivalent in cement})}{100}$$

4.2.6.8. **Option 8**. Perform annual testing as required for any deviations from Options 1–5 or use mix design options listed in Table 10. Laboratories performing ASTM C1260, ASTM C1567, and ASTM C1293 testing must be listed on the Department's MPL. Before use of the mix, provide a certified test report signed and sealed by a licensed professional engineer demonstrating the proposed mixture conforms to the requirements of Table 10.

Provide a certified test report signed and sealed by a licensed professional engineer, when HPC is required, and less than 20% of the cement is replaced with SCMs, demonstrating ASTM C1202 test results indicate the permeability of the concrete is less than 1,500 coulombs tested immediately after either of the following curing schedules:

- Moisture cure specimens 56 days at 73°F.
- Moisture cure specimens 7 days at 73°F followed by 21 days at 100°F.

Table 10
Option 8 Testing and Mix Design Requirements

Scenario	ASTM C1260 Result		Testing Requirements for Mix Design Materials or Prescriptive Mix Design Options[1]
	Mix Design Fine Aggregate	Mix Design Coarse Aggregate	
A	> 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of each aggregate[2] to 0.08% when tested individually in accordance with ASTM C1567, or Use a minimum of 40% Class C fly ash with a maximum CaO^3 content of 25%.
B	≤ 0.10%	≤ 0.10%	Use a minimum of 40% Class C fly ash with a maximum CaO^3 content of 25%, or Use any ternary combination which replaces 35% to 50% of cement.
	≤ 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Use a minimum of 20% of any Class C fly ash, or Use any ternary combination which replaces 35% to 50% of cement.
C	≤ 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of coarse and intermediate[2] aggregate to 0.08% when tested individually in accordance with ASTM C1567, or Use a minimum of 40% Class C fly ash with a maximum CaO^3 content of 25%.
D	> 0.10%	≤ 0.10%	Use a minimum of 40% Class C fly ash with a maximum CaO^3 content of 25%, or Use any ternary combination which replaces 35% to 50% of cement.
	> 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Determine the dosage of SCMs needed to limit the 14-day expansion of fine aggregate to 0.08% when tested in accordance with ASTM C1567.

1. Do not use Class C fly ash if the ASTM C1260 value of the fine, intermediate, or coarse aggregate is 0.30% or greater, unless the fly ash is used as part of a ternary system.
2. Intermediate size aggregates will fall under the requirements of mix design coarse aggregate.
3. Average the CaO content from the previous ten values as listed on the mill certificate.

4.2.7. **Optimized Aggregate Gradation (OAG) Concrete**. The gradation requirements in Table 3 and Table 4 do not apply when OAG concrete is specified or used by the Contractor unless otherwise shown on the plans. Use Tex-470-A to establish the optimized aggregate gradation. Use at least 420 lb. per cubic yard of cementitious material when OAG concrete is used unless otherwise approved. Use a coarse aggregate with a maximum nominal size of 1-1/2 in. for Class P concrete. Use a coarse aggregate for all other classes of concrete with a maximum nominal size not larger than:

- 1/5 the narrowest dimension between sides of forms, or
- 1/3 the depth of slabs, or
- 3/4 the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, individual tendons, bundled tendons, or ducts.

Make necessary adjustments to individual aggregate stockpile proportions during OAG concrete production when the gradation deviates from the optimized gradation requirements.

4.2.8. **Self-Consolidating Concrete (SCC)**. Provide SCC meeting the following requirements shown in Table 11 when approved for use in precast concrete. Use concrete with a slump flow that can be placed without vibration and will not segregate or excessively bleed.

Increase the slump flow of a given concrete mix above the values shown in Table 11 when approved, provided the concrete has the same or lower water-to-cementitious material ratio and meets all other requirements listed in Table 11. Request approval to exceed the slump flow limits sufficiently in advance for proper evaluation by the Engineer.

Table 11
Mix Design Requirements for SCC

Tests	Test Method	Acceptable Limits
Slump Flow for Precast Concrete	ASTM C1611	22 to 27[1]
Slump Flow for Drilled Shafts	ASTM C1611	19 to 24[1]
T_{50}, sec	ASTM C1611	2 to 7
VSI Rating	ASTM C1611	0 or 1
Passing Ability, in.	ASTM C1621	≤ 2
Segregation Column, %	ASTM C1610	≤ 10
Bleeding, %	ASTM C232	≤ 2.5

1. These slump flow limits are generally acceptable for most applications. However, slump flow limits may be adjusted during mix design approval process and when approved by the Engineer.

4.3. **Concrete Trial Batches**. Perform preliminary and final trial batches when required by the plans, or when previous satisfactory field data is not available. Submit previous satisfactory field data to the Engineer showing the proposed mix design conforms to specification requirements when trial batches are not required and before concrete is placed.

Perform preliminary and final trial batches for all self-consolidating concrete mix designs.

4.3.1. **Preliminary Trial Batches**. Perform all necessary preliminary trial batch testing when required, and provide documentation including mix design, material proportions, and test results substantiating the mix design conforms to specification requirements.

4.3.2. **Final Trial batches**. Make all final trial batches using the proposed ingredients in a mixer that is representative of the mixers to be used on the job when required. Make the batch size at least 50% of the mixer's rated capacity. Perform fresh concrete tests for air content and slump, and make, cure, and test strength specimens for compliance with specification requirements. Test at least one set of design strength specimens, consisting of 2 specimens per set, at 7-day, 28-day, and at least one additional age unless otherwise directed. Before placing, provide the Engineer the option of witnessing final trial batches, including the testing of the concrete. If not provided this option, the Engineer may require additional trial batches, including testing, before the concrete is placed.

Conduct all testing listed in Table 11 when performing trial batches for self-consolidating concrete. Make an additional mixture with 3% more water than the preliminary trial batch. Make necessary adjustments to the mix design if this additional mixture does not meet requirements of Table 11. Cast and evaluate mock-ups for precast concrete that are representative of the actual product as directed. Provide the Engineer the option of witnessing final trial batches, including the testing of the concrete and the casting of the mock-ups before placement. If not provided this option, the Engineer may require additional trial batches, including testing and mock-ups, before the concrete is placed.

Establish 7-day compressive strength target values using the following formula for each Class A, B, and E concrete mix designs to be used:

$$\text{Target value} = \text{Minimum design strength} \times \frac{\text{7 - day avg. trial batch strength}}{\text{28 - day avg. trial batch strength}}$$

Submit previous satisfactory field data, data from a new trial batch, or other evidence showing the change will not adversely affect the relevant properties of the concrete when changes are made to the type, brand, or source of aggregates, cement, SCM, water, or chemical admixtures. Submit the data for approval before making changes to the mix design. A change in vendor does not necessarily constitute a change in materials or source. The Engineer may waive new trial batches when there is a prior record of satisfactory performance with the ingredients. During concrete production, dosage changes of chemical admixtures used in the trial batches will not require a re-evaluation of the mix design.

The Contractor has the option of performing trial batches in conjunction with concrete placements except for SCC mixtures, when new trial batches are required during the course of the project. If the concrete fails to meet any requirement, the Engineer will determine acceptability and payment adjustments.

Establish the strength–maturity relationship in accordance with Tex-426-A when the maturity method is specified or permitted. When using the maturity method, any changes in any of the ingredients, including changes in proportions, will require the development of a new strength–maturity relationship for the mix.

4.3.3. **Mix Design of Record**. Once a trial batch or previously satisfactory field data substantiates the mix design, the proportions and mixing methods used become the mix design of record. Do not exceed mix design water-to-cement ratio.

4.4. **Production Testing**.

4.4.1. **Aggregate Moisture Testing**. Determine moisture content per Tex-409-A or Tex-425-A for coarse, intermediate, and fine aggregates at least twice a week, when there is an apparent change, or for new shipments of aggregate. When aggregate hoppers or storage bins are equipped with properly maintained electronic moisture probes for continuous moisture determination, moisture tests per Tex-409-A or Tex-425-A are not required. Electronic moisture probes, however, must be verified at least every 90 days against Tex-409-A and be accurate to within 1.0% of the actual moisture content.

When producing SCC, and when aggregate hoppers or storage bins are not equipped with electric moisture probes, determine the moisture content of the aggregates before producing the first concrete batch each day. Thereafter, determine the moisture content every 4 hr. or when there is an apparent change while SCC is being produced.

4.4.2. **Aggregate Gradation Testing**. Perform a sieve analysis in accordance with Tex-401-A on each stockpile used in the blend at least one day before producing OAG concrete when producing optimized aggregate gradation concrete. Perform sieve analysis on each stockpile after every 10,000 cubic yards of OAG concrete produced. Provide sieve analysis data to the Engineer.

4.5. **Measurement of Materials**.

4.5.1. **Non-Volumetric Mixers**. Measure aggregates by weight. Correct batch weight measurements for aggregate moisture content. Measure mixing water, consisting of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures, by volume or weight. Measure ice by weight. Measure cement and supplementary cementing materials in a hopper and on a separate scale from those used for other materials. Measure the cement first when measuring the cumulative weight. Measure concrete chemical admixtures by weight or volume. Measure batch materials within the tolerances of Table 12.

Table 12
Mix Design Batching Tolerances—Non-Volumetric Mixers

Material	Tolerance (%)
Cement, wt.	-1 to +3
SCM, wt.	-1 to +3
Cement + SCM (cumulative weighing), wt.	-1 to +3
Water, wt. or volume	±3[1]
Fine aggregate, wt.	±2
Coarse aggregate, wt.	±2
Fine + coarse aggregate (cumulative weighing), wt.	±1
Chemical admixtures, wt. or volume	±3

1. Allowable deviation from target weight not including water withheld or moisture in the aggregate. The Engineer will verify the water-to-cementitious material ratio is within specified limits.

Ensure the quantity measured, when measuring cementitious materials at less than 30% of scale capacity, is accurate to not less than the required amount and not more than 4% in excess. Ensure the cumulative quantity, when measuring aggregates in a cumulative weigh batcher at less than 30% of the scale capacity,

is measured accurate to ±0.3% of scale capacity or ±3% of the required cumulative weight, whichever is less.

Measure cement in number of bags under special circumstances when approved. Use the weights listed on the packaging. Weighing bags of cement is not required. Ensure fractional bags are not used except for small hand-mixed batches of approximately 5 cu. ft. or less and when an approved method of volumetric or weight measurement is used.

4.5.2. **Volumetric Mixers**. Provide an accurate method of measuring all ingredients by volume, and calibrate equipment to assure correct measurement of materials within the specified tolerances. Base tolerances on volume–weight relationship established by calibration, and measure the various ingredients within the tolerances of Table 13. Correct batch measurements for aggregate moisture content.

Table 13
Mix Design Batching Tolerances—Volumetric Mixers

Material	Tolerance
Cement, wt. %	0 to +4
SCM, wt. %	0 to +4
Fine aggregate, wt. %	±2
Coarse aggregate, wt. %	±2
Admixtures, wt. or volume %	±3
Water, wt. or volume %	±1

4.6. **Mixing and Delivering Concrete**.

4.6.1. **Mixing Concrete**. Operate mixers and agitators within the limits of the rated capacity and speed of rotation for mixing and agitation as designated by the manufacturer of the equipment. Provide concrete in a thoroughly mixed and uniform mass with a satisfactory degree of uniformity when tested in accordance with Tex-472-A.

Do not top-load new concrete onto returned concrete.

Adjust mixing times and batching operations as necessary when the concrete contains silica fume to ensure the material is completely and uniformly dispersed in the mix. The dispersion of the silica fume within the mix will be verified by the Construction Division, Materials and Pavements Section, using cylinders made from trial batches. Make necessary changes to the batching operations, if uniform dispersion is not achieved, until uniform and complete dispersion of the silica fume is achieved.

Mix concrete by hand methods or in a small motor-driven mixer when permitted, for small placements of less than 2 cu. yd. For such placements, proportion the mix by volume or weight.

4.6.2. **Delivering Concrete**. Deliver concrete to the project in a thoroughly mixed and uniform mass, and discharge the concrete with a satisfactory degree of uniformity. Conduct testing in accordance with Tex-472-A when there is a reason to suspect the uniformity of concrete and as directed.

Maintain concrete delivery and placement rates sufficient to prevent cold joints.

Adding chemical admixtures or the portion of water withheld is only permitted at the jobsite, under the supervision of the Engineer, to adjust the slump or slump flow of the concrete. Do not add water or chemical admixtures to the batch after more than an amount needed to conduct slump testing has been discharged. Turn the drum or blades at least 30 additional revolutions at mixing speed to ensure thorough and uniform mixing of the concrete. When this water is added, do not exceed the approved mix design water-to-cementitious material ratio.

Before unloading, furnish the delivery ticket for the batch of concrete containing the information required on Department Form 596, "Concrete Batch Ticket." The Engineer will verify all required information is provided on the delivery tickets. The Engineer may suspend concrete operations until the corrective actions are

implemented if delivery tickets do not provide the required information. The Engineer will verify the design water-to-cementitious material ratio is not exceeded.

Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14. Concrete may be discharged after these times provided the concrete temperature and slump meet the requirements listed in this Item and other pertinent Items. Perform these tests with certified testing personnel per Section 421.4.8.1., "Certification of Testing Personnel." Provide the Engineer the option of witnessing testing of the concrete. If not provided this option, the Engineer may require additional testing before the concrete is placed.

Table 14
Concrete Discharge Times

Fresh Concrete Temperature, °F	Max Time After Batching for Concrete Not Containing Type B or D Admixtures, min.	Max Time After Batching for Concrete Containing Type B or D Admixtures,[1] min.
90 and above	45	75
75 ≤ T < 90	60	90
T < 75	90	120

1. Concrete must contain at least the minimum manufacturer's recommended dosage of Type B or D admixture.

4.7. **Placing, Finishing, and Curing Concrete**. Place, finish, and cure concrete in accordance with the pertinent Items.

4.8. **Sampling and Testing of Concrete**. Unless otherwise specified, all fresh and hardened concrete is subject to testing as follows:

4.8.1. **Certification of Testing Personnel**. Contractor personnel performing testing must be either ACI-certified or qualified by a Department-recognized equivalent written and performance testing program for the tests being performed. Personnel performing these tests are subject to Department approval. Use of a commercial laboratory is permitted at the Contractor's option. All personnel performing testing using the maturity method must be qualified by a training program recognized by the Department before using this method on the job.

4.8.2. **Fresh Concrete**. Provide safe access and assistance to the Engineer during sampling. Fresh concrete will be sampled for testing at the discharge end if using belt conveyors or pumps. When it is impractical to sample at the discharge end, a sample will be taken at the time of discharge from the delivery equipment and correlation testing will be performed and documented to ensure specification requirements are met at the discharge end.

4.8.3. **Testing of Fresh Concrete**. Test for the fresh properties listed in Table 15.

Table 15
Fresh Concrete Tests

Tests	Test Methods
Slump[1]	Tex-415-A
Temperature[1]	Tex-422-A
Air Content[2]	Tex-414-A, Tex-416-A or ASTM C457

1. Job-control testing performed by the Contractor.
2. Only required during concrete trial batch when air-entrained concrete is specified on the plans.

Concrete with a slump lower than the minimum placement slump in Table 9 after the addition of all water withheld, or concrete exhibiting segregation and excessive bleeding may be rejected.

When SCC exceeds the maximum placement slump flow or VSI rating, the Engineer will immediately resample and retest the concrete slump flow and VSI rating. If the concrete exceeds the maximum placement slump flow or VSI rating after the retest, the concrete will be rejected.

4.8.3.1. **Job-Control Testing**. Perform job-control concrete temperature and slump testing as specified in Table 16 unless otherwise specified. Provide the Engineer the opportunity to witness the testing. The Engineer may

require a retest if not given the opportunity to witness. Immediately notify the Engineer of any concrete temperature or slump nonconformity issues. Furnish a copy of all test results to the Engineer daily.

Table 16
Job-Control Testing Frequencies

Concrete Placements	Frequency
Bridge Deck Placements	Test the first few loads, then every fifth load delivered.
All Other Structural Class Concrete Placements	One test every 60 cu. yd. or fraction thereof.
Non-Structural Class Concrete Placements	One test every 180 cu. yd. or fraction thereof.

Immediately resample and retest the concrete slump when the concrete exceeds the slump range at time of placement. If the concrete exceeds the slump range after the retest, and is used at the Contractor's option, the Engineer will make strength specimens as specified in Article 421.5., "Acceptance of Concrete."

4.8.3.2. **Strength Specimen Handling**. Remove specimens from their molds and deliver Department test specimens to curing facilities within 24 to 48 hr. after molding, in accordance with pertinent test procedures unless otherwise shown on the plans or directed. Clean and prepare molds for reuse if necessary.

5. ACCEPTANCE OF CONCRETE

The Engineer will sample and test the fresh and hardened concrete for acceptance. The test results will be reported to the Contractor and the concrete supplier. Investigate the quality of the materials, the concrete production operations, and other possible problem areas to determine the cause for any concrete that fails to meet the required strengths as outlined below. Take necessary actions to correct the problem including redesign of the concrete mix. The Engineer may suspend all concrete operations under the pertinent Items if the Contractor is unable to identify, document, and correct the cause of the low strengths in a timely manner. Resume concrete operations only after obtaining approval for any proposed corrective actions. Concrete failing to meet the required strength as outlined below will be evaluated using the procedures listed in Article 421.6., "Measurement and Payment."

5.1. **Structural Concrete**. For concrete classes identified as structural concrete in Table 8, the Engineer will make and test 7-day and 28-day specimens. Acceptance will be based on attaining the design strength given in Table 8.

5.2. **Class P and Class HES**. The Engineer will base acceptance in accordance with Item 360, "Concrete Pavement," and Item 361, "Repair of Concrete Pavement."

5.3. **All Other Concrete**. For concrete classes not identified as structural concrete in Table 8, the Engineer will make and test 7-day specimens. The Engineer will base acceptance on the 7-day target value established in accordance with Section 421.4.3., "Concrete Trial Batches."

6. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

The following procedure will be used to evaluate concrete where one or more project acceptance test specimens fail to meet the required design strength specified in this Item or on the plans:

- The concrete for a given placement will be considered structurally adequate and accepted at full price if the average of all test results for specimens made at the time of placement meets the required design strength provided no single test result is less than 85% of the required design strength.
- The Engineer will perform a structural review of the concrete to determine its adequacy to remain in service if the average of all test results for specimens made at the time of placement is less than the required design strength or if any test results are less than 85% of the required design strength. If the in-

situ concrete strength is needed for the structural review, take cores at locations designated by the Engineer in accordance with Tex-424-A. The Engineer will test the cores. The coring and testing will be at the Contractor's expense.

- If all of the tested cores meet the required design strength, the concrete will be paid for at full price.
- If any of the tested cores do not meet the required design strength, but the average strength attained is determined to be structurally adequate, the Engineer will determine the limits of the pay adjustment using the following formula:

$$A = B_p\left[-5.37\left(\frac{S_a}{S_s}\right)^2 + 11.69\left(\frac{S_a}{S_s}\right) - 5.32\right]$$

where:
A = Amount to be paid per unit of measure for the entire placement in question
S_a = Actual average strength from cylinders or cores. Use values from cores, if taken.
S_s = Minimum required strength (specified)
B_p = Unit Bid Price

- If the structural review determines the concrete is not adequate to remain in service, the Engineer will determine the limits of the concrete to be removed.
- The decision to reject structurally inadequate concrete or to apply the pay adjustment factor will be made no later than 56 days after placement.

Item 422
Concrete Superstructures

1. DESCRIPTION

Construct reinforced concrete bridge slabs, decks, flat slabs, slab and girder units (pan formed), approach slabs, or other bridge superstructure elements as indicated.

2. MATERIALS

2.1. **Concrete**. Provide concrete conforming to Item 421, "Hydraulic Cement Concrete." Provide Class S or S (HPC) concrete for all cast-in-place concrete unless otherwise shown on the plans. Provide the class of concrete for precast components indicated on the plans or in pertinent governing Items.

2.2. **Reinforcing Steel**. Provide reinforcing steel in accordance with Item 440, "Reinforcement for Concrete."

2.3. **Structural Grout**. Provide grout in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications" or as indicated on the plans.

2.4. **Expansion Joint Material**. Provide materials in accordance with DMS-6310, "Joint Sealants and Fillers."

- Provide preformed bituminous fiber expansion joint material unless indicated otherwise.
- Provide a Class 4, 5, or 7 low-modulus silicone sealant unless otherwise directed.
- Provide asphalt board that conforms to dimensions shown on the plans.
- Provide re-bonded neoprene filler that conforms to the dimensions shown on the plans.

2.5. **Foam Bedding Strips for Prestressed Concrete Panels**. Use extruded polystyrene conforming to ASTM C578, Type VI (40 psi compressive strength) or as specified.

Provide a manufacturer's certification or data sheet stating the foam meets these requirements. Use an adhesive or bonding agent compatible with polystyrene as recommended by the polystyrene manufacturer.

2.6. **Evaporation Retardants**. Provide evaporation retardants in accordance with DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

2.7. **Curing Materials**. Provide membrane curing compounds in accordance with DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

Provide cotton mats that consist of a filling material of cotton "bat" or "bats" (at least 12 oz. per square yard) completely covered with unsized cloth (at least 6 oz. per square yard) stitched longitudinally with continuous parallel rows of stitching spaced at less than 4 in., or tuft both longitudinally and transversely at intervals less than 3 in. Provide cotton mats that are free from tears and in good general condition. Provide a flap at least 6 in. wide consisting of 2 thicknesses of the covering and extending along one side of the mat.

Provide polyethylene sheeting that is at least 4 mils thick and free from visible defects. Provide opaque white sheeting when the ambient temperature during curing exceeds 90°F.

Provide burlap-polyethylene mats made from burlap impregnated on one side with a film of opaque white pigmented polyethylene, free from visible defects. Provide laminated mats that have at least one layer of an impervious material such as polyethylene, vinyl plastic, or other acceptable material (either as a solid sheet or impregnated into another fabric) and are free of visible defects.

Provide burlap material which complies with AASHTO M 182, Class 3 (10 oz. per square yard) with the following additions:

- Manila hemp may also be used to make burlap.
- Do not use burlap fabricated from bags.
- Do not use burlap containing any water soluble ingredient which will retard the setting time of concrete.

Provide used burlap complying with the requirements stated above, and that only has been used previously for curing concrete. "Like new" cleanliness is not expected, but contamination with any substance foreign to the concrete curing process, such as grease or oil, will be cause for rejection.

2.8. **Epoxy**. Provide epoxy materials that conform to DMS-6100, "Epoxies and Adhesives," unless otherwise specified.

3. EQUIPMENT

3.1. **Fogging Equipment**. Use fogging equipment that can apply water in a fine mist, not a spray. Produce the fog using equipment that pumps water or water and air under high pressure through a suitable atomizing nozzle. Use hand-held mechanical equipment portable enough to use in the direction of any prevailing wind and adaptable for intermittent use to prevent excessive wetting of the concrete.

3.2. **Transporting and Placing Equipment**. Use appropriate transporting and placing equipment such as buckets, chutes, buggies, belt conveyors, pumps, or other equipment as necessary. Do not transport or convey concrete through equipment made of aluminum. Use carts with pneumatic tires for carting or wheeling concrete over newly placed slabs.

Use tremies that are watertight to control the fall of concrete and of large enough diameter to allow the placement of the concrete but less than 14 in. in diameter.

Use pumps with lines at least 5 in. inside diameter (I.D.) where Grade 2 or smaller coarse aggregate is used and at least 8 in. I.D. for Grade 1 coarse aggregate.

3.3. **Vibrators**. Use immersion-type vibrators for consolidation of concrete. Provide at least 1 standby vibrator for emergency use. Furnish vibrator head covered by a rubberized or elastomeric cover when used near epoxy coated reinforcing steel.

3.4. **Screeds and Work Bridges for Bridge Slabs**. Use a self-propelled transverse screed or a mechanical longitudinal screed for bridge slabs. Use transverse screeds that are able to follow the skew of the bridge for skews greater than 15° unless otherwise approved. Equip transverse screeds with a pan float. Manually operated screeding equipment may be used if approved for top slabs of culverts, small placements, or unusual conditions. Use screeds that are rigid and heavy enough to hold true to shape and have sufficient adjustments to provide for the required camber or section. Equip the screeds, except those of the roller drum type, with metal cutting edges.

Use sufficient work bridges for finishing operations for bridge slabs. Mount a carpet drag to a work bridge or a moveable support system that can vary the area of carpet in contact with the concrete. Use carpet pieces long enough to cover the entire width of the placement. Splice or overlap the carpet as necessary. Ensure enough carpet is in contact longitudinally with the concrete being placed to provide the desired surface finish. Use artificial grass-type carpeting with a molded polyethylene pile face with a blade length between 5/8 and 1 in. and minimum weight of 70 oz. per square yard. Ensure the carpet has a strong, durable backing not subject to rot and the facing is adequately bonded to the backing to withstand the intended use. A burlap drag, attached to the pan float on a transverse screed, may be used instead of the carpet drag.

3.5. **Temperature Recording Equipment**. Use strip chart temperature recording devices, recording maturity meters in accordance with Tex-426-A, or other approved devices that are accurate within ±2°F within the range of 32°F to 212°F.

3.6. **Artificial Heating Equipment**. Use artificial heating equipment as necessary for maintaining the concrete temperatures as specified in Section 422.4.6.11., "Placing Concrete in Cold Weather."

3.7. **Sawing Equipment**. Use sawing equipment capable of cutting grooves in completed bridge slabs and top slabs of direct traffic culverts. Provide grooves that are 1/8 to 3/16 in. deep, nominally 1/8 in. wide, and spaced at 1 in. Use sawing equipment capable of cutting grooves in hardened concrete within 18 in. of the barrier rail or curb.

3.8. **Spraying Equipment**. Use mechanically powered pressure sprayers with appropriate atomizing nozzles for the application of membrane curing. Mechanically driven spraying equipment, adaptable to the rail system used by the screeds, may be used for applying membrane curing to bridge slabs. Use hand-pressurized spray equipment equipped with 2 or 3 fan-spray nozzles if approved. Ensure the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.

3.9. **Concrete Testing Equipment**. Provide testing equipment for the Engineer's use in accordance with Section 421.3.3., "Testing Equipment."

4. CONSTRUCTION

Obtain approval for proposed construction methods before starting work. Approval of construction methods and equipment does not relieve the Contractor's responsibility for safety or correctness of methods, adequacy of equipment, or completion of work in full accordance with the Contract. Attend the pre-construction (pre-pour) meetings for bridge slabs conducted by the Engineer. Provide and obtain approval for proposed finishing methods, interim curing methods, and final curing methods.

Unless otherwise shown on the plans, it is the Contractor's option to perform testing on structural concrete (structural classes of concrete are identified in Table 8 of Section 421.4.1., "Classification of Concrete Mix Designs,") to determine the in-situ strength to address the schedule restrictions listed below. The Engineer may require the Contractor to perform this testing for concrete placed in cold weather. Make enough test specimens for Contractor-performed testing to ensure strength requirements are met for the operations listed below. Make at least 1 set of test specimens for each element cast each day. Cure these specimens under the same conditions as the portion of the structure involved for all stages of construction. Ensure safe handling, curing, and storage of all test specimens. Provide testing personnel, and sample and test the hardened concrete in accordance with Section 421.4.8., "Sampling and Testing of Concrete." The maturity method, Tex-426-A, may be used for in-situ strength determination for schedule restrictions if approved. Coring will not be allowed for in-situ strength determination for schedule restrictions. Provide the Engineer the opportunity to witness all testing operations. Report all test results to the Engineer.

If the Contractor does not wish to perform schedule restriction testing, the Engineer's 7-day lab-cured tests, performed in accordance with Article 421.5., "Acceptance of Concrete," will be used for schedule restriction determinations. The Engineer may require additional time for strength gain to account for field curing conditions such as cold weather.

4.1. **Schedule Restrictions and Inspection Hold-Points**.

4.1.1. **Placement of Superstructure Members**. Place or cast superstructure members after the substructure concrete has attained a compressive strength of 3,000 psi.

4.1.2. **Longitudinal Screeding of Bridge Slabs**. Place a longitudinal screed directly on previously placed concrete slabs to check and grade an adjacent slab only after the previously placed slab has aged at least 24 hr. Place and screed the concrete after the previously placed slabs have aged at least 48 hr. Maintain curing of the previously placed slabs during placement.

4.1.3. **Staged Placement of Bridge Slabs on Continuous Steel Units**. Ensure the previously placed concrete attains a compressive strength of 3,000 psi when staged placement of a slab is required or used before

placing the next stage placement. Multiple stages may be placed in a single day if approved by the Engineer of Record.

4.1.4. **Storage of Materials on the Structure**. Obtain approval to store materials on completed portions of a structure once a compressive strength of 3,000 psi has been attained. Maintain proper curing if materials will be stored on structures before completion of curing.

4.1.5. **Placement of Equipment and Machinery**. Do not place erection equipment or machinery on the structure until the concrete has attained the design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," unless otherwise approved.

4.1.6. **Carting of Concrete** Cart, wheel, or pump concrete over completed slabs after the completed concrete has attained a compressive strength of 3,000 psi. Maintain curing during these operations.

4.1.7. **Placing Bridge Rails**. Reinforcing steel and concrete for bridge rails may be placed on bridge slabs once the slab concrete has attained a compressive strength of 3,000 psi. Ensure the slab concrete has attained its design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," before placing railing concrete if slipforming methods are used for railing concrete.

4.1.8. **Opening to Construction Traffic**. Bridges may be opened to all construction traffic when the design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," has been attained if curing is maintained. Avoid crossing bridges at high speeds until railing concrete, if present, has attained a compressive strength of 3,000 psi.

4.1.9. **Opening to Full Traffic**. Bridges may be opened to the traveling public when the design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," has been attained for all structural elements including railing subject to impact from traffic and when curing has been completed for all slabs. Obtain approval before opening bridges to the traveling public.

4.1.10. **Inspection Hold-Points**. Notify Engineer of progress of work and when work is complete before beginning next stage of work.

- Beam erection and bracing
- Formwork, including setting of precast panels
- Placing reinforcing steel
- Screed dry run and pre-pour clear cover checks
- Attend pre-pour meeting conducted by the Engineer
- Post-curing crack inspection

4.2. **Forms**. Submit forming plans for decks or slabs on beams or girders, overhangs, cast-in-place spans, and bracing systems for girders when the overhang exceeds 3 ft. 6 in. Submit similar plans for other units of the superstructure as directed. Show all essential details of proposed forms and bracing. Have a licensed professional engineer design, seal, and sign these plans. Department approval is not required, but the Department reserves the right to request modifications to the plans. The Contractor is responsible for the adequacy of these plans.

Design job-fabricated formwork assuming a weight of 150 pcf for concrete, and include a minimum liveload allowance of 50 psf of horizontal surface of the form. Do not exceed 125% of the allowable stresses used by the Department for the design of structures.

Use conventional forms, permanent metal deck forms, or prestressed concrete panels for slabs on beams or girders unless indicated otherwise. Use permanent metal deck forms or conventional forms for thickened slabs, diaphragms, or other regions as shown on the plans where prestressed concrete panels are not used. Provide prestressed concrete panels as shown on the plans and in accordance with Item 424, "Precast Concrete Structural Members (Fabrication)." Provide copies of the precast panel layout drawings from the panel fabricator.

Use only material that is inert, non-biodegradable, and nonabsorptive for forms to be left in place.

Overhang form supports that transmit a horizontal force to a steel girder or beam or to a prestressed concrete beam are permitted provided a satisfactory structural analysis has been made of the effect on the girder or beam as indicated in the submitted formwork plans.

Use beam bracing as indicated on the plans when overhang brackets are used on prestressed concrete beam spans with slab overhangs not exceeding 3 ft. 6 in. Provide and design additional support or bracing for the outside beams regardless of the type of beam used for spans with overhangs exceeding this amount.

Attachment of forms or screed supports for bridge slabs to steel I-beams or girders may be by welding subject to the following requirements:

- Do not weld to tension flanges or to areas indicated on the plans.
- Weld in accordance with Item 448, "Structural Field Welding."

When setting forms of any type take into account:

- deflections due to cast-in-place slab concrete and railing shown in the dead load deflection diagram,
- differential beam or girder deflections due to skew angles and the use of certain stay-in-place slab forming systems, and
- deflection of the forming system due to the wet concrete.

Securely stake forms to line and grade and maintain in position for bridge approach slabs. Rigidly attach inside forms for curbs to the outside forms.

Construct all forms to permit their removal without marring or damaging the concrete. Clean all forms and footing areas of any extraneous matter before placing concrete. Provide openings in forms if needed for the removal of laitance or foreign matter.

Treat the facing of all forms with bond-breaking coating of composition that will not discolor or injuriously affect the concrete surface. Take care to prevent coating of the reinforcing steel.

Complete all preparatory work before placing concrete.

4.2.1. **Precast Panels**. Profile each beam to determine the actual camber or sag of the beams before placing panels. Adjust the profile grade line, panel elevation, and bearing seat elevations as needed to obtain the required cover over the slab reinforcement and slab thickness while maintaining ride quality. Make adjustments over suitable increments when a profile grade line adjustment is necessary, depending on span lengths, so the revised grade line will produce a uniform profile and good riding qualities. Obtain approval for the grade adjustments before placement. Consider actual beam camber in adjacent spans or slab placements when adjusting the grade line. Inspect each panel before being placed for cracks and other damage. Refer to Section 424.4.3.1., "Defects and Breakage," for rejection criteria due to cracking and other damage.

4.2.2. **Permanent Metal Decking**. Submit signed and sealed design calculations in addition to the required formwork drawings. Design and install formwork in accordance with the plans and formwork drawings. The plans will govern in cases where the plans and the formwork drawings conflict.

4.2.3. **Conventional Forms**. Provide properly seasoned good-quality lumber free from imperfections that would affect its strength or impair the finished surface of the concrete. Provide timber or lumber that meets or exceeds the requirements for species and grade in the submitted formwork plans.

Maintain forms or form lumber that will be reused so that it stays clean and in good condition. Do not use any lumber that is split, warped, bulged, or marred or that has any defect that will produce inferior work; remove such lumber from the work.

Use plywood at least 3/4 in. thick. Use plywood for forming surfaces that remain exposed that meets the requirements for B-B Plyform Class I or Class II Exterior of the U.S. Department of Commerce Voluntary Product Standard PS 1.

Space studs and joists so that the facing form material remains in true alignment under the imposed loads.

Place forms with the form panels symmetrically (long dimensions set in the same direction) for surfaces exposed to view and receiving only an ordinary surface finish as defined in Section 420.4.13., "Ordinary Surface Finish." Make horizontal joints continuous.

Make molding for chamfer strips or other uses of materials of a grade that will not split when nailed and can be maintained to a true line without warping. Dress wood molding on all faces. Fill forms at all sharp corners and edges with triangular chamfer strips measuring 3/4 in. on the sides unless otherwise shown on the plans.

4.3. **Placing Reinforcement**. Place reinforcement as provided in Item 440, "Reinforcement for Concrete." Do not weld reinforcing steel supports to I-beams or girders or to reinforcing steel except where shown on the plans.

4.4. **Drains**. Install and construct weep holes and roadway drains as shown on the plans.

4.5. **Extending Existing Slabs**. Verify pertinent dimensions and elevations of the existing structure before ordering any required materials.

4.5.1. **Removal**. Remove portions of the existing structure to the lines and dimensions shown on the plans or as directed. Dispose of these materials as shown on the plans or as directed. Remove any metal railing without damaging it, and stack it neatly on the right of way at locations that do not interfere with traffic or construction or at locations shown on the plans. All removed metal railing remains the property of the Department unless otherwise shown on the plans. Repair any portion of the remaining structure damaged as a result of the construction. Do not use explosives to remove portions of the existing structure unless approved in writing. Do not use a demolition ball, other swinging weight, or impact equipment unless shown on the plans. Use pneumatic or hydraulic tools for final removal of concrete at the "break" line. Use removal equipment, as approved, that will not damage the remaining concrete.

4.5.2. **Reuse of Removed Portions of Structure**. Detach and remove all portions of the old structure that are to be incorporated into the extended structure to the lines and details as specified on the plans or as directed. Move the unit to be reused to the new location specified using approved methods. Place the reinforcement and extension concrete according to the plan details.

4.5.3. **Breaking Back Bridge Slabs**. Saw the top surface of the slab for bridge slabs and direct traffic slabs of box culverts along the "break" line to a depth of 1/2 in. before breaking back. Do not cut the reinforcement at the "break" line. Sever the concrete at the "break" line. Do not damage the remaining reinforcement within 1 lap length of the "break" line during removal of the designated portion of the existing structure.

4.5.4. **Splicing Reinforcing Steel**. Splice new reinforcing bars to exposed bars in the existing structure using lap splices in accordance with Item 440, "Reinforcement for Concrete," unless otherwise shown on the plans. The new reinforcing steel does not need to be tied to the existing steel where spacing or elevation does not match that of the existing steel provided the lap length is attained. Weld in accordance with Item 448, "Structural Field Welding," when welded splices are permitted. Install any required dowels in accordance with Section 422.4.6.10., "Installation of Dowels and Anchor Bolts."

4.5.5. **Concrete Preparation**. Roughen and clean concrete surfaces that are in contact with new construction before the placing of forms. Prepare these construction joint surfaces in accordance with Section 422.4.6.7., "Construction Joints."

4.6. **Placing Concrete**. Do not place concrete unless approval is obtained for the hold-point inspections as outlined in Section 422.4.1.10., "Inspection Hold-Points" and the pre-pour meeting has been conducted. Give the Engineer sufficient advance notice before placing concrete in any unit of the structure to permit the final inspection of forms, reinforcing steel placement, and other preparations. Obtain approval for proposed curing

methods based on forecast weather conditions for the expected duration of the pour and use the evaporation rate nomograph as mentioned below to determine the required curing options.

Follow the sequence of placing concrete shown on the plans or specified.

Do not place concrete when impending weather conditions would impair the quality of the finished work. Place concrete in early morning or at night or adjust the placement schedule for more favorable weather if conditions of wind, humidity, and temperature are such that concrete cannot be placed without the potential for plastic shrinkage cracking. Consult the evaporation rate nomograph in the Portland Cement Association's *Design and Control of Concrete Mixtures* or the evaporation rate spreadsheet available on the Department's website for shrinkage cracking potential. Adequately illuminate the entire placement site when mixing, placing, and finishing concrete in non-daylight hours as approved.

Furnish adequate shelter to protect the concrete against damage from rainfall or from freezing temperatures as outlined in this Item if changes in weather conditions require protective measures after work starts. Continue operations during rainfall only if approved. Use protective coverings for the material stockpiles. Cover aggregate stockpiles only to the extent necessary to control the moisture conditions in the aggregates.

Allow at least 1 curing day after the concrete has achieved initial set before placing strain on projecting reinforcement to prevent damage to the concrete.

4.6.1. **Placing Temperature**. Place superstructure concrete only when its temperature at the time of placement is between 50°F and 85°F. Increase the minimum placement temperature to 60°F if Ground Granulated Blast Furnace (GGBF) slag is used in the concrete.

4.6.2. **Transporting Time**. Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14 of Item 421, "Hydraulic Cement Concrete."

4.6.3. **Workability of Concrete**. Place concrete with a slump as specified in Section 421.4.2.5., "Slump." Placing concrete with slump exceeding maximum specified may result in bridge deck cracking and be subject to Section 422.4.10., "Defective Work." Water may be added to the concrete before discharging any concrete from the truck to adjust for low slump provided the maximum mix design water-cement ratio is not exceeded. Mix concrete after introduction of any additional water or chemical admixtures in accordance with Section 421.4.6., "Mixing and Delivering Concrete." Do not add water or chemical admixtures after any concrete has been discharged.

4.6.4. **Transporting Concrete**. Use a method and equipment capable of maintaining the rate of placement shown on the plans or required by this Item to transport concrete to the forms. Transport concrete by buckets, chutes, buggies, belt conveyors, pumps, or other methods.

Protect concrete transported by conveyors from sun and wind to prevent loss of slump and workability. Shade or wrap with wet burlap pipes through which concrete is pumped as necessary to prevent loss of slump and workability.

Arrange and use chutes, troughs, conveyors, or pipes so the concrete ingredients will not be separated. Terminate such equipment in vertical downspouts, when necessary, to prevent segregation. Extend open troughs and chutes, if necessary, down inside the forms or through holes left in the forms.

Keep all transporting equipment clean and free from hardened concrete coatings. Discharge water used for cleaning clear of the concrete.

4.6.5. **Preparation of Surfaces**. Thoroughly wet all forms, prestressed concrete panels, T-beams, slab beams, and concrete box beams on which concrete is to be placed before placing concrete on them. Remove free water from the surface or beam lines before placing concrete. Provide surfaces that are in a moist, saturated surface-dry condition when concrete is placed on them.

Ensure the subgrade or foundation is moist before placing concrete for bridge approach slabs.

4.6.6. **Expansion Joints**. Construct joints and devices to provide for expansion and contraction in accordance with plan details and the requirements of this Section and Item 454, "Bridge Expansion Joints."

Prevent bridging of concrete or mortar around expansion joint material in bearings and expansion joints.

Use forms adaptable to loosening or early removal in construction of all open joints and joints to be filled with expansion joint material. Loosen these forms as soon as possible after final concrete set to permit free movement of the span without requiring full form removal and avoid expansion or contraction damage to the adjacent concrete.

Provide preformed fiber joint material or a high density foam in the vertical joints of the roadway slab, curb, median, or sidewalk when the plans show a Type A joint, and fill the top 1 in. with the specified joint sealing material unless noted otherwise. Install the sealer in accordance with Item 438, "Cleaning and Sealing Joints," and the manufacturer's recommendations.

Use light wire or nails to anchor any preformed fiber joint material to the concrete on 1 side of the joint.

Ensure that finished joints conform to the plan details with the concrete sections completely separated by the specified opening or joint material.

Remove all concrete within the joint opening soon after form removal and again where necessary after surface finishing to ensure full effectiveness of the expansion joint.

4.6.7. **Construction Joints**. A construction joint is formed by placing plastic concrete in direct contact with concrete that has attained its initial set. Monolithic placement means the manner and sequence of concrete placing does not create a construction joint.

Make construction joints of the type and at the locations shown on the plans. Do not make joints in bridge slabs not shown on the plans unless approved. Additional joints in other members are not permitted without approval. Place authorized additional joints using details equivalent to those shown on the plans for joints in similar locations.

Make construction joints square and normal to the forms unless otherwise required. Use bulkheads in the forms for all vertical joints.

Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter, and saturate it with water. Remove all free water and moisten the surface before concrete or bonding grout is placed against it. Ensure the surface of the existing concrete is in a saturated surface-dry (SSD) condition just before placing subsequent concrete. Prewet the existing concrete by ponding water on the surface for 24 hr. before placing subsequent concrete. Use high-pressure water blasting to achieve SSD conditions 15 to 30 min. before placing the concrete if ponding is not possible. An SSD condition is achieved when the surface remains damp when exposed to sunlight for 15 min.

Draw forms tight against the existing concrete to avoid mortar loss and offsets at joints.

Bonding agents are not required unless indicated otherwise. Coat the joint surface with bonding mortar, grout, epoxy, or other material as indicated on the plans or other Items if a bonding agent is required. Provide Type V epoxy per DMS-6100, "Epoxies and Adhesives," for bonding fresh concrete to hardened concrete. Place the bonding epoxy on a clean, dry surface, and place the fresh concrete while the epoxy is still tacky. Place bonding mortar or grout on a surface that is SSD, and place the concrete before the bonding mortar or grout dries. Place other bonding agents in accordance with the manufacturer's recommendations.

4.6.8. **Handling and Placing**. Minimize segregation of the concrete and displacement of the reinforcement when handling and placing concrete. Produce a uniform, dense, compact mass.

Do not allow concrete to free-fall more than 5 ft. Remove any hardened concrete splatter ahead of the plastic concrete.

Fill each part of the forms by depositing concrete as near its final position as possible. Do not deposit large quantities at one point and run or work the concrete along the forms.

Avoid cold joints in a monolithic placement. Sequence successive layers or adjacent portions of concrete so they can be vibrated into a homogeneous mass with the previously placed concrete before it sets.

4.6.9. **Consolidation**. Carefully consolidate concrete and flush mortar to the form surfaces with immersion type vibrators. Do not use vibrators that operate by attachment to forms or reinforcement except where approved on steel forms.

Vibrate the concrete immediately after deposit. Systematically space points of vibration to ensure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Insert the vibrator vertically where possible except for slabs where it may be inserted in a sloping or horizontal position. Vibrate the entire depth of each lift, allowing the vibrator to penetrate several inches into the preceding lift. Do not use the vibrator to move the concrete to other locations in the forms. Do not drag the vibrator through the concrete. Thoroughly consolidate concrete along construction joints by operating the vibrator along and close to but not against the joint surface. Continue the vibration until the concrete surrounding reinforcements and fixtures is completely consolidated. Hand-spade or rod the concrete if necessary to ensure flushing of mortar to the surface of all forms. Concentrate vibration efforts along the beams lines when precast concrete panels are used for deck construction.

4.6.10. **Installation of Dowels and Anchor Bolts**. Install dowels and anchor bolts by casting them in-place or by grouting with grout, epoxy, or epoxy mortar unless noted otherwise. Form or drill holes for grouting. Use only epoxy when installing horizontal dowels into the edges of slabs. Follow the manufacturer's recommended installation procedures for pre-packaged grout or epoxy anchor systems. Test anchors if required on the plans or by other Items.

Drill holes for anchor bolts to accommodate the bolt embedment required by the plans. Make holes for dowels at least 12 in. deep unless otherwise shown on the plans. Make the hole diameter at least twice the dowel or bolt diameter, but the hole need not exceed the dowel or bolt diameter plus 1-1/2 in. when using cementitious grout or epoxy mortar. Make the hole diameter 1/16 to 1/4 in. greater than the dowel or bolt diameter when using neat epoxy unless indicated otherwise by the epoxy manufacturer.

Thoroughly clean holes of all loose material, oil, grease, or other bond-breaking substance, and blow them clean with filtered compressed air. Use a wire brush followed by oil-free compressed air to remove all loose material from the holes, repeating as necessary until no more material is removed. Ensure holes are in a surface-dry condition when epoxy type materials are used and in a surface-moist condition when cementitious grout is used. Develop and demonstrate for approval a procedure for cleaning and preparing the holes for installation of the dowels and anchor bolts. Completely fill the void between the hole and dowel or bolt with grouting material. Follow exactly the requirements for cleaning outlined in the product specifications for pre-packaged systems.

Provide a Type III epoxy per DMS-6100, "Epoxies and Adhesives," when neat epoxy is used for anchor bolts or dowels. Provide Type VIII epoxy per DMS-6100, "Epoxies and Adhesives," when an epoxy grout is used. Provide grout, epoxy, or epoxy mortar as the binding agent unless otherwise indicated on the plans.

Provide other anchor systems as required on the plans.

4.6.11. **Placing Concrete in Cold Weather**. Protect concrete placed under weather conditions where weather may adversely affect results. Permission given by the Engineer for placing during cold weather does not relieve the Contractor of responsibility for producing concrete equal in quality to that placed under normal conditions. If concrete placed under poor conditions is unsatisfactory, remove and replace it as directed at Contractor's expense.

Do not place concrete in contact with any material coated with frost or with a temperature of 32°F or lower. Do not place concrete when the ambient temperature in the shade is below 40°F and falling unless approved. Place concrete when the ambient temperature in the shade is at least 35°F and rising or above 40°F.

Provide and install recording thermometers, maturity meters, or other suitable temperature measuring devices to verify all concrete is effectively protected. Maintain the temperature of the top surface of bridge slabs and top slabs of direct traffic culverts at 50°F or above for 72 hr. from the time of placement and above 40°F for an additional 72 hr.

Use additional covering, insulated forms, or other means and, if necessary, supplement the covering with artificial heating. Avoid applying heat directly to concrete surfaces. Cure as specified in Section 422.4.8., "Final Curing," during this period until all requirements for curing have been satisfied.

Have on hand all necessary heating and covering material, ready for use, before permission is granted to begin placement when impending weather conditions indicate the possible need for temperature protection. Distress caused by concrete drying out as a result of delayed set and strength gain associated with cold weather are a result of the Contractor's actions and are subject to repair in accordance with Section 422.4.10., "Defective Work."

4.6.12. **Placing Concrete in Hot Weather**. Use an approved Type B or D set retarding agent in all concrete for superstructures and top slabs of direct traffic culverts, except concrete containing GGBF slag, when the temperature of the air is above 85°F unless otherwise directed.

Keep the concrete at or below the maximum temperature at time of placement as specified above. Sprinkle and shade aggregate stockpiles or use ice, liquid nitrogen systems, or other approved methods as necessary to control the concrete temperature.

4.6.13. **Placing Concrete in Superstructure**. Place simple span bridge slabs without transverse construction joints by using either a self-propelled transverse finishing machine or a mechanical longitudinal screed unless otherwise shown on the plans. Use of manually operated screeding equipment may be permitted for small placements or for unusual conditions such as narrow widening, variable cross slopes, or transitions. Support the screed adequately on a header or rail system stable enough to withstand the longitudinal or lateral thrust of the equipment. Adjust the profile grade line as necessary to account for variations in beam camber and other factors to obtain the required slab thickness and concrete cover over the slab reinforcement. Set beams and verify their surface elevations in a sufficient number of spans so that when adjustment is necessary, the profile grade line can be adjusted over suitable increments to produce a smooth riding surface. Take dead load deflection into account in setting the grades of headers and rail systems. Use construction joints, when required or permitted for slab placements on steel or prestressed concrete beams, as shown on the plans. Release falsework under the spans before placing concrete on steel girder or truss spans, and swing the spans free on their permanent supports.

Provide additional camber to offset the initial and final deflections of the span as indicated on the plans for concrete flat slab, concrete slab, and girder spans cast-in-place on falsework. Provide camber of approximately 3/8 in. for 30-ft. spans and 1/2 in. for 40-ft. spans to offset initial and final deflections for concrete slab and girder spans using pan forms unless otherwise directed. Provide a camber of 1/8 in. for 10-ft. spans but no more than 1/2 in. for concrete flat slab, concrete slab, and girder spans not using pan forms when dead load deflection is not shown on the plans.

Provide a camber of 1/4 in. in addition to deflection for slabs without vertical curvature on steel or prestressed concrete beams. Provide camber for specified vertical curvature and transverse slopes.

Make 1 or more passes with the screed over the bridge slab segment before placing concrete on it to ensure proper operation and maintenance of grades and clearances. Use an approved system of checking to detect any vertical movement of the forms or falsework. Maintain forms for the bottom surface of concrete slabs, girders, and overhangs to the required vertical alignment during concrete placing.

Level, strike off, and screed the surface while carrying a slight excess of concrete ahead of the screed to fill all low spots as soon as the concrete has been placed and vibrated in a section wide enough to permit working. Move longitudinal screeds across the concrete with a saw-like motion while their ends rest on headers or templates set true to the roadway grade or on the adjacent finished slab. Move transverse screeds longitudinally approximately 1/5 of the drum length for each complete out-and-back pass of the carriage. Screed the surface of the concrete enough times and at intervals to produce a uniform surface true to grade and free of voids.

Fog unformed surfaces of slab concrete in bridge slabs and in top slabs of direct traffic culverts from the time of initial strikeoff of the concrete until finishing is completed and required interim curing is in place. Do not use fogging as a means to add finishing water and do not work moisture from the fog spray into the fresh concrete.

Retard the concrete for simple spans only if necessary to complete finishing operations or as required by this Section. Bring the top of curb and sidewalk section to the correct camber and alignment when filling curb forms, and finish them as described in this Item.

4.6.13.1. **Transverse Screeding**. Install rails for transverse finishing machines that are supported from the beams or girders so the supports may be removed without damage to the slab. Prevent bonding between removable supports and the concrete in an acceptable manner. Do not allow rail support parts that remain embedded in the slab to project above the upper mat of reinforcing steel. Rail or screed supports attached to I-beams or girders are subject to the requirements of this Item. Place concrete at a minimum rate of 30 ft. of bridge slab per hour for transverse screeding unless otherwise shown on the plans. Deposit concrete parallel to the skew of the bridge so all girders are loaded uniformly along their length. Deposit slab concrete between the exterior beam and adjacent beam before placing concrete in the overhang portion of the slab. Furnish personnel and equipment capable of placing, finishing, and curing the slab at an acceptable rate to ensure compliance with the specifications. Place concrete in transverse strips. Start placement at the lowest end on profile grades greater than 1-1/2%.

At the Contractor's option, attach a pan drag and either a carpet or burlap drag to the screed assembly to float and provide surface micro-texture in one operation. Adjust the contact pressure of the pan drag to smooth high spots and fill any depressions left by the screed. Adjust the weight or position of the carpet or burlap drag to produce a smooth sandy micro-texture without blemishes, marks, or scratches deeper than 1/16 in. Fill screed rail support holes and holes from the Engineer's depth checks for slab thickness and reinforcing cover with concrete, and finish them to match the rest of the slab.

4.6.13.2. **Longitudinal Screeding**. Use of temporary intermediate headers will be permitted for placements over 50 ft. long if the rate of placement is rapid enough to prevent a cold joint and if these headers are designed for easy removal to permit satisfactory consolidation and finish of the concrete at their locations unless otherwise shown on the plans. Deposit slab concrete between the exterior beam and the adjacent beam before placing concrete in the overhang portion of the slab. Place concrete in longitudinal strips starting at a point in the center of the segment adjacent to 1 side except as this Section indicates, and complete the strip by placing uniformly in both directions toward the ends. Start placing at the lowest end for spans on a profile grade of 1-1/2% or more. Use strips wide enough that the concrete within each strip remains plastic until placement of the adjacent strip. Place the concrete in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs where monolithic curb construction is specified.

4.6.13.3. **Placements on Continuous Steel Units**. Place slabs on continuous steel units in a single, continuous operation without transverse construction joints using a self-propelled transverse finishing machine or a mechanical longitudinal screed unless otherwise shown on the plans. Retard the initial set of the concrete sufficiently to ensure concrete remains plastic in at least 3 spans immediately preceding the slab being placed. Use construction joints, when required for slab placements on steel beams or girders, as shown on the plans. Ensure the previously placed concrete attains a compressive strength of 3,000 psi when staged placement of a slab is required on the plans before placing the next stage concrete. Multiple stages may be placed in a single day if approved. Use an approved placing sequence that will not overstress any of the supporting members where plans permit staged placing without specifying a particular order of placement.

4.6.13.4. **Slab and Girder Units**. Place girders, slab, curbs of slab, and girder spans monolithically unless otherwise shown on the plans. Fill concrete girder stems first, and place the slab concrete within the time limits specified in this Item. Place concrete in the stems for a short distance if using a transverse screed, and then place the concrete in transverse strips. Fill the outside girder stem first, beginning at the low end or side, if using a longitudinal screed, and continue placement in longitudinal strips.

4.7. **Finish and Interim Curing of Bridge Slabs**. Obtain approval of the proposed interim curing methods, equipment, and materials at the pre-pour meeting before placing concrete. Take into account forecast weather conditions to determine the interim curing methods to use.

Use work bridges or other suitable facilities to perform all finishing operations and to provide access, if necessary, for the Engineer to check measurements for slab thickness and reinforcement cover.

Work the screeded surface to a smooth finish with a long-handled wood or metal float or hand-float it from work bridges over the slab. Floating may not be necessary if the pan float attached to a transverse screed produces an acceptable finish. Avoid overworking the surface of the concrete. Avoid use of finish water.

Perform sufficient checks, witnessed by the Engineer, with a long-handled 10-ft. straightedge on the plastic concrete to ensure the final surface will be within specified tolerances. Make the check with the straightedge parallel to the centerline. Lap each pass half over the preceding pass. Remove all high spots, and fill and float all depressions over 1/16 in. deep with fresh concrete. Continue checking and floating until the surface is true to grade and free of depressions, high spots, voids, or rough spots. Fill screed-rail support holes with concrete, and finish them to match the top of the slab.

Provide a uniform micro-texture using a carpet drag, burlap drag, or broom finish. Finish the surface to a smooth sandy texture without blemishes, marks, or scratches deeper than 1/16 in. Apply the surface texturing using a work bridge or platform immediately after completing the straightedge checks. Draw the carpet or burlap drag longitudinally along the concrete surface, adjusting the surface contact area or pressure to provide a satisfactory coarsely textured surface. A broom finish may be performed using a fine bristle broom transversely. For bridge approach slabs the carpet drag, burlap drag, or broom finish may be applied either longitudinally or transversely.

Evaporation protection is required if the evaporation rate exceeds 0.10 lbs/sf/hr based on the *Evaporation Calculation for Concrete Worksheet* as shown on the Department's website, the evaporation rate nomograph in the Portland Cement Association's *Design and Control of Concrete Mixtures* or if indicated on the plans.

4.7.1. **Evaporation Protection**. Use one of the following methods for evaporation protection.

4.7.1.1. **Evaporation Retardant**. Coat the concrete surface immediately after the carpet or burlap drag, or broom finish with a single application of evaporation retardant at a rate recommended by the manufacturer. Do not allow more than 10 min. to elapse between the texturing at any location and application of evaporation retardant. The evaporation retardant may be applied using the same work bridge used for surface texturing. Do not work the concrete surface once the evaporation retardant has been applied.

4.7.1.2. **Wet Burlap**. Place pre-wet burlap no more than 10 ft. behind the finishing operation. A work bridge may be required to avoid marring the surface. Ensure the wet burlap covers the entire surface. Use sprayers, hoses, sprinklers, or other similar methods to keep the burlap continuously wetted until application of the final curing.

4.7.2. **Interim Curing**. Apply interim curing using one of the following options after applying the evaporation protection (if needed):

4.7.2.1. **Membrane Cure**. Apply membrane interim curing at a rate of approximately 180 sq. ft. per gallon. Apply before the water sheen disappears but do not place over standing water. Fog as necessary to maintain the wet sheen. Do not spray membrane curing on a dry surface.

4.7.2.2. **Wet Burlap**. Place pre-wet burlap no more than 10 ft. behind the finishing operation. Burlap used for evaporation protection will also be considered as the interim curing.

4.8. **Final Curing**. Obtain approval of the proposed curing methods, equipment, and materials at the pre-pour meeting before placing concrete. Inadequate curing or facilities may delay all concrete placements on the job until remedial action is taken. Apply final curing as soon as possible after interim curing without damaging the surface finish. Check the adequacy of the curing each day of the curing period. Take corrective action or modify the curing methods as needed to maintain a moist concrete surface.

A curing day is a calendar day when the temperature, taken in the shade away from artificial heat, is above 50°F for at least 19 hr. or, on colder days if the temperature of all surfaces of the concrete is maintained above 40°F, for the entire 24 hr. The required curing period begins when all concrete has attained its initial set. Tex-440-A may be used to determine when the concrete has attained its initial set.

Cure all superstructure concrete according to the following, unless otherwise shown on the plans:

- Concrete using Type I or III cement: 8 days
- Concrete using Type I/II or II cement: 10 days
- Concrete with any type of SCM: 10 days

Place polyethylene sheeting, burlap-polyethylene blankets, laminated mats, or insulating curing mats in direct contact with the slab when the air temperature is expected to drop below 40°F during the first 72 hr. of the curing period. Weigh down these curing materials with dry mats to maintain direct contact with the concrete and provide insulation against cold weather. Supplemental heating or insulation may be required in cold and wet weather if the insulating cotton mats become wet or the concrete drops below the specified curing temperature. Avoid applying heat directly to concrete surfaces.

Use one of the following water curing methods for final curing. Keep all exposed surfaces of the concrete wet continuously for the required curing time. Use water for curing that meets the requirements for concrete mixing water in Section 421.2.5., "Water." Do not use seawater or water that stains or leaves an unsightly residue.

4.8.1. **Cotton Mats**. Keep the concrete continuously wet by maintaining wet cotton mats in direct contact with the concrete for the required curing time. Weight the mats adequately to provide continuous contact with all concrete. Cover surfaces that cannot be cured by direct contact with mats, forming an enclosure well anchored to the forms or ground so outside air cannot enter the enclosure. Provide sufficient moisture inside the enclosure to keep all surfaces of the concrete wet. Use of soaker hoses and plastic covering is acceptable provided the concrete surface remains continuously wet for the required curing duration.

4.8.2. **Burlap Mats**. The burlap used for interim curing may also be used for final curing if kept continuously wetted and completely covered with plastic sheeting. Overlap plastic sheeting and weigh down sufficiently so air cannot get under the plastic.

4.8.3. **Burlap-Polyethylene Mats**. Place these mats over soaker hoses or other similar methods to keep the concrete surface wetted for the duration of the curing period. Overlap the mats and weight down sufficiently so air cannot get under the mats.

4.9. **Removal of Forms and Falsework**. Forms for vertical surfaces may be removed after the concrete has aged 12 hr. after initial set provided the removal can be done without damage to the concrete unless otherwise directed.

Remove forms for inside curb faces and for bridge rails whenever removal can be done without damage to the curb or railing.

Leave in place weight-supporting forms and falsework spanning more than 1 ft. except as directed otherwise until the concrete has attained a compressive strength of 2,500 psi. Remove forms for other structural components as necessary.

Forms or parts of forms may be removed only if constructed to permit removal without disturbing forms or falsework required to be left in place for a longer period on other portions of the structure.

Remove all metal appliances used inside forms for alignment to a depth of at least 1/2 in. from the concrete surface. Make the appliances so that metal may be removed without undue chipping or spalling of the concrete, and so that it leaves a smooth opening in the concrete surface when removed. Do not burn off rods, bolts, or ties.

Remove all forms and falsework unless otherwise directed.

Apply an ordinary surface finish as the final finish to the bottom of bridge slabs between girders or beams, and vertical and bottom surfaces of interior concrete beams or girders unless otherwise noted.

Form marks and chamfer edges do not need to be smoothed for the bottom of bridge slabs between girders or beams. Remove all fins, runs, drips, or mortar from surfaces that will be exposed.

4.10. **Defective Work**. The Contractor is responsible for the ride quality of the finished bridge slab. The Engineer will use a 10 ft. straightedge (1/8 in. in 10 ft.) to verify ride quality and determine locations where corrections are needed. Submit a plan for approval to produce a ride of acceptable quality if the Engineer determines the ride quality is unacceptable. Make all corrections for ride before saw-cutting grooves.

Repair defective work as soon as possible. Remove and replace at the expense of the Contractor any defect that cannot be repaired to the satisfaction of the Engineer.

The Engineer will inspect the deck or slab for plastic shrinkage and settlement cracking after completion of final curing and within 5 days after curing mats are removed. Seal any noted shrinkage cracks attributable to Contractor placing, curing, and finishing practices using gravity feed crack repair as directed in accordance with Item 780, "Concrete Crack Repair," at no cost to the Department. Transverse cracks over interior bents in continuous slab units do not need to be sealed in this manner.

4.11. **Final Surface Texture**. Saw-cut grooves in the hardened concrete of bridge slabs, bridge approach slabs, and direct traffic culverts to produce the final texturing after completion of the required curing period unless otherwise noted. Cut grooves perpendicular to the structure centerline. Cut grooves across the slab within 18 in. of the barrier rail, curb, or median divider. Adjust groove cutting at skewed metal expansion joints in bridge slabs by using narrow-width cutting heads so all grooves end within 6 in. of the joint, measured perpendicular to the centerline of the metal joint. Leave no ungrooved surface wider than 6 in. adjacent to either side of the joint. Ensure the minimum distance to the first groove, measured perpendicular to the edge of the concrete joint or from the junction between the concrete and the metal leg of the joint, is 1 in. Cut grooves continuously across construction joints or other joints in the concrete less than 1/2 in. wide. Apply the same procedure described above where barrier rails, curbs, or median dividers are not parallel to the structure centerline to maintain the 18 in. maximum dimension from the end of the grooves to the gutter line. Cut grooves continuously across formed concrete joints. Provide either a carpet drag or broom finish for micro-texture when saw-cut grooves are not required on the plans. In this case ensure an adequate and consistent micro-texture is achieved by applying enough weight to the carpet and keeping the carpet or broom from getting plugged with grout. For surfaces that do not have adequate texture, the Engineer may require corrective action including diamond grinding or shot blasting.

Give a carpet drag, burlap drag, or broom finish to all concrete surfaces to be overlaid when the plans call for a concrete overlay (CO) to be placed on the slab (new construction). Saw-grooving is not required in this case. Provide an average texture depth for the finish of approximately 0.035 in. with no individual test falling below 0.020 in., unless otherwise shown on the plans, when tested in accordance with Tex-436-A. Revise finishing procedures to produce the desired texture if the texture depth falls below what is intended.

Give all concrete surfaces to be covered a lightly textured broom or carpet drag finish when the plans require an asphalt seal, with or without overlay, on the slab (new construction). Provide an average texture depth of approximately 0.025 in. when tested in accordance with Tex-436-A.

5. MEASUREMENT

Reinforced concrete slabs or decks on girders, beams, slab beams, double-T beams, or box beams placed under this Item will be measured by the square foot of slab surface area using the nominal dimensions and configuration shown on the plans. Transverse measurement will be made from outer edge of slab to outer edge of slab (including raised median and sidewalk sections). Longitudinal measurement will be made between ends of units or spans. Diaphragms, haunch concrete, reinforcement, and optional steel diaphragms will be considered as a portion of the slab unless otherwise shown. An estimated quantity for the haunch between the slab and beams will be included for the Contractor's information only. No measurement will be made during construction for variation in the amount of haunch concrete due to variations in camber of the beams.

Approach slabs and cast-in-place superstructure elements including flat slabs, slab and girder units (pan formed), and shear keys will be measured by the cubic yard. For slab and girder spans using pan forms, a quantity will be included for the screed setting required to provide proper camber in the roadway surface after form removal.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustment of quantities is required.

The quantities of concrete and reinforcing steel shown on the plans are based on a conventionally formed slab. These quantities include amounts for concrete diaphragms, brackets and other required attachments, and haunch concrete when required, based on the profile grade, theoretical camber, and dead load deflection of the beams. No additional measurement will be made for concrete or reinforcing steel due to a variation in camber of the beams from theoretical camber, or for additional quantities required by optional methods of forming.

Additional concrete that may be required by an adjustment of the profile grade line during construction, to ensure proper slab thickness, will not be measured for payment.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the various superstructure elements specified. This price is full compensation for furnishing, hauling, mixing, placing, curing, and finishing concrete; furnishing and placing reinforcing steel; grouting and pointing; furnishing and placing drains and expansion joint material (except where specifically furnished under another Item); furnishing and placing metal flashing strips; forms (removable and permanent) and falsework; prestressed concrete panels; furnishing and placing concrete and reinforcement for raised medians, sidewalks, sign mounts, luminaire brackets, and other concrete appurtenances; removing designated portions of existing slab; cleaning, bending, and cutting exposed existing reinforcing steel; welding reinforcing steel; doweling; cleaning and preparing concrete surfaces; and equipment, labor, tools, and incidentals.

Price will be adjusted in accordance with Section 421.6., "Measurement and Payment," when required to address non-compliance of project acceptance testing.

Diaphragm concrete will not be paid for directly but is subsidiary to the slab unless otherwise shown on the plans.

Structural steel, anchor bolts, armor joints, sealed expansion joints, rail (including the concrete parapet portion), and concrete median barrier will be measured and paid for in accordance with pertinent bid items.

In addition to the work described above, for extending structures the unit prices bid is full compensation for removing and disposing of the designated portion of the existing structure; removing, stockpiling and replacing headwall units for reuse; cleaning, bending, and cutting of exposed reinforcing steel; splicing or

welding of new reinforcing steel to existing reinforcing steel; installation of dowels; and cleaning and preparing existing concrete surfaces.

Item 423
Retaining Walls

1. DESCRIPTION

Furnish, construct, and install retaining walls.

2. MATERIALS

2.1. **General**. Furnish materials in accordance with the following:

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- Item 445, "Galvanizing"
- Item 458, "Waterproofing Membranes for Structures"
- Item 556, "Pipe Underdrains"

Use concrete for retaining walls that conforms to the requirements of Table 1 unless otherwise shown on the plans.

Table 1
Concrete for Retaining Walls

Application	Concrete
Cast-in-place, non-reinforced	Class A
Cast-in-place, reinforced	Class C
Precast	Class H, f'_c = 4,000 psi

Furnish concrete for machine-made concrete block units in accordance with ASTM C90, Class 1, Type II, except the minimum 28-day compressive strength must be 4,000 psi with maximum moisture absorption of 7%.

Provide Type 1 filter fabric in accordance with DMS-6200, "Filter Fabric." Provide filter fabric rated as UV-resistant when used as part of the exposed facing for a temporary wall.

Joint fillers, pads, waterstops, and other incidental materials must be as shown on the plans or approved by the Engineer.

Epoxy coat all steel used in concrete panels and coping including connectors, dowels, stirrups, and reinforcing steel when the plans call for epoxy coating of steel earth reinforcements.

2.2. **Definitions**. This Item uses the following terms:

- **Permanent Wall**. A retaining wall with a design service life of 75 years. All walls are presumed to be permanent walls unless otherwise specified on the plans.
- **Temporary Wall**. A retaining wall so designated by description, with a design service life of 3 years.
- **Mechanically Stabilized Earth (MSE) Wall**. A wall consisting of a volume of select backfill with tensile earth reinforcement elements distributed throughout. Permanent MSE walls use a precast concrete panel as a facing element. Temporary MSE walls use welded wire fabric with filter fabric backing as a facing element.
- **Concrete Block Wall**. A retaining wall that uses machine-made, precast concrete block units as facing elements. The walls may use a volume of select fill with tensile earth reinforcements distributed throughout, or may use only the facing unit and unit fill weight for support.

2.3. **Fabrication**.

2.3.1. **Cast-in-Place**. Meet Item 420, "Concrete Substructures."

2.3.2. **Formed Precast**. Meet Item 424, "Precast Concrete Structural Members (Fabrication)."

2.3.3. **Machine-Made Precast**. Furnish machine-made concrete block units in accordance with ASTM C90, sampled and tested in accordance with ASTM C140. Furnish units with molded dimensions within 1/8 in. of specified dimensions, except height must be within 1/16 in.

2.4. **Backfill**.

2.4.1. **Non-Select**. Furnish non-select backfill for walls other than temporary and permanent MSE and concrete block walls as indicated on the plans. Non-select fill will meet Item 132, "Embankment," of the type specified on the plans. Provide material with a maximum plasticity index of 30 if no type is specified as determined by Tex-106-E.

2.4.2. **Select**. Select backfill is required in specific areas of permanent and temporary MSE and concrete block-type retaining walls. Provide select backfill that is free from organic or otherwise deleterious materials and that conforms to the gradation limits shown in Table 2 as determined by Tex-401-A.

Provide backfill that does not contain shale, caliche, or other soft, poor-durability coarse aggregate particles. Reclaimed Asphalt Pavement (RAP) is not allowed. Crushed Concrete or manufactured sand is allowed for temporary walls with a service life of 3 years or less. Test each source of backfill for durability/soundness using Tex-411-A, 5-cycle magnesium sulfate soundness. Backfill material with a maximum 5-cycle soundness loss exceeding 25% will be rejected. Alternately, Tex-461-A, Micro-Deval abrasion may be used if the corresponding results show loss is not greater than 20%, otherwise Tex-411-A governs aggregate verification.

Type AS, BS, and DS particles larger than 1/4 in. must be angular or completely crushed. Provide mechanically crushed gravel or stone backfill. Gravel from each aggregate source will have a minimum of 95% two or more mechanically induced crushed faces, as Tex-460-A, Part I determines. Rounded rock or rounded gravel is not allowed. Natural sand meeting the requirements of this Section is permitted for use.

Table 2
Select Backfill Gradation Limits

Type	Sieve Size	Percent Retained
AS	3"	0
	1/2"	50–100
	#4	See Note
	#40	85–100
	#200	95–100
BS	3"	0
	#4	See Note
	#40	40–100
	#200	85–100
CS	3"	0
	#4	See Note
	#200	75–100
DS	3"	0
	3/8"	85–100
	#200	95–100

Note—Use No. 4 sieve for determination of rock backfill as described in this main paragraph, "Backfill."

When the backfill gradation results in 85% or more material retained on the No. 4 sieve, the backfill will be considered rock backfill. All Type DS backfill is considered rock backfill.

In addition to the requirements for Type CS select fill, the fraction finer than the No. 200 sieve must have a Plasticity Index (PI) in accordance with Tex-106-E not greater than 6.

Furnish Type BS backfill for permanent walls; Type CS backfill for temporary walls; and Type DS backfill for areas of walls subject to inundation unless otherwise shown on the plans, or below the 100-year flood elevation as noted on the plans.

Furnish backfill meeting the requirements of this Section but with a maximum particle size of 3/4 in. when nonmetallic or epoxy coated earth reinforcements are used.

2.4.3. **Drainage Aggregate**. Use drainage aggregate to fill the void within concrete block units and in the zone 1 ft. behind the units. Provide drainage aggregate that is free from organic or otherwise deleterious materials and that conforms to the gradation limits in Table 3 as Tex-110-E determines.

Table 3
Drainage Aggregate Gradation Limits

Sieve Size	Percent Retained
1"	0
3/4"	25–50
1/2"	50–100
#4	75–100

2.4.4. **Cement-Stabilized Backfill**. Use cement-stabilized backfill when required or as approved. Stabilize Type CS backfill with 5% hydraulic cement by dry weight of the backfill material. Use a stationary plant to thoroughly mix the backfill material, cement, and water. Place and compact the backfill within 2 hours of mixing. Provide special drainage provisions when cement-stabilized backfill is used, as shown on the plans.

2.4.5. **Electrochemical**. Provide backfill meeting the following additional requirements for permanent retaining wall systems using galvanized metallic earth reinforcements:

- The pH is between 5.5 and 10.0 as Tex-128-E determines.
- Resistivity is more than 3,000 ohm-cm as Tex-129-E determines.
- Material with resistivity between 1,500 and 3,000 ohm-cm may be used if the chloride content is less than 100 ppm and the sulfate content is less than 200 ppm as Tex-620-J determines.

Perform electrochemical testing on the raw, unstabilized backfill material when cement-stabilized backfill is used.

2.5. **Earth Reinforcements**. Furnish earth reinforcements that meet the design requirements. Galvanize or epoxy coat all steel elements for permanent walls in contact with soil. Epoxy coat in accordance with Item 440, "Reinforcement for Concrete," except provide a minimum 18-mil coating thickness. Epoxy coat the reinforcing only when shown on the plans or as approved. Use connection hardware that is likewise nonmetallic or epoxy coated when using nonmetallic or epoxy coated earth reinforcements.

3. CONSTRUCTION

3.1. **General**. Construct retaining walls in accordance with details shown on the plans, on the approved working drawings, and to the pertinent requirements of the following Items:

- Item 110, "Excavation"
- Item 132, "Embankment"
- Item 400, "Excavation and Backfill for Structures"
- Item 420, "Concrete Substructures"
- Item 458, "Waterproofing Membranes for Structures"
- Item 556, "Pipe Underdrains"

Construct required piling or drilled shafts in accordance with the pertinent specification.

3.2. **Options**. When optional design details are shown on the plans, the Contractor is required to use the same facing design within an area of continuous retaining walls.

Provide drawings for review indicating the proposed design arrangement when proposing the use of 2 or more systems.

3.3. **Working Drawings**. When proprietary wall systems are used for permanent or temporary walls, submit casting drawings, construction drawings, and design calculations bearing the seal of a licensed professional engineer for review and approval following the Department's *Guide to Electronic Shop Drawing Submittal* process. Upon completion of construction, submit a set of reproducible as-built drawings.

3.3.1. **Casting Drawings**. Include all information necessary for casting wall elements, including railing and coping when prefabricated. Show shape and dimensions of panels; size, quantity, and details of the reinforcing steel; quantity, type, size, and details of connection and lifting hardware; and additional necessary details.

3.3.2. **Construction Drawings**. Include a numbered panel layout showing horizontal and vertical alignment of the walls as well as the existing and proposed groundlines. Include all information needed to erect the walls, including the proposed leveling pad elevations; the type and details of the soil reinforcing system (if applicable); the details and manufacturer of all pads, fillers, and filter fabric; the limits and dimensions of structural backfill; details necessary to incorporate coping, railing, inlets, drainage, and electrical conduit; and additional necessary details.

Leveling pad elevations may vary from the elevations shown on the plans. Provide at least 1 ft. of cover from the top of the leveling pad to finish grade unless a different minimum cover or a specified minimum leveling pad elevation is shown.

3.3.3. **Design Calculations**. Include calculations covering the range of heights and loading conditions on the project. Calculations for both internal and external stability as described on the plans will be required. Include a summary of all design parameters used; material types, strength values, and assumed allowables; loads and loading combinations; and factor-of-safety parameters.

3.4. **Permanent MSE Walls**. Grade the foundation for the structure level to a width equal or exceeding the length of the reinforcing system. Perform proof rolling on retaining wall foundation area to identify any loose, soft, or unsuitable materials in accordance with Item 216, "Proof Rolling." Material not meeting a maximum rut depth of 1 in. per pass of pneumatic tire roller should continue to be rolled or removed and replaced with suitable material. Pneumatic tire rolling will be waived for portions of wall with a reinforcement length of 8'; for these conditions proof rolling will be required with a smooth-wheeled vibratory roller or other approved roller.

Place drilled shafts and piling located within the MSE volume before construction of the wall. Place any required pipe underdrain before construction of the wall. Complete MSE wall construction before construction of abutment caps and abutment wing walls. Completion of walls and abutment should be in conjunction with project phasing or to allow for completion of walls that meets the proper placement and compaction at abutments.

Place the concrete leveling pad as shown on the construction drawings. Provide a wood float finish, and wait a minimum of 24 hr. before beginning panel erection. No curing or strength testing of the leveling pad concrete is required.

Shim the first row of panels as necessary to achieve correct alignment. Use plastic shims or other material that will not deteriorate. Remove and replace the leveling pad or provide a grout level-up as directed if the required shim height exceeds 1 in.

Place filter fabric behind the wall along the joint between the leveling pad and the panels. Grout areas where filter fabric spans more than 6 in. at leveling pad steps.

Place and compact fill material over the leveling pad to an elevation even with or above the surrounding ground after backfilling the first row of panels. Do not allow water to accumulate and stand at the base of the wall.

Place filter fabric behind all wall joints and at the intersection of retaining walls with other structures, including riprap. Cover joints at least 6 in. on each side and use adhesive to hold the filter fabric in place.

Exercise care while lifting, setting, and aligning panels to prevent damage to the panels. Discontinue any operation that results in chipping, spalling, or cracking of panels. Remove and replace damaged panels, or repair as approved by the Engineer.

Provide external bracing for the initial row of panels. Use wooden wedges, clamps, or other means necessary to maintain position and stability of panels during placement and compaction of backfill. Remove wooden wedges as soon as the panel or coping above the wedged element is erected and backfilled. Remove all wedges after completing the wall.

Review plumbness and position of each row of panels before placing the subsequent row. Remove and rebuild any portion of the wall that is out of tolerance. Modify panel batter and bracing, and backfill material, placement, and compaction methods as required to maintain wall tolerances.

Construct walls to a local vertical and horizontal alignment tolerance of 3/4 in. when measured along a 10-ft. straightedge relative to vertical and horizontal wall control line. Construct walls to an overall vertical tolerance (plumbness from top to bottom) of 1/2 in. per 10 ft. of wall height. Construct walls so the maximum offset at any panel joint is between 3/8 in. and 3/4 in. and no joint is open to the extent the filter fabric is visible from the front of the wall.

Place backfill to closely follow the erection of each row of panels. Place the select and embankment backfill to the same elevation where possible, and operate the compaction equipment over the interface. Do not create a continuous, distinct, vertical joint between the select and embankment backfill. Complete the embankment after construction of the retaining wall.

Maintain the stability of the interface area between the existing ground and the select fill when building a wall against existing ground. Remove and recompact any material that loosens, caves, or fails.

Compact backfill to provide at least 95% of density determined in accordance with Tex-114-E. Field density determination will be made in accordance with Tex-115-E.

Sprinkle backfill as required to ensure adequate uniformly distributed moisture in each lift before and during compaction. Place fill in lifts of 8 in. or less (loose measurement). Place fill in a manner that avoids segregation of the fill. Decrease the lift thickness if necessary to obtain the required compaction. Use hand-operated or walk-behind compaction equipment in the 3 ft. wide strip adjacent to the wall panels. Do not displace panels or distort or damage the reinforcement system during compaction. Modify backfill material, placement, and compaction methods as necessary to meet density requirements while maintaining wall tolerances.

Place rock backfill or material the Engineer determines too coarse for density testing in accordance with Section 132.3.4.1., "Ordinary Compaction."

Place and compact the backfill to the reinforcement level, at each earth reinforcement level, before placing the reinforcement. Place earth reinforcements perpendicular to the face of the wall. Remove slack in connections before placing backfill. Pre-tension each layer of reinforcement to remove slack before placing backfill for systems using nonmetallic earth reinforcements. Use devices capable of mechanically applying and holding the required force. Do not operate tracked equipment directly on any reinforcement.

Cover the rock backfill with filter fabric before placing the 2 ft. of backfill immediately below the pavement structure or top of wall when rock backfill is used. Overlap the fabric at least 18 in. at splices, and extend it past the edge of the rock backfill at least 18 in. Use backfill that contains sufficient fines to fill the voids in a

compacted state above the filter fabric. Place a horizontal layer of filter fabric as noted above when transitioning from rock backfill to finer grained backfill anywhere within the wall volume.

Prevent surface water or rainwater from damaging the retaining walls during construction. Shape the backfill to prevent water from ponding or flowing on the backfill or against the wall face. Remove and replace any portion of the retaining wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

3.5. **Temporary MSE Walls**. Provide a facing system rigid enough to maintain a smooth and straight wall face both during and after construction.

Grade and compact the foundation for the structure as described in Section 423.3.4., "Permanent MSE Walls."

Place earth reinforcement and facing system in accordance with the approved working drawings. Backfill the 2-ft. zone immediately behind the facing with clean, coarse rock meeting the requirements of Coarse Aggregate Grade 1, 2, or 3 of Item 421, "Hydraulic Cement Concrete," or of Type DS backfill as described in Section 423.2.4.2., "Select." Cement-stabilized backfill as described in Section 423.2.4.4., "Cement-Stabilized Backfill," may be used in place of the coarse rock.

Place and compact backfill in accordance with Section 423.3.4., "Permanent MSE Walls."

Construct walls to a vertical and horizontal alignment tolerance of 3 in. when measured along a 10-ft. straightedge. Construct walls to an overall vertical tolerance (plumbness from top to bottom) of 2 in. per 10 ft. of wall height. Place adjacent facing elements so the maximum out-of-plane offset at any facing element joint is less than 1 in. Place facing elements and filter fabric with no gaps in the facing or fabric.

Prevent surface water or rainwater from damaging the retaining walls during and after construction. Place temporary berms or curbs, shape the backfill, or use other approved methods to prevent water from flowing against or over the wall face. Remove and replace any portion of the wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

3.6. **Concrete Block Retaining Walls**. The concrete block units may be sampled and tested by the Engineer before shipment or upon delivery to the construction site. Display for approval, samples of block units indicating the color, texture, and finish. Store, transport, and handle all block units carefully to prevent cracking or damage.

Grade and compact the foundation for the structure, and place the leveling pad as described in Section 423.3.4., "Permanent MSE Walls."

Place the concrete block facing units in accordance with the approved working drawings. Fill the voids within the units and fill the 1-ft. zone immediately behind the facing with drainage aggregate as described in Section 423.2.4.3., "Drainage Aggregate." Systems tested without unit fill may omit the fill as indicated on the approved drawings. Systems with approved filter fabric details may omit the drainage aggregate in the 1-ft. zone immediately behind the facing.

Place reinforcements and backfill for walls using earth reinforcements in accordance with the requirements of Section 423.3.4., "Permanent MSE Walls." Pay particular attention to the connection details of the earth reinforcements to the concrete block units.

Construct walls to a vertical and horizontal alignment tolerance of 1-1/2 in. when measured along a 10-ft. straightedge. Construct walls to an overall vertical tolerance (deviation from the vertical or battered control line, top to bottom) of 1 in. per 10 feet of wall height. Place adjacent facing elements so the maximum out-of-plane offset at any facing element joint is less than 1 in. Place facing elements with maximum 1/4-in. gaps between block units.

Prevent surface water or rainwater from damaging the retaining walls during construction. Shape the backfill to prevent water from ponding or flowing on the backfill or against the wall face. Remove and replace all portions of the retaining wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

4. MEASUREMENT

This Item will be measured by the square foot of the front surface area of the wall. Unless otherwise shown on the plans, the area will be measured from 1 ft. below finished grade of the ground line on the face of the exterior wall to the top of the wall including any coping required (not including railing).

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Retaining Walls" of the type or special surface finish specified. This price is full compensation for excavation in back of retaining walls and for footings; furnishing and placing footings, leveling pads, copings, and traffic railing foundations; furnishing, placing, and compacting backfill (except in embankment areas), including cement for stabilization; proof rolling; furnishing and placing concrete, reinforcing steel, waterproofing material, filter material and drain pipe, joint material, water stop, and filter fabric when required; fabricating, curing, and finishing all panels; furnishing and placing earth reinforcement, anchorage systems, and fasteners; wall erection; and equipment, labor, tools, and incidentals.

Retaining wall backfill areas that are also in embankment areas will be considered part of the quantities measured and paid for under Item 132, "Embankment."

When drilled shafts are required, they will be measured and paid for as specified in Item 416, "Drilled Shaft Foundations." When piling is required, it will be measured and paid for as specified on the plans for piling of the appropriate type.

Item 424

Precast Concrete Structural Members (Fabrication)

1. DESCRIPTION

Fabricate precast prestressed and precast nonstressed concrete members. This Item, in conjunction with DMS-7300, "Precast Concrete Fabrication Plants," applies to both multi-project and project-specific fabrication plants. For this Item, the following definitions apply:

- **Prestressing**. The introduction of internal stresses (pre-tensioning or post-tensioning) into a structural member by tensioning and anchoring strands, bars, or wires to counteract the stresses resulting from the applied load.
- **Pre-Tensioning**. The application of prestressing force to the tensioning devices before casting concrete.
- **Post-Tensioning**. The application of prestressing force to the tensioning devices after concrete has hardened.
- **Tendon**. Any single unit used to apply prestressing force to the member. For post-tensioned units, a tendon is a bar, group of wires, or group of strands with common end anchorage.
- **Multi-Project Fabrication Plant**. A facility at an offsite location that fabricates precast prestressed or precast nonstressed members. This definition also applies to single Contract offsite facilities.
- **Project-Specific Fabrication Plant**. A temporary facility at or near the project location that fabricates precast prestressed or precast nonstressed members for only one Contract. This definition may be applied to temporary facilities that fabricate for multiple Contracts, if approved.
- **Nonstressed Members**. Precast concrete members that have not been pre-tensioned or post-tensioned.
- **Prestressed Members**. Precast concrete members fabricated by the process of pre-tensioning, post-tensioning, or a combination of both methods.
- **Minor Prestressed Members**. Includes piling, bridge deck panels, and sound wall panels.
- **Major Prestressed Members**. Includes all other prestressed members not listed as minor prestressed members.
- **I-Beams**. For this specification all I-girders and bulb-tee beams are referred to as I-beams.
- **Self-Consolidating Concrete (SCC)**. A highly workable concrete that can flow through densely reinforced or complex structural elements under its own weight and adequately fill voids without segregation or excessive bleeding without the need for vibration.
- **Temperature Probe**. Thermocouple for measuring concrete temperature or air temperature.
- **Temperature Recording Device**. Data logger for recording temperatures from the temperature probes.

2. EQUIPMENT

2.1. **Field Office and Inspection Laboratory**. Provide a field office and inspection laboratory for multi-project and project-specific fabrication plants in accordance with DMS-7300, "Precast Concrete Fabrication Plants."

2.2. **Furnishings and Laboratory Equipment**. Provide furnishings and laboratory equipment for multi-project and project-specific fabrication plants in accordance with DMS-7300, "Precast Concrete Fabrication Plants."

2.3. **Plant Facilities**. Provide plant facilities for multi-project and project-specific fabrication plants that produce prestressed members in accordance with DMS-7300, "Precast Concrete Fabrication Plants."

2.4. **Batch Plant**. Provide batch plant onsite for SCC construction unless otherwise approved. Do not use volumetric mixers for SCC.

3. MATERIALS

Furnish materials in accordance with Item 425, "Precast Prestressed Concrete Structural Members" and other pertinent Items.

4. CONSTRUCTION

4.1. **General Requirements**.

4.1.1. **Shop Drawings**. Prepare and electronically submit shop drawings before fabrication as documented in the *Guide to Electronic Shop Drawing Submittal* available on the Bridge Division website. Provide one complete approved 11 × 17-in. set in hardcopy to the Department inspector at the fabrication plant. Stamp it "For Construction Division Inspector." The Engineer may require additional complete hardcopy sets.

Provide a title block on each sheet in the lower right corner with the following information:

- sheet index data shown on lower right corner of the project plans,
- sheet numbering for shop drawings,
- name of structure or stream,
- name of owner or developer,
- name of fabricator or supplier, and
- name of Contractor.

4.1.1.1. **Prestressed Members**. Furnish shop drawings for prestressed members unless otherwise shown on the plans or in other Items. Submit the proposed designs on forms furnished by the Department when optional designs are permitted by the plans. Obtain approval of these designs before casting. Approval of optional designs does not relieve the Contractor from the responsibility of furnishing a satisfactory completed structure. Provide submittals for precast post-tensioned members in accordance with this specification and Item 426, "Post-Tensioning."

4.1.1.2. **Nonstressed Members**. Furnish shop drawings for nonstressed members when required by the plans or pertinent Items.

4.1.2. **Plant Approval**.

4.1.2.1. **Plant Submittals**. Provide submittals in accordance with DMS-7300, "Precast Concrete Fabrication Plants," for each particular plant operation. This requirement does not apply to project-specific nonstressed member fabrication plants.

4.1.2.2. **Plant Audits**. Multi-project and project-specific fabrication plants must pass initial and periodic Department-directed plant audits in accordance with DMS-7300, "Precast Concrete Fabrication Plants."

4.1.3. **Notice of Beginning Work**. Give adequate notice before beginning work as specified in Table 1. Include a schedule for all fabrication processes and dates when inspections are to occur.

Table 1
Notice of Beginning Work

Plant Location	Notice Required
In Texas	7 days
In the contiguous United States	21 days
Outside the contiguous United States	60 days

Perform no Department work in the plant before the Engineer authorizes fabrication. The Contractor must bear all Department travel costs when changes to their fabrication or inspection schedules are not

adequately conveyed to the Department. When fabrication is performed outside of the contiguous 48 states, the additional cost of inspection will be in accordance with Article 6.4., "Sampling, Testing, and Inspection."

4.1.4. **Personnel Qualifications**. Provide qualified personnel in accordance with DMS-7300, "Precast Concrete Fabrication Plants," for each particular plant operation.

4.1.5. **Quality Responsibilities**. The quality responsibilities for the Contractor for each particular plant operation will be in accordance with DMS-7300, "Precast Concrete Fabrication Plants."

4.2. **Fabrication**. Prepare a casting schedule on Department-approved forms per DMS-7300, "Precast Concrete Fabrication Plants," and submit it daily to the Department before fabrication. This requirement does not apply to project-specific minor prestressed member or project-specific nonstressed member fabrication plants. Perform fabrication during daylight hours unless the production site has an approved lighting system. Submit lighting details electronically to the Engineer for review before installing lighting system. Allow for plant and Department inspection in accordance with Item 6, "Control of Materials."

4.2.1. **Forms**. Design forms to prevent damage to the concrete from restraint as the concrete shrinks, from form expansion and contraction from thermal changes, from stripping operations, and from dimensional changes due to pre-tensioning. Forms, regardless of material, must conform to the profiles, dimensions, and tolerances of the finished product as specified on the plans and in this Item. Maintain forms free from dents, grease, or other foreign materials that may affect the appearance of the member, and clean forms thoroughly before each casting operation and immediately before applying a form-release agent.

4.2.1.1. **External Forms**. Construct side and bottom forms of steel unless otherwise approved or noted on the plans. Timber forms, when permitted, must meet the requirements of Section 420.4.4., "Forms." End headers may be of other material as approved.

Construct forms with sufficient thickness, external bracing and stiffeners, and anchorage to withstand the forces generated during concrete placement and consolidation. Do not stabilize forms with bracing and holding devices that will remain in the finished member.

Provide corners with a chamfer or radius where shown on the plans.

Maintain forms sufficiently mortar-tight to prevent damage that requires repair to the finished product. Where sections of forms will be joined, an offset of 1/16 in. for flat surfaces and 1/8 in. for corners and bends is permitted. Longitudinal form joints in prestressed concrete beams are not permitted except for in the side forms of slab beams, decked slab beams, box beams, and X-beams or as shown on the plans. Do not allow vertical or horizontal gaps or offsets to exceed 1/4 in. between adjacent sections of built-up end headers.

Check the grade and alignment of forms each time they are set, and maintain them during placement of concrete.

Apply a form-release agent, in accordance with the manufacturer's recommendations, to the facing of forms before placing concrete. Use a form-release agent that facilitates form removal and does not affect any required coating, painting, or color-staining operations. Do not use materials that appreciably stain or react with the concrete. Remove excess form-release agent from the form surface before casting, and ensure it does not contaminate strands, reinforcing steel, and embedments. Use a clear form-release agent of the same brand throughout the casting of retaining wall panels per structure, unless it can be shown that a different form-release agent does not change the appearance of the concrete.

Construct the forms to facilitate removal of members without damage to the concrete.

Construct and maintain the soffit (liner) to provide a maximum 1/4 in. variation from the theoretical plane, and do not allow the soffit to vary more than 1/4 in. between any 2 points in any 50-ft. length.

At the Contractor's option, construct side forms for bridge deck panels and prestressed piling with a draft for ease of product removal. Maintain product dimensional tolerances per Table 3. A maximum 1/4 in. draft is allowed for bridge deck panels.

4.2.1.2. **Internal Forms**. Use solid expanded polystyrene conforming to ASTM C578 Type I for forming internal voids. The form material must be inert, non-biodegradable, non-absorptive, and strong enough to maintain sufficient rigidity to withstand the forces generated during concrete placement and consolidation without damage. Other materials for forming internal voids may be used when approved. Provide certification of conformance for void forms. The Engineer may require samples to be submitted when needed.

Anchor internal void forms to prevent movement or misalignment while placing concrete. Provide hold-down devices for all types of void forms at 30-in. maximum spacing unless otherwise approved. Do not use internal hold-down or lateral bracing devices that will remain in the finished member unless approved. Provide enough bearing area on the void form to prevent penetration of hold-down devices into the void form. Splice void form sections to prevent separation or misalignment during concrete placement and consolidation operations.

During casting, verify and document void form placement at 10-ft. maximum spacing using an approved method.

Vent void forms without solid cores to eliminate high air pressure caused by heat of hydration. Insert a 3/4-in. diameter plastic tube into the top of the void before placing concrete, and leave it in place until there is no possibility of damage from pressure. Remove the plastic tube afterwards and seal the hole with an approved repair material and procedure.

Drain prestressed concrete box beams and U-beams through the bottom flange by forming holes in each voided area as shown on the plans.

4.2.2. **Prestressing**. Perform pre-tensioning in accordance with this Item and post-tensioning in accordance with Item 426, "Post-Tensioning."

4.2.2.1. **Prestressing Equipment**. Furnish hydraulic jacks with sufficient capacity for prestressing the steel. Equip the jacks with instruments for monitoring the hydraulic pressure. Provide gauges at least 6 in. in diameter and with means to prevent the gauge pointer from fluctuating. Electronic pressure transducers with digital indicators may be used. Pressure gauges or electronic pressure indicators must indicate the load directly to 1% of the maximum gauge or sensor/indicator capacity or 2% of the maximum load applied, whichever is smaller.

Calibrate each jack and its gauge with the cylinder extension in the approximate position at final jacking force. Jacks and gauges for post-tensioning and single-strand pre-tensioning must be calibrated as a unit. Have certified calibration charts furnished by an independent laboratory and with each jack and gauge used on the project. Provide certified calibration of each ram before starting stressing operations on the project and:

- every 6 mo. thereafter for post-tensioning operations,
- every 12 mo. thereafter for pre-tensioning operations, and as requested by the Engineer.

The calibration frequency for multiple-strand pre-tensioning equipment may be extended to every 24 mo. thereafter if an approved master gauge system monitors it. The master gauge must check this equipment when suspect results occur and at least every 6 mo. Calibrate the master gauge per the manufacturer's recommendations and at least every 12 mo.

Recalibrate jacks and gauges when a malfunction occurs, when repairs such as replacing the seals, changing the length of the hydraulic lines, or changing the pump occur, or when using gauges that have not been calibrated with the jack. Extra compensation will not be allowed for the initial or subsequent calibrations.

Post-tensioning jacks must have provisions for measuring tendon elongation directly on the strand, bar, or wire. The jacks must be capable of slow release of force to properly seat the tendon anchors.

Single-strand stressing jacks for pre-tensioning must have provisions for measuring the elongation directly on the strand.

Multi-strand detensioning jacks must have sufficient capacity and throw to permit simultaneous release of the entire load in the strands. Use an approved single-strand flame-release procedure to release the remaining load if there is not enough throw in the multi-strand jacks to release all load in the strands.

4.2.2.2. **Pre-Tensioning**. Pre-tension all strands to a uniform initial load between 5% and 25% of the final load unless otherwise approved. Apply the load within a tolerance of:

- ±100 lb. per strand if the designated initial load is less than or equal to 10% of the final load, or
- ±200 lb. per strand if the designated initial load is greater than 10% of the final load.

Measure the initial load with a calibrated dynamometer or other suitable equipment.

Do not allow the modulus of elasticity of individual strands to vary more than 1% from each other when multiple-strand tensioned. Use a weighted average modulus of elasticity of strands to calculate elongation for multiple-strand tensioning operations.

Establish reference marks on the strand for measuring elongation after initial tensioning. Provide means for measuring the elongation of the strand to an accuracy of 1% of the theoretical elongation or 1/8 in., whichever is smaller. Establish independent references on the strand adjacent to each anchorage, to indicate slippage that may occur between the time of initial stressing and final release of the strands.

Do not allow the stress in the strand to exceed 80% of the specified ultimate tensile strength of the strand at any time.

Do not use any portion of the strand that has been previously gripped with chucks in the length of strand to be tensioned, except where gripped with chucks during initial tensioning. Do not drive over prestressing strand.

Strand chucks designed with spring caps must be used with the spring caps. Visually inspect strand chucks that are not equipped with spring caps to ensure all wedges are evenly seated after applying initial load. Correct unevenly seated wedges by releasing the stress, repositioning wedges, and reapplying the initial load.

Failure of individual wires in a 7-wire strand is acceptable if the total area of wire failure is not more than 2% of the total cross-sectional area of all strands in the member, and if no more than 1 wire fails in any single strand. Any setup with one or more broken wires must be examined by a licensed professional engineer or Quality Control Supervisor (as defined in DMS-7300, "Precast Concrete Fabrication Plants,") to determine the cause before continuing stressing operations on the particular casting line.

4.2.2.2.1. **Strand Splicing**. Do not splice draped strands. One splice per straight strand will be permitted subject to the following:

- Locate splices outside the members.
- Splice strands with the lay or twist in the same direction to avoid unraveling.
- Splice all straight strands in a multiple-strand tensioning operation so an adjustment can be made for the average seating loss.
- Cut strand ends to be spliced with shears, abrasive saws, or grinders to remove regions where chucks were previously seated. Cut in the same manner at least 12 in. from strand ends to be spliced that were previously flame cut.

4.2.2.2.2. **Single and Multiple Straight Strand Tensioning**. After initial tensioning, apply the required load to the strands as shown on the plans by means of single-strand or multiple-strand hydraulic jacks equipped with calibrated gauges. Verify the final load in the strands by observing either the gauge pressure or elongation and independently checking the other. The final load and elongation must agree within 5% of the computed theoretical values. Additionally, the final load and elongation must agree algebraically with each other within 5%. Suspend tensioning operations until the problem has been identified and corrected in the event of discrepancies greater than these tolerances.

Verify uniform application of load to strands for multiple-strand-tensioning systems by measuring the movement on opposite sides of the anchorage.

4.2.2.2.3. **Draped Strand Tensioning**. Verify the intermediate load by observing either the gauge pressure or elongation and independently checking the other when draped strands are tensioned in a straight or partially-draped position before application of final load. The intermediate or final load, if strands are tensioned in the final position and elongation must agree within 5% of the computed theoretical values. Additionally, the intermediate or final load and elongation must agree algebraically with each other within 5%. Suspend tensioning operations until the problem has been identified and corrected in the event of discrepancies greater than these tolerances.

After application of final load, measurements on individual draped strands to establish differential stresses at selected points on the member will be averaged at a cross-section of the member, and the averages must be within 5% of the theoretical elongation. The measured elongation of any individual draped strand must not vary from the theoretical elongation by more than 10% at any measured cross-section. Suspend tensioning operations until the problem has been identified and corrected in the event of discrepancies greater than these tolerances.

Other methods to measure the intermediate load and final load in the draped strands may be submitted for approval.

4.2.2.2.4. **Strand Debonding**. Encase strands in plastic sheathing along the entire debonded length, and seal the ends with waterproof tape when shown on the plans. Use split plastic sheathing only if the seam is sufficiently sealed with waterproof tape to prohibit grout infiltration. Do not use sheathing that will permanently alter the physical or chemical properties of the surrounding concrete.

Full-length debonding of straight strands will be approved on an individual basis. Full-length debonding, when permitted, must be symmetrical about the vertical centerline of the beam and limited to 10% of the total number of straight strands or 6 straight strands, whichever is less. Do not debond draped strands full length. When using a concrete anchor block to combined strand patterns the same criteria applies.

4.2.2.3. **Combined Pre-Tensioning and Post-Tensioning**. When the plans call for a combination of pre-tensioning and post-tensioning, all of the requirements for pre-tensioning in this specification and for post-tensioning in Item 426, "Post-Tensioning," apply.

4.2.3. **Placing Reinforcing Steel**. Place reinforcing steel in accordance with Item 440, "Reinforcement for Concrete." Reinforcing steel projection outside of the member must not be more than 1/2 in. or less than 3/4 in. from plan dimension unless otherwise approved. Do not damage sheathing for strand debonding. Do not tie reinforcing steel to debonded strand regions.

Weld steel components in accordance with Item 448, "Structural Field Welding." Provide welding procedure specifications (WPSs) for approval, and welding personnel certifications per the applicable AWS code.

4.2.4. **Quality of Concrete**. Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." Use the class of concrete shown on the plans or in the pertinent Item for each type of structure or unit. Provide concrete meeting the approved mix design water-cement ratio. SCC is not allowed for project-specific fabrication plants unless approved by the Engineer. Mix concrete for a period of 1 min. for 1 cu. yd. and 15 sec. for each additional cu. yd. of rated capacity of the mixer. Count the mixing time from the time all materials are in the drum. Increase mixing time if necessary to achieve a uniform mix. Control concrete by

compressive strength tests of cylinders or other pertinent performance tests detailed on the plans or pertinent Items. Concrete compressive-strength test cylinders will be made, cured, and tested in accordance with Tex-704-I. Cure release-of-tension strength cylinders in accordance with Tex-715-I when match-cure technology is used.

High-strength concrete (f'_c > 9,000 psi) is accepted based on 56-day compressive strength testing. Concrete design-strength test cylinders for high-strength concrete will be made, cured, and tested in accordance with Tex-704-I.

Product with concrete that fails to meet minimum design compressive strength requirements will be reviewed. Concrete that has been determined to be structurally adequate may be accepted at an adjusted price based on the formula in Article 421.6., "Measurement and Payment." If the Engineer requires cores be taken to determine the strength of the in-situ concrete, the coring will be at the Contractor's expense and in accordance with Tex-424-A. All cores from precast members must meet 100% of the minimum design compressive strength requirements. For concrete that has been determined to be structurally adequate, coring of the in-situ concrete will not be allowed for the purpose of avoiding the price adjustment. The Department may require reimbursement for testing of cores. Testing by an approved commercial testing laboratory will be at the Contractor's expense. Test results from a commercial laboratory must be sealed by a licensed professional engineer.

SCC used for prestressed beams must have a Modulus of Elasticity of 5,000 ksi at 28 days. Test the concrete mix design before use in accordance with ASTM C469.

4.2.5. **Placing Concrete**. Place concrete only when its temperature at time of placement is between 50°F and 95°F.

Take responsibility for producing quality concrete under any weather condition and ensure adequate weather protection provisions are on-site and available for immediate use.

Provide immediate protective measures without compromising the quality of the product if rainfall occurs after concrete placing operations have started. Failure to immediately provide adequate weather protection may be cause for rejection of the affected product.

Maintain concrete transporting equipment clean and free from hardened concrete coatings.

At the time of concrete placement, reinforcing steel, strands, and embedments must be free of dirt, oil, or other bond-breaking substances.

Place and adequately consolidate concrete while all lifts are in a plastic state. Concrete must not exhibit segregation or excessive bleeding. Minimize concrete flow lines and displacement of the reinforcing steel, strands, embedments, and ducts during concrete placement. Concrete must not exhibit segregation or excessive bleeding.

Place concrete as near as possible to its final position in the forms except when using SCC. Do not deposit large quantities of concrete at one location and run or work it along the forms to other locations except for SCC. Place SCC in a manner to avoid segregation.

Do not allow fresh concrete to free-fall more than 8 ft. unless approved.

Work the coarse aggregate back from the face of the concrete, and force the concrete under and around the reinforcing steel, strands, embedments, and ducts. If prestressed concrete I-beams are cast in multiple lifts, the thickness of the first lift must be slightly above the juncture of the bottom flange and web.

Cast prestressed concrete box beams monolithically in 2 stages, maintaining the concrete in the previously placed bottom slab in a plastic state until the web (side wall) concrete is placed and vibrated into the bottom slab unless approved by the Engineer.

The maximum time between the addition of mixing water or cement to the concrete batch and the placing of concrete in the forms is 30 min. for concrete delivered in non-agitated delivery equipment and 60 min. for concrete delivered in agitated delivery equipment. If conditions of wind, humidity, and temperature cause quick stiffening of the concrete, the required placement times may be reduced and an approved retarder may be required, or increased if currently in use. Submit a plan for approval, if necessary, to demonstrate the concrete can be properly placed, consolidated, and finished without reducing placement time limits.

The maximum acceptable placement slump will be in accordance with Item 421, "Hydraulic Cement Concrete," unless otherwise specified. When the maximum acceptable placement slump or slumpflow is exceeded, the affected concrete will be rejected and retesting for slump or slumpflow will not be allowed regardless of the concrete placement times.

Additional requirements for precast mass placements will be in accordance with Item 420, "Concrete Substructures." In the case of a conflict between the 2 Items the more stringent requirements apply.

4.2.5.1. **Placing Concrete in Cold Weather**. Maintain concrete temperature between 50°F and 95°F at time of placement as specified in Section 424.4.2.5., "Placing Concrete," and maintain the concrete temperature of precast members at or above 50°F during the specified curing period as specified in Section 424.4.2.7., "Curing of Concrete." Do not place concrete when the atmospheric temperature in the shade is below 40°F and falling unless approved. Concrete may be placed when the atmospheric temperature in the shade is at least 35°F and rising or above 40°F, provided adequate cold-weather protection provisions are on-site and available for immediate use before placing concrete when weather conditions indicate a possible need for temperature protection. When required, provide necessary covering material or an approved accelerated curing system in accordance with Section 424.4.2.7.4., "Accelerated Curing," and do not allow any concrete to remain unprotected for longer than 1 hr. after placement. Do not place concrete in contact with any material coated with frost or with material at a temperature of 32°F or lower. Do not apply heat directly to concrete surfaces if accelerated curing is used. Take protective measures to ensure the difference between air temperature and concrete surface temperature does not cause thermal cracking.

Maintain aggregates free from ice, frost, and frozen lumps. Heat the aggregate and the water when needed to produce the minimum concrete placement temperature of 50°F, but:

- do not allow the water temperature to exceed 180°F or the aggregate temperature to exceed 150°F,
- heat the aggregate uniformly to eliminate overheated areas in the stockpile that might cause flash set of the cement, and
- provide an aggregate and water mixture temperature between 50°F and 85°F before introduction of the cement.

4.2.5.2. **Placing Concrete in Hot Weather**. Keep concrete at or below 95°F at time of placement in accordance with Section 424.4.2.5., "Placing Concrete." Use any of the following methods, as needed, to control the concrete placement temperature:

- Cool the aggregate by sprinkling or fogging (fine mist) with water, shading, or using an approved liquid nitrogen system and procedure.
- Cool the fresh concrete by using chilled mixing water, partially replacing mixing water with shaved or crushed ice, or using an approved system and procedure to discharge liquid nitrogen into concrete during batching.

Apply a fog spray (fine mist) of water to this steel just before placing concrete when the temperature of steel forms, strand, or reinforcing steel is greater than 120°F. Water droplets left on the form surfaces must not adversely affect surface finishes.

When field conditions are such that evaporation of water from the concrete makes the surface finishing operation difficult, a fog spray (fine mist) of water may be applied above the concrete surface. Do not fog directly toward the concrete or in any manner that will wash cement paste from the fresh concrete surface or cause water to puddle. Do not fog as a means to add finishing water and do not work moisture from the fog spray into the fresh concrete. An approved evaporation retardant conforming to DMS-4650, "Hydraulic

Cement Concrete Curing Materials and Evaporation Retardants," is also acceptable if used in accordance with the manufacturer's recommendations. Do not apply the evaporation retardant when floating and troweling concrete. Do not allow it to puddle or be worked into the concrete surface immediately after application. Misuse of fog spray or evaporation retardant will be cause for disallowing its use. Shade the concrete during casting if necessary.

Use an approved retarder, in accordance with the manufacturer's recommendations, when the air temperature is above 85°F if necessary to control concrete slump loss and lengthen the time for placing, consolidating, and finishing operations.

4.2.5.3. **Consolidation of Concrete**. Consolidate concrete thoroughly with high-frequency vibration immediately after placement. For prestressed concrete beams and piling, internal vibration is required and may be supplemented with external vibration.

Provide at least 1 on-site standby vibrator of the type being used for emergency use.

Perform concrete vibration using trained personnel and proper timing and spacing to ensure adequate consolidation. Revise the concrete placement and consolidation procedures, and review the concrete mix design and batching procedures, if necessary, when unacceptable defects such as excessive honeycombing, aggregate or mortar pockets or surface air voids (bugholes) are present. Provide supplemental vibrators or modify the vibration system when required to accomplish thorough consolidation of the concrete and complete embedment of the strands, reinforcing steel, embedments, or ducts. Avoid segregation or excessive bleeding of the concrete during vibration.

4.2.5.3.1. **Internal Vibration**. Insert vibrators into the concrete immediately after concrete placement at points spaced to ensure uniform vibration of the entire concrete mass. Limit the insertion spacing to within the radius where the vibrators are visibly effective. Allow the vibrators to sink into the concrete by their own weight and penetrate into previously placed lifts that are still in a plastic state to thoroughly consolidate the layers together and prevent cold joints. Withdraw the vibrators slowly to avoid forming holes after the concrete is thoroughly consolidated.

Do not allow prolonged contact of vibrators with forms so vibrator marks on concrete surfaces are minimal. Do not use vibrators to move concrete to other locations in the forms.

Use vibrators with nonmetallic vibrating heads to prevent damage to the epoxy coating when epoxy coated reinforcing steel is used. Increase the consolidation time and decrease the insertion spacing, if necessary, when using these vibrators.

4.2.5.3.2. **External Vibration**.

4.2.5.3.2.1. **Form Vibrators**. Form vibrators may be used to consolidate thin members, supplement internal vibration, or consolidate members with highly congested reinforcing steel.

Determine the size, number, and location of external vibrators to provide enough intensity of vibration to the desired area of the form. Adjust the spacing, frequency, amplitude, and duration of vibration according to the concrete mix and size of member to produce uniform consolidation of the concrete.

4.2.5.3.2.2. **Surface Vibrators**. Use vibratory screeds to consolidate thin sections. Move vibratory screeds at a rate that will bring enough mortar to the surface to embed and cover the coarse aggregate. Do not over vibrate by causing an excessive amount of mortar to be brought to the surface.

4.2.5.3.2.3. **Vibrating Tables**. Determine the size, number, and location of external vibrators to provide enough intensity of vibration to the desired area of the form. Adjust the spacing, frequency, amplitude, and duration of vibration according to the concrete mix and size of member to produce uniform consolidation of the concrete.

4.2.5.3.3. **Vibration of Self-Consolidating Concrete (SCC)**. Vibrate SCC only when approved by the Engineer. Provide an adequate amount of viscosity modifying admixture (VMA) in SCC mix when internal vibration is allowed by the Engineer.

4.2.6. **Finishing of Concrete**. Finished, unformed surfaces must not have distortions greater than 1/4 in. Screed or rough-float unformed surfaces of members, bringing enough mortar to the surface to embed and cover the coarse aggregate. Provide a uniform rough wood float finish to the surface of the member unless otherwise shown on the plans. Do not loosen aggregate when roughening the surface with a broom or when providing a tine finish.

Provide a smooth metal trowel finish for surfaces at anchor bolt locations.

4.2.7. **Curing of Concrete**. Cure concrete to promote early cement hydration by providing adequate moisture on exposed surfaces and by maintaining the concrete temperature or curing enclosure air temperature at the concrete surface within the limits specified in this Section. Provide uniform temperature and moisture on the surfaces to prevent differential shrinkage that may cause warping or cracking. Prevent temperature differentials within the concrete that cause thermal cracking.

Begin curing after the finishing operation, before the formation of plastic shrinkage cracks, and as soon as damage to the surface finish will not occur. Provide fog spray or an evaporation retardant after finishing and before curing if needed to prevent plastic shrinkage cracks. Apply fog spray or evaporation retardant in accordance with Section 424.5.2.4.2., "Placing Concrete in Hot Weather." Keep exposed concrete surfaces continuously wet for the duration of the specified curing period, unless an approved liquid membrane-forming curing compound is used. Membrane curing compound is only permitted as noted in this Section or in the pertinent Item.

Approved equipment and materials for curing must be on-site and available for immediate use before placing concrete. Provide temperature probes to monitor the concrete temperature or curing enclosure air temperature as specified in Table 2.

Table 2
Temperature Probe Requirements

Condition	Major Prestressed Members	Minor Prestressed Members	Nonstressed Members
Forecasted atmospheric temperature ≥ 50°F during specified curing period	2 concrete temperature probes per casting line to monitor high concrete temperature regions[5]	2 concrete temperature probes per casting line to monitor high concrete temperature regions[1,5]	N/A
Forecasted atmospheric temperature < 50°F during specified curing period	2 concrete temperature probes per casting line to monitor high concrete temperature regions,[5] and 2 concrete temperature probes per casting line to monitor low concrete temperature regions[2,5]	2 concrete temperature probes per casting line to monitor high concrete temperature regions,[1,5] and 2 concrete temperature probes per casting line to monitor low concrete temperature regions[2,5]	1 concrete temperature probe per 100 cubic yards of concrete or fraction thereof to monitor low concrete temperature regions[2]
Forecasted atmospheric temperature < 40°F during additional 3-day curing period[3]	N/A	1 concrete temperature probe per similar curing condition for prestressed piling only	N/A
When accelerated curing is used	2 temperature probes per casting line to monitor curing enclosure air temperature at concrete surfaces[4,5]	2 temperature probes per casting line to monitor curing enclosure air temperature at concrete surfaces[4,5]	1 temperature probe per 100 cubic yards of concrete or fraction thereof to monitor curing enclosure air temperature at concrete surfaces

1. Excluding prestressed bridge deck panels and prestressed retaining wall panels.
2. When accelerated curing is used, concrete temperature probes to monitor low concrete temperature regions are not required.
3. After attaining specified release-of-tension strength.
4. These probes are in addition to the concrete temperature probes required for monitoring high concrete temperature regions.
5. Place probes at the beginning and end of casting line.

Attach each temperature probe to a separate temperature recording device unless multi-channel temperature recording devices are used, in which case 1 high concrete temperature probe and 1 low concrete

temperature probe may be attached to the same recording device. When accelerated curing is used, 1 curing enclosure air temperature probe may also be attached to this multi-channel temperature recording device.

Inadequate curing facilities or lack of attention to the proper curing of concrete will be cause for the Engineer to stop concrete placement until approved curing is provided. Inadequate curing may be cause for rejection of the affected product.

Forms may be removed at the discretion of the Contractor at any time after the concrete has reached sufficient strength to prevent physical damage to the member. Do not interrupt curing for more than 60 min. during form removal.

The following curing requirements apply for prestressed members:

- Cure concrete continuously, except as allowed during form removal, until the compressive strength of the concrete has reached the specified release-of-tension strength and until detensioning has been performed.
- Maintain concrete temperatures between 50°F and 150°F during the curing period. The maximum allowable concrete temperature may be increased to 170°F if the Contractor uses one of the concrete mix design options listed in Section 421.4.2.6., "Mix Design Options," other than options 6, 7, and 8. The Engineer may require lowering of the total cementitious content in the concrete mix design to the limits specified in Item 421, "Hydraulic Cement Concrete," for repeated violations of the maximum curing temperature.
- Membrane curing is permitted only for unformed surfaces of prestressed wall panels and interim curing on unformed surfaces of prestressed piling. Use Type 1-D or Type 2 curing compound conforming to DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants," for this application.
- Water cure prestressed piling an additional 3 days after attaining the specified release-of-tension strength. Do not interrupt curing for more than 4 hr. when moving piling to the storage area. Maintain the concrete temperature of piling at 50°F or above during this additional curing period.

The following curing requirements apply for nonstressed members:

- Cure concrete continuously, except as allowed during form removal, for 4 days or until the compressive strength of the concrete has reached the design strength.
- Maintain concrete temperatures between 50°F and 150°F during the curing period. The maximum allowable concrete temperature may be increased to 170°F if the Contractor uses one of the concrete mix design options listed in Section 421.4.2.6., "Mix Design Options," other than options 6, 7, and 8.
- Membrane curing is permitted on nonstressed members, except for surfaces to be painted or color-stained.

Cure members for an additional 24 hr. beginning immediately after the normal curing period if they are out of cure at any time other than during the allowable 60 min. for form removal or during the allowable 4 hr. for moving piling to storage.

Members failing to meet the concrete temperature requirements or curing enclosure air temperature requirements during curing will be reviewed. Repeated failure to maintain proper concrete temperatures may be cause for rejection of the affected product.

4.2.7.1. **Water Curing**. Water curing provides additional moisture to concrete and prevents moisture loss. Water used for curing must meet the requirements for concrete mixing and curing water specified in Section 421.2.5., "Water." Do not use seawater or water that stains or leaves an unsightly residue that cannot be removed. Monitor and maintain a temperature differential between curing water and concrete surface temperature that prevents thermal cracking.

4.2.7.1.1. **Wet Mat Method**. Use water-saturated cotton mats, burlap, burlap-polyethylene sheeting, or other approved moisture-retaining materials. Anchor the wet mats adequately to provide continuous contact with exposed concrete surfaces.

4.2.7.1.2. **Water Spray Method**. Use overlapping sprays, sprinklers, or soil-soaker hoses so concrete surfaces are kept continuously wet.

4.2.7.1.3. **Ponding Method**. Use an approved retarder when the air temperature is above 85°F in accordance with the manufacturer's recommendations if necessary to control concrete slump loss and lengthen the time for placing, consolidating, and finishing operations.

4.2.7.2. **Moisture Retention Curing**. Moisture retention curing prevents moisture loss from the concrete.

4.2.7.2.1. **Form Curing Method**. Concrete surfaces in direct contact with forms that are left in place will not require additional curing methods unless cold-weather protection is necessary.

4.2.7.2.2. **Impermeable Cover Method**. Cover exposed concrete surfaces with polyethylene sheeting, burlap-polyethylene sheeting, impervious paper, or other approved impermeable materials placed in close contact with concrete surfaces to keep them continuously wet. Provide additional moisture inside the enclosure in accordance with Section 424.4.2.7.1., "Water Curing," if this is not enough to keep exposed concrete surfaces continuously wet.

4.2.7.3. **Membrane Curing**. Liquid membrane-forming curing compound is a moisture retention covering that is applied as a liquid. It is only permitted as noted in Section 424.4.2.7., "Curing of Concrete."

Use Type 1-D or Type 2 membrane curing compound in accordance with DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants." Apply membrane curing compound with equipment and in a manner specified in Section 420.3.5., "Spraying Equipment" and Section 420.4.10.3., "Membrane Curing," respectively.

Do not contaminate reinforcing steel, embedments, or concrete surfaces that will later be in direct contact with cast-in-place concrete unless the curing compound can be completely removed to the satisfaction of the Engineer when applying membrane curing compound.

Use membrane curing compounds that do not appreciably stain the concrete.

4.2.7.4. **Accelerated Curing**. Accelerated curing is defined as curing with artificial heat provided to the curing enclosure or forms.

Test accelerated-curing facilities for a minimum of 48 hr. to demonstrate temperature variations do not exceed 20°F between any points in the curing enclosure. Submit accelerated curing facility drawings and test results, and obtain approval before using these facilities for Department work. The test may be performed on the entire casting line with either freshly cast concrete inside the forms or with empty forms. Provide 1 curing enclosure air temperature probe per 100 feet of casting line when accelerated curing facilities are being tested.

Maintain the air temperature in the curing enclosure between 50°F and 85°F until initial set of the concrete (as determined in accordance with Tex-440-A when establishing mix designs under representative temperature conditions) and for at least 3 hr. after concrete placement. The concrete temperature may then be raised uniformly at a maximum rate of 36°F per hour. Provide an unobstructed air space of at least 6 in. between surfaces of the concrete and the curing jacket.

Monitor and maintain the curing enclosure air temperature between 50°F and 160°F during accelerated curing for prestressed and nonstressed concrete members. Do not allow the air temperature to exceed 160°F for more than 1 cumulative hour during the entire curing period. Do not allow the air temperature to exceed 170°F at any time during the specified curing period. Arrange the location of the heat discharge into

the curing enclosure so temperature variations do not exceed 20°F between any points in the curing enclosure.

Provide curing enclosure air temperature probes to monitor the temperature at the concrete surface as specified in Table 2.

Provide enough moisture inside the curing enclosure to keep exposed concrete surfaces continuously wet for the specified curing period.

Provide other acceptable curing methods for the remaining curing period if accelerated curing is terminated before the specified curing period has elapsed.

4.2.7.4.1. **Steam Curing**. Steam cure in accordance with the requirements of accelerated curing. Position steam outlets so live steam is not applied directly on the concrete, forms, or test cylinders.

4.2.7.4.2. **Alternate Methods**. Other methods of accelerated curing, such as the use of radiant heaters or portable heater, may be permitted if they meet the requirements of accelerated curing. The use of any alternate method requires written approval.

4.2.8. **Detensioning**. Release the tension in the strands after concrete strength requirements are met using a sequence to minimize premature wire breakage or shock and damage to the concrete members. Release strands by multiple-strand detensioning or single-strand flame detensioning. Ensure strands are not released individually with single-strand jacks.

Flame-release each strand simultaneously at both ends of the casting bed, using a symmetrical sequence prepared by a licensed professional engineer if strands are released individually. Heat the strands over an approved strand length and duration when flame detensioning so that the metal slowly elongates and gradually loses strength. Do not abruptly flame-cut strand by holding the heat source in a concentrated location on the strand. Submit the flame-release procedures and sequences for approval. Approval of flame-release sequences does not relieve the Contractor from responsibility for meeting the product workmanship requirements of Section 424.4.3., "Workmanship."

Release the tension in the strand hold-down anchor slowly to minimize shock and damage to the concrete member when draped strands are used. Heat the anchor until the metal slowly elongates and gradually loses strength if heat is used to release the hold-down anchor. Provide positive external hold-downs to offset the vertical forces in the members when the sum of the hold-down forces is greater than half the weight of the member or for any amount of vertical force that has previously caused cracking. External hold-downs are to remain on each member until detensioning has been complete.

4.3. **Workmanship**. Formed surfaces must not have excessive surface honeycombing, aggregate or mortar pockets, air voids, lift lines, stains, or vibrator marks. Remove form-joint-offset marks in excess of the tolerances specified in Section 424.4.2.1.1., "External Forms," and fins and rough edges along chamfer lines, in a manner that will not damage the member. Repair fabrication holes, except box beam and U-beam drain holes, with an approved repair material and procedure.

Recess strands in accordance with the *Concrete Repair Manual* unless otherwise shown on the plans. Submit for approval any other moisture-barrier systems for protecting strands.

Before shipment of members, remove:

- concrete, paste, dirt, oil, or other bond-breaking substances from exposed reinforcing steel, and
- laitance, dirt, oil, or other bond-breaking substances from concrete surfaces to be in contact with cast-in-place concrete.

4.3.1. **Defects and Breakage**. Members that sustain damage or surface defects during fabrication, handling, storage, hauling, or erection are subject to review. Evaluate and repair members in accordance with the *Concrete Repair Manual*. Submit proposed deficiencies in accordance with the Department's NCR guidelines

and obtain approval before performing repairs. Repair work must reestablish the member's structural integrity, durability, and aesthetics to the satisfaction of the Engineer.

When deficiencies occur, determine the cause and take immediate corrective action. Failure to take corrective action, leading to similar repetitive deficiencies, could be cause for rejection of members.

Cracks that extend to the nearest reinforcement plane and fine surface cracks that do not extend to the nearest reinforcement plane, but are numerous or extensive, are subject to review.

Cracks in prestressed members that tend to close upon transfer of stress to the concrete are acceptable. Cracks that do not tend to close are subject to review.

Seal cracks in I-beam ends exceeding 0.005 in. in width as directed. The fabricator must decrease the spacing of Bars R and S in I-beam by providing additional bars to help limit crack width. No less than 1 in. clearance between bars will be permitted. The fabricator must take approved corrective actions if cracks greater than 0.005 in. form. All work, material, and engineering related to these cracks will be at the Contractor's expense.

Prestressed bridge deck panels will be rejected for any of the following conditions:

- any crack extending to the reinforcing plane and running parallel and within 1 in. of a strand for at least 1/3 of the embedded strand length; or
- any transverse or diagonal crack, including corner cracks and breaks, intersecting at least 2 adjacent strands and extending to the reinforcing plane.

Prestressed bridge deck panels that sustain damage, cracks not listed above, or surface defects during fabrication, handling, storage, hauling, or erection are subject to review.

4.3.2. **Tolerances**.

4.3.2.1. **Prestressed Members**. Allowable tolerances for the dimensions and configurations shown on the plans or approved shop drawings are shown in Table 3.

Variations greater than those specified in Table 3 are subject to review. However, these tolerances do not relieve the Contractor from the responsibility of furnishing a completed structure that is in reasonably close conformity with the lines, grades, cross-sections, dimensions, and details specified. Correct members not meeting these tolerances at no additional expense to the Department, to achieve a satisfactory completed structure. This also includes costs for correction due to variations in vertical beam camber. Correction may require replacement of the member.

Horizontal misalignment (sweep) in beams, which may increase at a later time and exceed the tolerance shown in Table 3, may be acceptable if the members can be hauled, erected, and aligned to within the allowable tolerance without being damaged. Store these members in a manner that will minimize the sweep.

Embedments must be firmly held in proper position to avoid movement during concrete placement. Place embedments in accordance with the manufacturer's recommendations. Place weld clip inserts for permanent metal deck forming no more than 1/16 in. from the beam edge.

Table 3
Allowable Tolerances for Prestressed Members

Dimension	I-beams	U-beams	Box and Slab Beams	Double-T Beams	Bridge Deck Panels	Piling	Wall Panels[1]
Length (perpendicular to strands for bridge deck panels)	±1"	±1"	±1"	±3/4"	±1/2"	−1"[2]	±3/16"
Width (parallel to strands for bridge deck panels)	+3/4" −1/4"	±1/4"	±1/4"	±1/2"	±1/2"	±1/4"	±3/16"
Nominal depth (thickness in case of panels)	+1/2" −1/4"	±1/4"	±1/4"	±1/4"	+1/4" −1/8"	±1/4"	±3/16"
Thickness: top slab or flange	+1/2" −1/4"	±1/2"	±1/2"	±1/4"	NA	NA	NA
Thickness: bottom slab or flange	+1/2" −1/4"	±1/2"	±1/2"	NA	NA	NA	NA
Thickness: web or wall	+3/4" −1/4"	±1/2"	±1/2"	±1/4"	NA	NA	NA
Horizontal alignment (deviation from straightness of all panel edges)	±1/8" per 10' of length	±1/8" per 10' of length, 3/4" Max	±1/4"	±1/4"	±1/8"	±1/8" per 10' of length	±1/8" per 10' of length, 1/2" Max
Deviation of ends (horizontal skew)	±1/2"	±1/2"	±1/2"	±1/2"	±1/2"	±1/8"	±1/4" per 5' of width, 1/2" Max
Deviation of ends (vertical batter)	±1/2"[8]	±1/2"[8]	±1/2"	±1/2"	NA	±1/8"	±1/4"
Notched end areas (for diaphragms): depth	±1/4"	NA	±1/4"	±1/4"	NA	NA	NA
Notched end areas (for diaphragms): length	+2" −1"	NA	+2" −1"	+2" −1"	NA	NA	NA
Bearing surfaces: perpendicular to vertical axis	±1/8"	NA	NA	±1/16"	NA	NA	NA
Bearing surfaces: deviation from plane	±1/16"	±1/8"	±1/8"	±1/16"	NA	NA	±1/16[3]
Anchor hole location: from end of member	+3/4" −1/4"	±1/4"	±1/4"	+3/4" −1/4"	NA	NA	NA
Anchor hole location: longitudinal spacing	±3/4"	±1/2"	±1/2"	±3/4"	NA	NA	NA
Anchor hole location: transverse location	±1/4"	±1/4"	±1/4"	±1/4"	NA	NA	NA
Diaphragm or lateral tie location	±1/2"	NA	±1/2"	±1/2"	NA	NA	NA
Position of internal void form (longitudinal for box beams and U-beams)	NA	±1"	±1"[4,5]	NA	NA	±1/2"	NA
Projection of reinforcing steel outside of member	+1/2" −3/4"	+1/2" −3/4"	+1/2" −3/4"	+1/2" −3/4"	+1/2" −3/4"	NA	+1/2" −3/4"
Position of strands: vertical	±1/4"[6]	±1/4"	±1/4"	±1/4"	±1/8"[7]	±1/4"	±1/8"
Position of strands: horizontal	±1/4"	±1/4"	±1/4"	±1/4"	±1/2"	±1/4"	±1/2"
Debonded length of strands	±3"	±3"	±3"	±3"	NA	NA	NA
Position of strand hold-down points	±6"	±6"	±6"	±6"	NA	NA	NA
Position of handling devices: parallel to length	±6"	±6"	±6"	±6"	As shown on the plans	±6"	±6"
Position of handling devices: transverse to length	±1"	±1"	±1"	±1"	As shown on the plans	±1"	±1"
Local flatness of formed surfaces (excluding bearing surface)	±1/4" in 10'	±1/4" in 10'	±1/4" in 10'	±1/4" in 10'	±1/4"	±1/4" in 10'	±1/4" in 10'
Bow (length and width)	NA	NA	NA	NA	NA	NA	±1/4" per 10'

1. Prestressed and nonstressed wall panels (tie back, C-wall, sound wall, etc.) except MSE wall panels.
2. Maximum length as approved.
3. Measured along the panel depth at the top and bottom panel sides.
4. Voided box beams only.
5. Length of box beam internal void form +1 in., −6 in.
6. For draped strands, the tolerance for vertical position of strands at the end of the beam may be increased to ±1/2 in. provided the tested concrete compressive strength, before release of tension into the member, is at least 5% greater than the release-of-tension strength shown on the plans.
7. Measured from bottom of panel.
8. 3/4 in. maximum for beams exceeding a height of 54 in.

4.3.2.2. **Nonstressed Members**. The allowable tolerances for nonstressed members are as specified in Table 4 unless otherwise shown on the plans. The allowable tolerances for nonstressed wall panels, except MSE wall panels, are as specified in Table 3.

Table 4
Allowable Tolerances for Nonstressed Members

Member	Dimension	Tolerance
MSE wall panels and wall components[1] (coping, posts, etc.)	All dimensions (including deviation from edge straightness)	±3/16 in.
	Deviation of ends (horizontal skew)	±1/4 in. in 5 ft., ±1/2 in. Max
	Local flatness of formed surfaces	±1/8 in. in 5 ft.
	Connection hardware	±1/2 in.

1. Includes wall components for tie-back walls, C-walls, sound walls, etc.

4.4. **Storage and Handling**. Mark members for identification immediately after form removal as shown on approved shop drawings in accordance with the requirements of the pertinent Items or as required. Do not change any identification markings or transfer material to other projects without approval from the Engineer. Inspect members immediately before shipping to the jobsite for damage that may have occurred in storage. Store and handle prestressed and nonstressed members in accordance with Item 425, "Precast Prestressed Concrete Structural Members."

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to bid items of the Contract.

Item 425
Precast Prestressed Concrete Structural Members

1. DESCRIPTION

Furnish and erect precast prestressed concrete members fabricated by pre-tensioning, post-tensioning, or a combination of the two.

2. MATERIALS

Use materials that meet requirements of the following Items.

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 426, "Post-Tensioning"
- Item 427, "Surface Finishes for Concrete"
- Item 434, "Bridge Bearings"
- Item 440, "Reinforcement for Concrete"
- Item 442, "Metal For Structures"
- Item 445, "Galvanizing"
- Item 448, "Structural Field Welding"
- DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants"
- DMS-7300, "Precast Concrete Fabrication Plants"

2.1. **Prestressing Hardware**. Furnish prestressing hardware that meets the manufacturer's specifications.

2.2. **Concrete**. Furnish concrete of the class shown on the plans.

2.3. **Prestressing Steel**. Furnish prestressing steel conforming to one of the following types:

- 7 wire steel strand meeting DMS 4500, "Steel Strand, Uncoated Seven-Wire Stress Relieved and Low Relaxation for Prestressed Concrete,"
- alloy bars meeting ASTM A 722, or
- steel wire meeting ASTM A 421.

Maintain copies of the manufacturer's certified Domestic Certification Form D 9 PS 1 for 7 wire steel strand and supply to the Department upon request. Use 7 wire steel strand produced by a prequalified manufacturer on the list maintained by the Construction Division. The Department may take samples in accordance with Tex 710 I to verify compliance with specification requirements.

Assign an individual lot number to all bars from each size and heat, all wire from each coil, and all strand from each reel, and tag the material for accurate identification at the jobsite. Identify each lot of anchorage assemblies and couplers in a similar manner. Unidentified prestressing steel, anchorage assemblies, or couplers received at the site will be rejected. Loss of positive identification of these items at any time will be cause for rejection.

2.4. **Post-Tensioning System**. Furnish post-tensioing system as required by Item 426, "Post-Tensioning" and the plans.Construction

3. CONSTRUCTION.

Fabricate precast prestressed concrete members in accordance with Item 424, "Precast Concrete Structural Members (Fabrication)." Fabricate railroad structures in accordance with the latest AREMA *Manual for Railway Engineering* and Item 424, "Precast Concrete Structural Members (Fabrication)." In the case of a conflict between the AREMA manual and Item 424, "Precast Concrete Structural Members (Fabrication)," the more stringent requirements apply.

3.1. **Handling, Storing, Hauling, and Erection of Precast Prestressed Concrete Members**. Properly handle, store, haul, and erect all members so that they are placed in the structure in a manner to avoid excessive bending stresses and without damage. Lift members with approved lifting devices as shown on the shop drawings or as approved.

Maintain beams in an upright position at all times, and raise and support them near the ends to prevent torsion unless approved on shop or erection drawings.

Do not move members from the casting yard until all requirements of the pertinent Items have been met. Haul beams to the project site after at least 7 days have elapsed since casting unless otherwise approved.

The storage area must be clean and well drained. Prevent excessive or differential settlement of members by storing on:

- stable ground and
- dunnage of sufficient size, shape, and strength to prevent crushing.

Place dunnage a distance no more than 3% of the beam length from the beam ends. When approved, cantilever beams may be supported at locations other than near the ends. Support concrete box beams and U-beams under the solid end block area during handling, storage, hauling, and erection.

Separate members with blocking arranged in vertical planes that will not crush under load when members are stacked. Stack members so lifting devices are accessible and undamaged. Use dunnage or blocking material that will not damage or stain the required finish.

Rearrange improperly stored members and inspect them for damage. Members that are improperly stored and become cracked, warped, or otherwise damaged in storage may be rejected.

Securely tie or brace all beams during erection in accordance with minimum erection and bracing standards. Protect traffic against falling objects during the erection of diaphragms and other structural members, during the placing of cast-in-place concrete, and during the erection and dismantling of forms when railroad or roadway traffic must be maintained beneath beams already placed. Protect traffic with nets or flooring with openings not larger than 1 in. or as approved.

Fit mating surfaces to prevent excessive grout leakage when erecting precast prestressed concrete bridge deck panels. Fill the joint with grout or seal it with an acceptable caulking compound before placing the cast-in-place portion of the slab if such fit is not provided.

Finish surfaces of beams or other members after slab placement in accordance with Section 420.4.13., "Ordinary Surface Finish," and Item 427, "Surface Finishes for Concrete."

Correct beam discrepancies including, but not limited to horizontal misalignment or variations in vertical camber, to achieve a satisfactory completed structure at no additional expense to the Department. Correction may require replacement of the member.

3.2. **Packaging, Storing, and Handling of Prestressing Steel**. Protect prestressing steel against physical damage and rust or other results of corrosion, from manufacture to grouting or encasing in concrete. Prestressing steel with physical damage will be rejected. Replace any reel containing broken wires. Provide wire that is bright and uniformly colored, without foreign matter or pitting on the surface.

Package prestressing steel in containers or shipping forms for protection from physical damage and corrosion during shipping and storage. A corrosion inhibitor must be:

- placed in the package or form,
- incorporated in a corrosion inhibitor carrier type packaging material, or
- applied directly to the steel when permitted.

The corrosion inhibitor must not have deleterious effect on the steel, concrete, or bond strength of steel to concrete. Inhibitor carrier-type packaging material must conform to the provisions of federal specification MIL PRF 3420G. Immediately replace damaged packaging or forms, or restore them to original condition.

Have the shipping package or form clearly marked with the corrosion inhibitor type, packaging date, and a statement that the package contains high-strength prestressing steel.

Handle prestressing steel carefully to avoid abrading, nicking, or kinking the strand, bar, or wire. Protect prestressing steel from damage and corrosion by storing it above the ground on platforms, skids, or other approved supports. Any pitting or tightly adhering rust on prestressing steel will be cause for rejection of the steel. Do not weld or torch-cut near any prestressing steel, so that it is not exposed to weld spatter, direct heat, or short-circuited current flow.

When prestressing steel for post-tensioning is installed in the ducts, any rust that forms during the first 14 days after installation will not be cause for rejection of the steel.

4. MEASUREMENT

This Item will be measured by the foot, square foot, square yard, cubic yard, or each member. This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurement or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Prestressed Concrete" of the specified structural component and type or size. This price is full compensation for fabricating, hauling, and erection of the members; furnishing and tensioning of prestressing steel; furnishing and placing reinforcing steel and duct; furnishing and placing bearing plates, elastomeric bearings, bars, anchorage plates, and appurtenances; grouting holes; repairs; special treatment of end anchorages and shoes as required; erection bracing; and equipment, labor, tools, and incidentals.

Precast prestressed concrete bridge deck panels will not be paid for directly but will be subsidiary to pertinent Items.

Precast prestressed concrete piling will be paid for as specified in Item 409, "Prestressed Concrete Piling."

No additional compensation will be made for alternate designs or for any increase in quantities required to accommodate alternate designs, including quantities paid for under other Items.

Item 426
Post-Tensioning

1. DESCRIPTION

Furnish, store, and handle post-tensioning materials and perform post-tensioning of cast-in-place and precast structural units.

2. MATERIALS

Furnish materials that meet requirements of the most current versions of the following documents unless indicated otherwise: Post-Tensioning Institute's *Guide Specification for Grouted Post-Tensioning* (PTI/ASBI M50) and Post-Tensioning Institute's *Specification for Grouting of Post-Tensioned Structures* (PTI M55).

2.1. **Prestressing Steel**. Furnish prestressing steel strand conforming to one of the following types:

- Seven-wire steel strand meeting DMS-4500, "Steel Strand, Uncoated Seven-Wire Stress Relieved and Low Relaxation for Prestressed Concrete," or
- Grade 150, high strength, coarse thread bars meeting ASTM A722.

2.2. **Post-Tensioning System**. Furnish a post-tensioning system following the minimum requirements for Protection Level 2 (PL-2) in accordance with PTI/ASBI M50. Prequalify post-tensioning systems using tests on complete tendons for compliance with the requirements of PTI/ASBI M50.

The following exceptions apply:

- The embedded parts of the anchorage are not required to be galvanized or epoxy coated, unless otherwise noted on the plans.
- Provide pre-packaged grouts in accordance with DMS-4670, "Grouts for Post-Tensioning" and Class C grout per PTI M55. Do not use grouts that exceed the manufacturers' recommend shelf life or 6 months, whichever is less.
- Provide unbonded single strand tendons in accordance with PTI M10.2-00: "Specification for Unbonded Single Strand Tendons."

3. EQUIPMENT

3.1. **Stressing Equipment**. Provide hydraulic jacks, pressure gauges, and other stressing equipment that meets PTI/ASBI M50.

3.2. **Grouting Equipment**. Provide grout mixing, testing, and pumping equipment that meets PTI M55.

4. CONSTRUCTION

The requirements of Item 420, "Concrete Substructures," and Item 422, "Concrete Superstructures," will govern for cast-in-place construction. Item 424, "Precast Concrete Structural Members (Fabrication)," will govern for precast concrete units or members.

4.1. **Qualifications of Personnel**. Perform all work for post-tensioning, including duct and hardware installation, strand insertion, and tendon or bar stressing, under the direct supervision of an individual certified as a PTI Level 2 Bonded PT Field Specialist. Perform all grouting operations under the direct supervision of an

individual who has received a Grouting Technician Certification from the American Segmental Bridge Institute (ASBI).

4.2. **Required Submittals**. Submit information required in this Section for post-tensioned elements, in addition to forming and falsework plans required by Item 420, "Concrete Substructures" and Item 424, "Precast Concrete Structural Members (Fabrication)." Include all necessary construction information in these submittals for cast-in-place and precast construction including, but not limited to the information required in this Section.

4.3. **Design Calculations**. Provide design procedures, coefficients, allowable stresses, tendon spacing, and clearances in accordance with the AASHTO LRFD *Bridge Design Specifications* and PTI/ASBI M50 unless otherwise shown on the plans. Submit sufficient calculations to support the proposed system and method of post-tensioning including friction loss diagrams. When the required jacking force for a particular type of tendon, duct, and configuration is furnished on the plans, design calculations are not required except to adjust for conditions different from those shown on the plans.

4.3.1. **Post-Tensioning Details**. Provide drawings with details that meet the requirements of PTI/ASBI M50 and this specification.

4.3.2. **Grouting Plan**. Submit for approval written grouting procedures at least 4 weeks before the start of the element's construction. Include items required by PTI M55.

Include the names of people responsible for PT installation and grouting operations, with the foreman of each grouting crew certified as a PTI Level 2 Bonded PT Field Specialist and ASBI Certified Grouting Technician.

4.4. **Packaging, Storing, and Handling of Post-Tensioning Components**. Package, store, and handle post-tensioning steel, grout, duct, and other accessories in accordance with PTI/ASBI M50 and PTI M55 unless otherwise indicated. Acceptance and rejection criteria for strand will follow PTI/ASBI M50 and PTI M55.

The following exceptions apply:

- Grout storage onsite will be limited to 30 days unless approval by the Engineer is given in advance of material delivery.
- Install grout caps and ensure vents are closed at all times so that water and other contaminants cannot enter the duct before strand installation.
- Do not flush ducts at any time.

4.5. **Duct and Prestressing Steel Installation for Post-Tensioning**. Follow PTI/ASBI M50 for duct and prestressing steel installation procedures and requirements unless otherwise specified. Verify that concrete strength requirements on the plans are met for stressing and staged loading of post-tensioned structural elements.

Stress the tendons within 7 days of installing the strand in the ducts unless otherwise approved in advance. Follow the tensioning procedure noted in the approved post-tensioning details.

4.6. **Grouting**. Grout in accordance with PTI M55.

Grout within 14 days of tendon stressing unless otherwise specified or approved. Obtain approval to extend the grouting time before stressing tendons.

Do not allow the grout temperature to exceed 85°F during mixing and pumping. Do not grout when the ambient temperature is below 35°F. Field-test the grout in accordance with Table 1 during grout installation. Perform field-testing by trained personnel at the Contractor's expense while witnessed by the Engineer. Pump at the lowest pressure possible that will maintain a continuous flow of grout.

Table 1
Requirements for Field-Testing of Grout

Test	Frequency	Requirement
Schupak Pressure Bleed Test (ASTM C1741)	1 per day	per DMS-4670
Fluidity test (Tex-437-A, Method 2)	2 every 2 hr. 2 min. per day	per DMS-4670
Compressive Strength test (3" × 6" cylinders)	1 per day	per DMS-4670
Mud Balance test (Tex-130-E Part II)[1]	2 per day	per DMS-4670

1. Take one sample from the mixer and one sample from the farthest duct outlet.

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 427
Surface Finishes for Concrete

1. DESCRIPTION

Finish concrete surface as specified.

2. MATERIALS

Furnish materials in accordance with this Article for the type of surface finish specified.

2.1. **Coatings**.

2.1.1. **Adhesive Grout and Concrete Paint**. Provide coatings in accordance with DMS-8110, "Coatings for Concrete." Match color of coating with Federal Standard 595C color 35630, concrete gray, unless otherwise shown on the plans.

2.1.2. **Opaque Sealer**. Provide penetrating-type sealer in accordance with DMS-8110, "Coatings for Concrete." Match color of coating with Federal Standard 595C color 35630, concrete gray, unless otherwise shown on the plans.

2.1.3. **Silicone-Based Paint**. Provide silicone resin emulsion paint (SREP) meeting the requirements of DMS-8141, "Paint, Silicon Resin for Concrete." Match color of coating with Federal Standard 595C color 35630, concrete gray, unless otherwise shown on the plans.

2.2. **Exposed Aggregate Finish**. Provide approved aggregates meeting the grading requirements shown on the plans. Provide gravel consisting of predominantly rounded particles unless otherwise shown on the plans. Use crushed stone when a bush-hammered finish is desired. Provide a concrete surface retardant. Provide clear Type II permanent anti-graffiti coating in accordance with DMS-8111, "Anti-Graffiti Coatings."

3. EQUIPMENT

The Engineer may require demonstration of the equipment's capabilities.

3.1. **Low-Pressure Water Blasting**. Use equipment capable of supplying a minimum pressure at the nozzle end of 3,000 psi at a minimum flow rate of 3 gpm. Use a 0° rotary, vibratory, or wobble-type nozzle. Use equipment capable of including abrasives in the water stream when specified on the plans.

3.2. **Abrasive Blasting**. Use equipment with filters to produce oil-free air and also water-free air when dry air is required.

3.3. **Slurry Blasting**. Use equipment capable of combining air and abrasives with water to form a wet blast media capable of cleaning and preparing surface without creating dust.

3.4. **Spraying**. Use equipment with fluid and air pressure regulators and gauges to allow for adjustment to produce a uniform spray pattern for spray applications.

3.5. **Off-the-Form Finish Forms**. Use nonstaining, nonporous, high-quality forming materials (e.g., steel or medium-density and high-density overlaid plywood forms). Use steel or high-density overlaid plywood forms when the same form will be used more than twice.

3.6. **Form Liners**. Provide form liners capable of producing a patterned finish as shown on the plans. Use form liners that provide a clean release from the concrete surface without pulling or breaking the textured concrete.

4. CONSTRUCTION

Provide the finish specified on the plans for the specific surface areas.

4.1. **Surface Areas of Finish**. "Surface area of finish" designates the areas where the specified surface is to be applied.

4.1.1. **Surface Area I**.

- surfaces of railing;
- exterior vertical faces of fascia beams, slabs, slab spans, arches, and box girders;
- the outside bottom surface of fascia beams and girders;
- the underside of overhanging slabs to the point of juncture of the supporting beam;
- the entire underside of slab spans when shown on the plans;
- vertical and underside surfaces of bents and piers;
- all surfaces of tie beams, abutments, bridge wingwalls, culvert headwalls and wingwalls, and retaining walls exposed to view after all backfill and embankment is placed; and
- all other exposed surfaces shown on the plans to require surface treatment.

4.1.2. **Surface Area II**. Surfaces of railing, all wingwalls, and the exterior vertical faces of slabs.

4.1.3. **Surface Area III**. Only the top and roadway faces of all concrete railing and bridge wingwalls.

4.1.4. **Surface Area IV**. Areas designated on the plans.

4.2. **Coatings**. Apply the coating specified on the plans.

4.2.1. **Preparation**. Clean the surface thoroughly before applying a coating by chemical cleaning, if required, and by blast cleaning.

Submit a containment plan that details the procedures proposed to keep public property, private property, and the environment from being adversely affected by the cleaning and painting operations. Do not discharge washwater into body of water or conveyance without TCEQ approval. Collect and properly dispose of any paint or debris dislodged as a result of cleaning operations.

4.2.1.1. **Chemical Cleaning**. Clean surfaces contaminated with oil, grease, or other contaminants by scrubbing the area with an approved detergent or other concrete cleaning material before blast cleaning. Do not use a solvent that will stain the surface or inhibit coating adhesion. Perform the following test to check for surface contamination of oil type materials:

- Spray the surface with a fine mist of potable water.
- Examine the area to see if water beads up.
- Clean the surface if beading is found.

4.2.1.2. **Blast Cleaning**. Blast clean the designated surface to remove weak surface material, curing compound, and other contaminants before applying a specified coating, leaving a lightly etched uniformly textured surface. Use an approved abrasive propelled by oil-free air with or without the addition of potable water, or blast with potable water with or without the addition of an approved abrasive at sufficient pressure to effectively clean and prepare the surface. Maintain the stand-off-distance of the nozzle to a maximum of 12 in. from the surface being cleaned when water blasting.

Do not damage concrete surface by gouging, spalling, or exposing coarse aggregate by the blasting operation.

Blow clean oil- and moisture-free air on all surfaces with sufficient pressure to remove loose particles immediately before application of any coating. Perform the following test to check for surface cleanliness as directed:

- Press a 10 in. long strip of 2 in. wide clear packing tape on the surface by rubbing with moderate pressure.
- Grasp the free end of the tape, and remove the tape from the surface with a sharp jerk.
- Examine the surface of the tape for clinging particles.

Continue cleaning the concrete surface until there are no particles clinging to the tape surface for subsequent tests. An additional test that can be used to check the surface for dust is to wipe the surface with a dark cloth and then examine the cloth for discoloration.

4.2.2. **Application**. Mix coating materials thoroughly with a mechanical mixer at a speed that causes the mixture to rotate entirely in the container. Ensure complete mixing by probing the container with a stirring device searching for non-dispersed or settled material.

Apply coatings once the new concrete has aged a minimum of 28 days except for the adhesive grout coating. Do not apply coatings when weather conditions will be detrimental to the final surface finish as determined by the Engineer. Do not apply coatings when surface temperature of the concrete exceeds 110°F.

Apply coatings to obtain a consistent color and texture.

4.2.2.1. **Adhesive Grout**. Apply coating on a moistened surface to a uniform minimum thickness of 1/16 in. Apply when ambient temperature is at least 50°F.

4.2.2.2. **Concrete Paint**. Apply the coating on a dry surface in 2 coats for a total maximum application rate of 150 sq. ft. per gallon. Match the color of the applied coating with the color standard shown on the plans. Do not thin material unless approved. Apply when ambient temperature is between 50°F and 100°F.

4.2.2.3. **Opaque Sealer**. Apply the coating to a dry surface in 2 coats for a total maximum application rate of 200 sq. ft. per gallon. Match the color of the applied coating with the approved color standard shown on the plans. Do not thin the material unless approved. Apply when ambient temperature is between 40°F and 100°F.

4.2.2.4. **Silicone Resin Paint**. Apply the coating on a dry surface in 2 coats at a rate not exceeding 300 sq. ft. per gallon per coat. Do not thin the material unless approved. Wait a minimum of 12 hr. between coats. Apply when ambient temperature is between 50°F and 100°F.

Repair surface finish where coating has been applied that exhibits peeling, flaking, or discoloration or has been damaged during construction. Remove defective or damaged coating. Clean and recoat repair area in accordance with the requirements of this Item.

4.3. **Special Surface Finishes**. Submit a work plan to the Engineer for any special finish shown on the plans. Include in the work plan the type of aggregates, materials, variation of panel or pattern arrangement, dimensions, construction methods, and other features affecting the work as is necessary for the "Special Surface Finish" specified.

4.3.1. **Blast Finish**. Provide surface profile as shown on the plans, or meet the minimum requirements of Section 427.4.2.1., "Preparation." Construct a 4 × 4 ft. sample panel using the same concrete used in construction of the member to receive the blast finish. Prepare the surface of the sample panel to meet the specified finish, and obtain approval of the sample finish. Use the approved sample panel finish as the standard for surfaces requiring a blast finish.

4.3.2. **Slurry Coat Finish**. Provide cementitious slurry coat finish to concrete surfaces within 14 days of placing concrete or later as approved. Water blast surface to moisten surface before application when application of slurry coat occurs more than 14 days after placing concrete. Do not apply slurry coat finish to surfaces receiving another type coating finish.

Submit for approval proposed slurry recipe including cement, latex concrete additive, with or without sand, and other additives before application. The Engineer will direct the level of surface texture the slurry coat will have, whether to include sand, and what fineness of sand is to be used. Tint mixture of slurry as specified on the plans and as directed. Maintain consistent slurry throughout project only modifying recipe to account for color variations being noticed as work progresses.

Rub in slurry with carborundum stone, stiff bristle brush, or other approved device. Limit thickness of applied slurry to a maximum of 1/16 in. thick. Demonstrate application methods for slurry coat and obtain approval of proposed surface. Apply slurry coat to obtain a tightly adhering cementitious finish to concrete surface. Remove material and reapply if slurry coat is not tightly adhering or is cracked.

4.3.3. **Rub Finish**. Provide a finish to the surface by rubbing the surface with a carborundum stone or other approved material. Begin rubbing the surface immediately after forms have been removed. Provide blast finish or other finish as directed at no additional cost to the Department if rubbing surface is delayed to the point where the surface is dry and unable to be rubbed to produce an acceptable finish. Perform the requirements to obtain the ordinary surface finish specified in Section 420.4.13., "Ordinary Surface Finish," concurrently with rubbing the surface. Rub concrete-patching areas after the patch material has thoroughly set and blend the patch in with the surrounding area to produce a surface with uniform color and texture where concrete patching is performed.

Keep the surface continuously wet after form removal until the rubbing is complete. Rub the surface sufficiently to bring the wetted concrete surface to a paste producing a smooth dense surface without pits, form marks, or other irregularities. Do not use cement grout to form the paste on the surface. Stripe the surface with a brush to conceal the rubbing pattern and allow the paste to reset. Wash the concrete with potable water after the paste has sufficiently set to leave it with a neat and uniform appearance and texture. Apply membrane curing, if required, in accordance with Item 420, "Concrete Substructures," after rubbing is complete.

4.3.4. **Off-the-Form Finish**. Provide a finish with minimal surface defects and uniform color and texture by using non-staining, non-porous, high-quality forming materials. Use the same type of forming materials for like elements for the entire structure.

Use mortar-tight forms to prevent leakage and discoloration. Seal joints with compressible gasket material, caulk, tape, or by other suitable means that are not detrimental to the concrete finish if necessary. Use one brand and type of form-release agents for all surfaces unless another product produces a similar concrete surface appearance. Do not use barrier-type (wax, fuel oil, carrier oil, etc.) release agents. Use form-release agents containing a rust inhibitor on steel forms. Clean rust off steel forms before use. Use plywood that will not cause discoloration of the concrete surface.

Direct special attention to consolidation and vibration of the concrete around the form surfaces to minimize bug holes. Modify concrete placement and vibration techniques if surface contains an excessive amount of bug holes. Remove all forms without interruption once form removal begins to prevent discoloration due to differing form curing times.

Do not use membrane curing on surfaces with off-the-form finish.

Repair honeycombed and spall areas with least dimension larger than 2 in. in accordance with the concrete surface repair procedures outlined in Item 420, "Concrete Substructures," to obtain an ordinary surface finish as defined in Section 420.4.13., "Ordinary Surface Finish." Patch honeycombed and spall areas with least dimension greater than 3/4 in. but smaller than 2 in. by filling defect with repair material omitting the chipping operation. Do not patch honeycombed and spall areas with least dimension smaller than 3/4 in. Perform required repairs as soon as forms are removed. Match repair material color and texture with surrounding

concrete surfaces. Minimize the area of repair by not smearing the repair material over acceptable concrete surfaces in an attempt to blend the repair with the surrounding concrete. Cut out form ties at least 1/2 in. below the surface, and patch accordingly. Perform repair work as soon as possible after removing forms so that concrete and repair material have similar ages. Replace or refurbish the forms when the Engineer determines defective formwork is causing an excessive amount of repair work.

4.3.5. **Form Liner Finish**. Provide patterned finish as shown on the plans. Do not splice form liner panels in a way that causes a noticeable transition or line between pieces. Wash and clean form liners after each use when the forms can be reused. Replace form liners that have become damaged or worn.

Construct a sample panel for each form liner finish. Approval is required to verify the sample panel meets the requirements of the plans and specifications before beginning work. Upon approval, the sample panel becomes the model panel that all other work will be compared against. Deviation in color, grade, or depth from the model panel is grounds for rejection of the form liner finish. Removal of defective work may be necessary as determined by the Engineer and in accordance with the surface finish requirements outlined in Item 420, "Concrete Substructures," to obtain an ordinary surface finish as defined in Section 420.4.13., "Ordinary Surface Finish."

Seal all form liner joints in a manner acceptable to the Engineer to prevent leakage at the surface.

4.3.6. **Exposed Aggregate Finish**. Provide exposed aggregate finish as indicated on the plans. Provide a depth of finish between 3/8 in. and 1/2 in. unless directed otherwise.

Apply a concrete surface retarder that penetrates approximately 1/4 in. into the forms or concrete surface to help achieve the desired finish. Apply 2 or 3 coats to wood forms to account for absorption if necessary. Tape or caulk form joints to prevent escape of the retarder during the placing operations. Protect the form surfaces from sun and rain while exposed to the atmosphere. Re-treat form surfaces with retarder if disturbed. Protect adjacent areas of concrete not requiring exposed aggregate finish from the retarder.

Remove forms 12 to 15 hr. after concrete placement but not before concrete has gained sufficient strength to support the self-weight of the member unless directed otherwise. Expose the aggregate for the finish immediately after form removal. Remove the grout paste covering the aggregate to be exposed by an approved method. Do not loosen the aggregate by the grout removal operation. Maintain required curing on all surfaces except for the time while the aggregate is being exposed. Cure using wet mats or membrane after the aggregate is exposed.

Repair defective areas as determined by the Engineer.

Re-clean exposed aggregate surfaces by an approved method. Apply a coat of clear Type II permanent anti-graffiti coating to cleaned exposed aggregate surface. Apply anti-graffiti coatings by spray, roller, or brush at the application rates recommended by the manufacturer and in accordance with Item 740, "Graffiti Removal and Anti-Graffiti Coating."

5. MEASUREMENT

When surface finishes for concrete is shown on the plans to be a pay item, measurement will be by the square foot of the type of surface finish specified.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurement or calculations will be made if adjustments of quantities are required.

6. PAYMENT

Unless otherwise specified on the plans, the work performed, materials furnished, equipment, labor, tools, and incidentals will not be paid for directly but will be considered subsidiary to pertinent Items.

When a surface finish for concrete is specified as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Adhesive Grout Finish," "Concrete Paint Finish," "Opaque Sealer Finish," "Silicone Resin Paint Finish," or "Blast Finish." This price is full compensation for materials; cleaning and preparing surfaces; application of materials; and equipment, labor, tools, and incidentals.

Slurry coat, rub, off-the-form, form liner, or exposed aggregate finishes (including anti-graffiti coating) will not be paid for under this Item but are subsidiary to other pertinent Items.

Item 429
Concrete Structure Repair

1. DESCRIPTION

Remove and repair unsound, delaminated, or spalled concrete.

2. MATERIALS

Submit all proposed repair materials for approval. Provide materials as outlined in the *Concrete Repair Manual* and in accordance with the requirements of the following Items.

- Item 421, "Hydraulic Cement Concrete"
- Item 431, "Pneumatically Placed Concrete"
- Item 440, "Reinforcement for Concrete"
- DMS-4655, "Concrete Repair Materials"
- DMS-6100, "Epoxies and Adhesives"

2.1. **Concrete Repair Materials**. Provide repair materials suitable for the appropriate horizontal, vertical, or overhead application meeting the requirements in DMS-4655, "Concrete Repair Materials." Use Type A materials when rapid strength gain is necessary and Type D (non-rapid) materials for standard concrete repairs unless otherwise noted on the plans. Use Type B ultra-rapid hardening materials or calcium aluminate cement (CAC) concrete only if indicated on the plans. Prepackaged repair materials not meeting the requirements of DMS-4655, "Concrete Repair Materials," or not on the Department's MPL may be used only with approval. Repair corrosion-induced spalls using materials that do not contain corrosion inhibitors unless indicated on the plans or approved. The Engineer may disallow any product based on its structural compatibility or appearance.

2.2. **Pneumatically Applied Materials**. Pneumatically applied concrete or mortar may be used, if approved, for any repair thickness. Provide and place pneumatically applied concrete in accordance with Item 431, "Pneumatically Placed Concrete." Prepare trial batches of any proposed repair material and application method as directed.

2.3. **Epoxy Mortars**. Use Type VIII neat epoxy or epoxy mortar per DMS-6100, "Epoxies and Adhesives," for repairs less than 1 in. thick unless noted otherwise on the plans.

2.4. **Concrete**. Provide Class C concrete for substructures, Class S concrete for decks, or concrete of the specified design strength unless noted otherwise as follows:

- as an option for vertical/overhead repairs greater than 6 in. thick;
- for full or partial depth slab repairs;
- for replacement of entire members or elements;
- as an option for horizontal repairs greater than 4 in. thick.

Submit a mix design for approval in accordance with Item 421, "Hydraulic Cement Concrete," unless otherwise shown on the plans. Include all pertinent information on admixtures. Do not use corrosion-inhibiting admixtures unless indicated on the plans or approved.

2.5. **Steel**. Provide steel pins, studs, or expansion bolts with a minimum diameter of 1/8 in. and a minimum length of 2 in. to attach reinforcement at the locations shown on the plans or as directed. Provide reinforcing steel, either welded wire fabric or reinforcing bars, as required by this Item or as shown on the plans.

3. CONSTRUCTION METHODS

Follow the procedures outlined in the *Concrete Repair Manual* unless approved otherwise. The Contractor may propose alternate repair methods for review and approval before commencing work.

Submit for approval all materials and methods of application at least 3 weeks before beginning any repair work.

Repair locations will be indicated on the plans or by the Engineer.

3.1. **Crack Repair**. Repair cracks in accordance with Item 780, "Concrete Crack Repair."

3.2. **Repair of Defective Work**. Repair or replace defective areas and patched areas that have debonded after completion of curing, as directed, at the Contractor's expense.

4. MEASUREMENT

This Item will be measured by the square foot, in place, as measured on the specified horizontal, vertical, or overhead surfaces of the completed repair as shown below or by the cubic yard for full element or member replacement. When a repair involves multiple surfaces, such as a corner, measurement will be made of all surfaces repaired. Bridge deck repairs will be measured by the square foot in place of the completed repair.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Structure Repair" of the kind specified. This price is full compensation for furnishing, placing, and curing all repair materials; removing concrete; saw-cutting; cleaning reinforcing steel; supplying and installing replacement or supplemental reinforcing steel, drive pins, studs, or expansion bolts; and equipment, labor, and incidentals.

Item 431
Pneumatically Placed Concrete

1. DESCRIPTION

Furnish and place pneumatically applied concrete for the construction of portions of structures, repairing concrete structures, encasement of structural steel members, lining ditches and tunnels, soil-nail walls, retaining walls, and other work as shown on the plans or as directed.

2. MATERIALS

Provide pre-bagged concrete materials for concrete structure repair and class of concrete shown on the plans for other work unless otherwise shown on the plans.

Submit pre-bagged materials information for approval. Material testing may be required before approval and installation test panels will be required in accordance with Section 431.2.4., "Proportioning and Mixing."

Provide materials in accordance with the pertinent requirements of the following Items with the exceptions noted in Section 431.2.1., "Exceptions to Item 421, 'Hydraulic Cement Concrete,'" Section 431.2.2., "Exceptions to Item 440, 'Reinforcement for Concrete,'" and Section 431.2.3., "Exception to DMS-6310, 'Joint Sealants and Fillers.'"

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- DMS-4655, "Concrete Repair Materials"
- DMS-6310, "Joint Sealants and Fillers"

2.1. **Exceptions to Item 421, "Hydraulic Cement Concrete**." Provide a fine aggregate that meets the requirements of Item 421, "Hydraulic Cement Concrete," Table 6, Grade 1, and a coarse aggregate that meets the requirements of Item 421, "Hydraulic Cement Concrete," Table 4, Grade 7, unless otherwise noted on the plans.

2.2. **Exceptions to Item 440, "Reinforcement for Concrete**." Provide mushroom headed steel anchors or expansion anchor hook bolts with a minimum diameter of 1/8 in. and a minimum length of 2 in. to attach reinforcement for the repair of concrete structures as shown on the plans or as directed. Reinforcing steel may be either welded wire fabric or reinforcing bars unless otherwise shown on the plans.

2.3. **Exception to DMS-6310, "Joint Sealants and Fillers**." Provide a preformed bituminous fiber material unless otherwise noted on the plans.

2.4. **Proportioning and Mixing**. Submit for approval a proposed mix design conforming to the basic mix design requirements provided in Table 1 unless otherwise shown on the plans.

Table 1
Classes of Concrete

Class	Ratio of Cement to Total Aggregate[1]	Minimum 7-Day Compressive Strength (psi)[2]
I	1:4	3,000
II	1:5	2,500

1. More cement may be used when approved.
2. Higher minimum strengths may be specified.

Measure the cement and aggregates by volume and mix with enough water to achieve the desired consistency. Use as little water as possible to achieve sufficient adhesion. Mix concrete sufficiently dry so it will not sag or fall from vertical or inclined surfaces or separate in horizontal work.

Prepare test panels using the same air pressure, nozzle tip, and position to be used for the production work to verify the mix design before approval. Apply a 3-in. layer of concrete to a plywood sheet with minimum dimensions of 18 in. × 18 in. for each test panel. Cure the test panels in the same manner as the proposed work.

Take 3 cores, each 2 in. in diameter, out of each test panel and test in compression at 7 days in accordance with Tex-424-A. The mix design will be approved when the average strength of the 3 cores conforms to the strengths shown in Table 1. Provide additional test panels as directed if there are any changes in materials, equipment, or nozzle operator during the work.

3. CONSTRUCTION

3.1. **Qualification**. Provide experienced personnel able to produce concrete satisfying plan requirements and of uniform quality as required. Provide documentation of nozzle operator's qualification for the process proposed and orientation of the application meeting the minimum requirements when shown on the plans.

Demonstrate nozzle operator's abilities by constructing test panels before commencement of work. Orient test panels to match application direction of placement. Include reinforcing steel in the test panel with similar spacing as in member. Qualification test panels may be used for mix verification in accordance with Section 431.2.4., "Proportioning and Mixing."

3.2. **Surface Preparation**. Grade the area of proposed work accurately to the elevation and dimensions shown on the plans when concrete is to be placed against soil. Compact with sufficient moisture to provide a firm foundation and to prevent absorption of water from the concrete but without free surface moisture.

Remove paint, rust, loose mill scale, grease or oil, and all other foreign materials that may reduce the bond of the concrete to the steel when concrete is used to encase structural steel members.

Remove all deteriorated or loose material by chipping with pneumatic, electric, or hand tools when concrete is placed against concrete or rock. Cut square or slightly undercut shoulders approximately 1 in. deep along the perimeter of repair areas. Sandblast the surface to clean all rust from exposed reinforcing steel and to produce a clean rough-textured surface on the concrete or rock. Wet the surface against which the concrete will be placed for at least 1 hour with potable water. Place the concrete when the surface has dried to a saturated surface-dry (SSD) condition. Achieve SSD conditions by high-pressure water blasting 15 to 30 min. before placing the repair material, soaking a minimum of 12 hr., or by other approved methods. An SSD condition is achieved when the surface remains damp when exposed to sunlight for 15 min.

Provide joints, side forms, headers, and shooting strips for backing or paneling. Use ground or gauging wires where necessary to establish thickness, surface planes, and finish lines.

3.3. **Reinforcement**. Place and secure reinforcement to ensure there is no displacement from impact of applying pneumatically placed concrete. Place reinforcing bars at a spacing not less than 2-1/2 in. Support reinforcing wire fabric or bars using mushroom headed anchors, expansion hook bolts, or grouted rebar capable of resisting a pullout force of 2,500 lb. Space anchors no more than 12 in. center-to-center on overhead

surfaces, 18 in. center-to-center on vertical surfaces, and 36 in. center-to-center on top horizontal surfaces. Use at least 3 anchors in each individual patch area. Do not use explosive force to shoot anchors into concrete. Check the resistance to pullout of the reinforcing anchors when directed. Notify the Engineer before installation of the anchors. Locate anchors so there is no damage to prestressing tendons or conduits embedded in the concrete.

Use reinforcement when performing repair work in all areas where the thickness of the concrete will exceed 1-1/2 in. Use a single layer of either 2 × 2 – W1.2 × W1.2 or 3 × 3 –W1.5 × W1.5 of welded wire fabric, or approved equivalent, unless noted otherwise on the plans. Use a single layer of wire fabric to reinforce each 4 in. thickness of patch or fractional part in areas where the concrete thickness exceeds 4 in. Encase completely each layer of wire fabric in concrete that has taken its initial set before installing the succeeding layer of wire fabric. Place the reinforcing fabric parallel to the finished surface, and support it so it will be at least 3/4 in. out from the surface to be covered. Provide at least 1 in. clearance between the finished concrete surface and all steel items including anchors, reinforcing bars, and wire fabric. Lap adjacent fabric sheets at least 6 in. and tie together securely at a spacing of no more than 18 in. Pre-bend fabric before installing to fit around corners and into re-entrant angles.

Pre-bend the welded wire fabric for encasement of steel members using a template to conform as nearly as possible to the outlines of the members to be encased. Drill holes between 1/2 and 1 in. in diameter in the webs of the members as close as possible to the flanges to allow for attachment of the reinforcing fabric. Space these holes at approximately 3 ft. on center. Use 3/8-in. diameter rods placed through these holes to secure the reinforcing fabric. Hold the reinforcing fabric at least 3/4 in. out from the surface of the steel member. Lap adjacent fabric sheets at least 6 in. and tie together at a spacing of no more than 12 in.

3.4. **Pneumatic Placement of Concrete**. Pneumatically applied concrete can be either dry-mix or wet-mix. The dry-mix process consists of dry-mixed fine aggregate and hydraulic cement to which water is added immediately before its pneumatic expulsion from a nozzle. The wet-mix process consists of mechanically premixed concrete pneumatically applied through a nozzle.

3.4.1. **General**. Place the concrete when the ambient temperature is above 35°F and rising and material temperature is between 50°F and 90°F for wet-mix and below 100°F for dry-mix. Do not place concrete against a surface containing frost, ice, or standing water. Protect concrete from freezing or quick drying after placement. Apply the concrete using pneumatic equipment that sprays the mix onto the prepared surface at a velocity less than 100 ft. per second for construction of portions of structures, repairing concrete structures, or encasement of structural steel members. Minimize rebound and produce a compacted dense homogenous mass. Do not apply concrete if high winds will prevent proper application or if rain could wash out the concrete.

Hold the nozzle approximately 2 to 4 ft. from the surface and position it so the concrete impinges nearly at right angles to the surface being covered. Use shooting strips to ensure straight lines, square corners, and a plane surface of concrete. Place to keep the trapping of rebound to a minimum. Slope the concrete off to a thin edge at the end of each day's work or at similar stopping periods requiring construction joint. Thoroughly clean and wet previously placed concrete before placing an adjacent or additional section. Apply a sufficient number of coats to obtain the required thickness. Place coats on vertical and overhead surfaces in layers of such thickness to prevent sloughing, sagging, tearing, or debonding. Provide a sufficient interval between successive layers in sloping, vertical, or overhead work to allow initial but not final set. Clean the surface to remove the thin film of laitance to provide for a bond with succeeding applications. Remove rebound and accumulated loose sand from the surface to be covered before placing of the original or succeeding layers of concrete. Correct any sags or other defects to the proper section as directed.

Place concrete to completely encase reinforcing steel. Encase reinforcing steel by shooting with sufficient velocity and plasticity that material flows around and behind reinforcement.

Apply the concrete using either the wet-mix or dry-mix process unless otherwise noted on the plans. Mix the materials thoroughly and uniformly using a paddle or drum type mixer designed for pneumatic application. Wet-mix process applications can use transit-mix concrete. Do not use the wet-mix process for repair of damaged concrete.

Clean mixing and placing equipment at regular intervals. Inspect the nozzle liner and water and air injection system daily; replace worn parts as necessary.

Do not reuse rebound or overspray concrete.

3.4.2. **Dry-Mix Process**. Use a compressor or blower capable of delivering a sufficient volume of oil-free air at the pressure shown in Table 2. Maintain steady pressure throughout the placing process.

Use a water pump with the size and capacity to deliver water to the nozzle with a pressure at least 15 psi more than the required air pressure.

The values shown in Table 2 are based on a hose length of 150 ft. with the nozzle less than 25 ft. above the delivery equipment. Increase operating pressure approximately 5 psi for each additional 50 ft. of hose and approximately 5 psi for each 25 ft. the nozzle is raised.

Table 2
Compressor Capacities

Compressor Capacity, CFM	Hose Diameter, in.	Maximum Size of Nozzle Tip, in.	Operating Air Pressure Available, psi
250	1	3/4	40
315	1-1/4	1	45
365	1-1/2	1-1/4	55
500	1-5/8	1-1/2	65
600	1-3/4	1-5/8	75
750	2	1-3/4	85

3.4.3. **Wet-Mix Process**. Operate the pump at a line pressure between 100 psi and 300 psi. Use delivery hoses between 1-1/2 in. and 3 in. in diameter. Use mixing equipment capable of thoroughly mixing the materials in sufficient quantity to maintain continuous placement.

3.5. **Construction Joints**. Use a square butt joint where the joint is subject to compressive stress or is over existing construction joints unless noted otherwise on the plans. Use tapered or square butt joints at other locations. Square the outside 1 in. of tapered joints perpendicular to the surface.

3.6. **Finish**. Use a sharp trowel to cut off all high spots after the concrete has been placed to the desired thickness or screed to a true plane as determined by shooting strips or by the original concrete surface. Lightly apply cutting screeds, where used, to all surfaces so as not to disturb the concrete for an appreciable depth. Work in an upward direction when concrete is applied on vertical surfaces. Give the finished concrete a final flash coat of about 1/8 in. unless directed otherwise. Obtain a uniform appearance on all exposed surfaces unless otherwise shown on the plans.

3.7. **Curing**. Cure encasements with water for 4 days. Cure repairs and structural construction using either a piece of wet burlap taped over the repaired area with a covering of 4-mil minimum plastic sheet also taped in place or membrane curing as approved. Overlap the burlap with the plastic sheet and continuously tape the edges with a tape at least 3 in. wide (air duct tape or better) to completely enclose the mat and hold in moisture. Cure in this manner for 4 days. Curing is not required for soil-nail walls unless walls are the final exposed surfaces, which in this case, cure at least 4 days in accordance with Item 420, "Concrete Substructures." Apply membrane curing in accordance with Section 420.2.7., "Curing Materials" for tunnel and ditch linings and vertical or overhead patches as approved.

3.8. **Repair of Defects**. Repair or replace debonded areas as directed.

4. MEASUREMENT

Measurement of pneumatically placed concrete for encasement of structural members will be by the square foot of the actual contact area.

Measurement of pneumatically placed concrete for repair of concrete structures will be by the cubic foot in place using the surface area times the average depth of the patch. When pneumatically placed concrete for repair of concrete structures is allowed or specified for Item 429, "Concrete Structure Repair," measurement and payment is in accordance with Article 429.5., "Payment."

5. PAYMENT

When pneumatically placed concrete is specified as a bid item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pneumatically Placed Concrete (Encasement)" or for "Pneumatically Placed Concrete (Repair)." This price is full compensation for cement, aggregate, water, and reinforcement; furnishing and installing steel anchors; removal of deteriorated or unsound concrete; mixing, placing, and curing pneumatically placed concrete; and equipment, labor, tools, and incidentals. Pneumatically placed concrete used for work other than encasement or repair will not be paid for directly but will be considered subsidiary to pertinent Items.

Item 432
Riprap

1. DESCRIPTION

Furnish and place concrete, stone, cement-stabilized, or special riprap.

2. MATERIALS

Furnish materials in accordance with the following Items.

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 431, "Pneumatically Placed Concrete"
- Item 440, "Reinforcement for Concrete"
- DMS-6200, "Filter Fabric"

2.1. **Concrete Riprap**. Use Class B Concrete unless otherwise shown on the plans.

2.2. **Pneumatically Placed Concrete Riprap**. Use Class II concrete that meets Item 431, "Pneumatically Placed Concrete," unless otherwise shown on the plans.

2.3. **Stone Riprap**. Use durable natural stone with a bulk specific gravity of at least 2.50 as determined by Tex-403-A unless otherwise shown on the plans. Provide stone that, when tested in accordance with Tex-411-A, has weight loss of no more than 18% after 5 cycles of magnesium sulfate solution.

Perform a size verification test on the first 5,000 sq. yd. of finished riprap stone for all types of stone riprap at a location determined by the Engineer. Test the riprap stone in accordance with ASTM D5519. Additional tests may be required. Do not place additional riprap until the initial 5,000 sq. yd. of riprap has been approved.

Provide grout or mortar in accordance with Item 421, "Hydraulic Cement Concrete," when specified. Provide grout with a consistency that will flow into and fill all voids.

Provide filter fabric in accordance with DMS-6200, "Filter Fabric." Provide Type 2 filter fabric for protection stone riprap unless otherwise shown on the plans. Provide Type 2 filter fabric for Type R, F, or Common stone riprap when shown on the plans.

2.3.1. **Type R**. Use stones between 50 and 250 lb. with at least 50% of the stones heavier than 100 lb.

2.3.2. **Type F**. Use stones between 50 and 250 lb. with at least 40% of the stones heavier than 100 lb. Use stones with at least 1 broad flat surface.

2.3.3. **Common**. Use stones between 50 and 250 lb. Use stones that are at least 3 in. in their least dimension. Use stones that are at least twice as wide as they are thick. When shown on the plans or approved, material may consist of broken concrete removed under the Contract or from other approved sources. Cut exposed reinforcement flush with all surfaces before placement of each piece of broken concrete.

2.3.4. **Protection**. Use boulders or quarried rock that meets the gradation requirements of Table 1. Both the width and the thickness of each piece of riprap must be at least 1/3 of the length. When shown on the plans or as approved, material may consist of broken concrete removed under the Contract or from other approved sources. Cut exposed reinforcement flush with all surfaces before placement of each piece of broken

concrete. Determine gradation of the finished, in-place, riprap stone under the direct supervision of the Engineer in accordance with ASTM D5519.

Table 1
In-Place Protection Riprap Gradation Requirements

Size	Maximum Size (lb.)	90% Size[1] (lb.)	50% Size[2] (lb.)	8% Size[3] Minimum (lb.)
12 in.	200	80–180	30–75	3
15 in.	320	170–300	60–165	20
18 in.	530	290–475	105–220	22
21 in.	800	460–720	175–300	25
24 in.	1,000	550–850	200–325	30
30 in.	2,600	1,150–2,250	400–900	40

1. Defined as that size such that 10% of the total riprap stone, by weight, is larger and 90% is smaller.
2. Defined as that size such that 50% of the total riprap stone, by weight, is larger and 50% is smaller.
3. Defined as that size such that 92% of the total riprap stone, by weight, is larger and 8% is smaller.

The Engineer may require in-place verification of the stone size. Determine the in-place size of the riprap stone by taking linear transects along the riprap and measuring the intermediate axis of the stone at select intervals. Place a tape measure along the riprap and determine the intermediate axis size of the stone at 2 ft. intervals. Measure a minimum of 100 stones, either in a single transect or in multiple transects, then follow ASTM D5519 Test Procedure Part B to determine the gradation. Table 2 is a guide for comparing the stone size in inches to the stone weight shown in Table 1.

Table 2
Protection Riprap Stone Size[1]

Size	Dmax (in.)	D90 (in.)	D50 (in.)	D8 (in.)
12 in.	13.76	10.14–13.29	7.31–9.92	3.39
15 in.	16.10	13.04–15.75	9.21–12.91	6.39
18 in.	19.04	15.58–18.36	11.10–14.21	6.59
21 in.	21.85	18.17–21.09	13.16–15.75	6.88
24 in.	23.53	19.28–22.29	13.76–16.18	7.31
30 in.	32.36	24.65–30.84	17.34–22.72	8.05

1. Based on a Specific Gravity of 2.5 and using the following equation for the intermediate axis diameter $D = \{(12*W)/(Gs*62.4*0.85)\}^{1/3}$

   where:
   D = intermediate axis diameter in in.;
   W = weight of stone in lbs.;
   Gs = Specific Gravity of stone.
   Note—If the Specific Gravity of the stone is different than 2.5, then the above equation can be used to determine the appropriate size using the actual Specific Gravity.

If required, provide bedding stone that, in-place, meets the gradation requirements shown in Table 3 or as otherwise shown on the plans. Determine the size distribution in Table 3 in accordance with ASTM D6913.

Table 3
Protection Riprap Bedding Material Gradation Requirements

Sieve Size (Sq. Mesh)	% by Weight Passing
3"	100
1-1/2"	50–80
3/4"	20–60
#4	0–15
#10	0–5

2.4. **Cement-Stabilized Riprap**. Provide aggregate that meets Item 247, "Flexible Base," for the type and grade shown on the plans. Use cement-stabilized riprap with 7% hydraulic cement by dry weight of the aggregate.

2.5. **Special Riprap**. Furnish materials for special riprap according to the plans.

3. CONSTRUCTION

Dress slopes and protected areas to the line and grade shown on the plans before the placement of riprap. Place riprap and toe walls according to details and dimensions shown on the plans or as directed.

3.1. **Concrete Riprap**. Reinforce concrete riprap with 6 × 6 – W2.9 × W2.9 welded wire fabric or with No. 3 or No. 4 reinforcing bars spaced at a maximum of 18 in. in each direction unless otherwise shown. Alternative styles of welded wire fabric that provide at least 0.058 sq. in. of steel per foot in both directions may be used if approved. A combination of welded wire fabric and reinforcing bars may be provided when both are permitted. Provide a minimum 6-in. lap at all splices. Provide horizontal cover of at least 1 in. and no more than 3 in. at the edge of the riprap. Place the first parallel bar no more than 6 in. from the edge of concrete. Use approved supports to hold the reinforcement approximately equidistant from the top and bottom surface of the slab. Adjust reinforcement during concrete placement to maintain correct position.

Sprinkle or sprinkle and consolidate the subgrade before the concrete is placed as directed. All surfaces must be moist when concrete is placed.

Compact and shape the concrete once it has been placed to conform to the dimensions shown on the plans. Finish the surface with a wood float after it has set sufficiently to avoid slumping to secure a smooth surface or broom finish as approved.

Cure the riprap immediately after the finishing operation according to Item 420, "Concrete Substructures."

3.2. **Stone Riprap**. Provide the following types of stone riprap when shown on the plans:

- **Dry Riprap**. Stone riprap with voids filled with only spalls or small stones.
- **Grouted Riprap**. Type R, F, or Common stone riprap with voids grouted after all the stones are in place.
- **Mortared Riprap**. Type F stone riprap laid and mortared as each stone is placed.

Use spalls and small stones lighter than 25 lb. to fill open joints and voids in stone riprap, and place to a tight fit.

Place mortar or grout only when the air temperature is above 35°F. Protect work from rapid drying for at least 3 days after placement.

Place filter fabric with the length running up and down the slope unless otherwise approved. Ensure fabric has a minimum overlap of 2 ft. Secure fabric with nails or pins. Use nails at least 2 in. long with washers or U-shaped pins with legs at least 9 in. long. Space nails or pins at a maximum of 10 ft. in each direction and 5 ft. along the seams. Alternative anchorage and spacing may be used when approved.

3.2.1. **Type R**. Construct riprap as shown in Figure 1 on the *Stone Riprap Standard* and as shown on the plans. Place stones in a single layer with close joints so most of their weight is carried by the earth and not the adjacent stones. Place the upright axis of the stones at an angle of approximately 90° to the embankment slope. Place each course from the bottom of the embankment upward with the larger stones in the lower courses.

Fill open joints between stones with spalls. Place stones to create a uniform finished top surface. Do not exceed a 6-in. variation between the tops of adjacent stones. Replace, embed deeper, or chip away stones that project more than the allowable amount above the finished surface.

Prevent earth, sand, or foreign material from filling the spaces between the stones when the plans require Type R stone riprap to be grouted. Wet the stones thoroughly after they are in place, fill the spaces between the stones with grout, and pack. Sweep the surface of the riprap with a stiff broom after grouting.

3.2.2. **Type F.**

3.2.2.1. **Dry Placement**. Construct riprap as shown in Figure 2 on the *Stone Riprap Standard*. Set the flat surface on a prepared horizontal earth bed, and overlap the underlying course to secure a lapped surface. Place the large stones first, roughly arranged in close contact. Fill the spaces between the large stones with suitably sized stones placed to leave the surface evenly stepped and conforming to the contour required. Place stone to drain water down the face of the slope.

3.2.2.2. **Grouting**. Construct riprap as shown in Figure 3 on the *Stone Riprap Standard*. Size, shape, and lay large flat-surfaced stones to produce an even surface with minimal voids. Place stones with the flat surface facing upward parallel to the slope. Place the largest stones near the base of the slope. Fill spaces between the larger stones with stones of suitable size, leaving the surface smooth, tight, and conforming to the contour required. Place the stones to create a plane surface with a variation no more than 6 in. in 10 ft. from true plane. Provide the same degree of accuracy for warped and curved surfaces. Prevent earth, sand, or foreign material from filling the spaces between the stones. Wet the stones thoroughly after they are in place, fill the spaces between them with grout, and pack. Sweep the surface with a stiff broom after grouting.

3.2.2.3. **Mortaring**. Construct riprap as shown in Figure 2 on the *Stone Riprap Standard*. Lap courses as described for dry placement. Wet the stones thoroughly before placing mortar. Bed the larger stones in fresh mortar as they are being place and shove adjacent stones into contact with one another. Spread excess mortar forced out during placement of the stones uniformly over them to fill all voids completely. Point up all joints roughly either with flush joints or shallow, smooth-raked joints as directed.

3.2.3. **Common**. Construct riprap as shown in Figure 4 on the *Stone Riprap Standard*. Place stones on a bed excavated for the base course. Bed the base course of stone well into the ground with the edges in contact. Bed and place each succeeding course in even contact with the preceding course. Use spalls and small stones to fill any open joints and voids in the riprap. Ensure the finished surface presents an even, tight surface, true to the line and grades of the typical sections.

Prevent earth, sand, or foreign material from filling the spaces between the stones when the plans require grouting common stone riprap. Wet the stones thoroughly after they are in place; fill the spaces between them with grout; and pack. Sweep the surface with a stiff broom after grouting.

3.2.4. **Protection**. Construct riprap as shown in Figure 5 on the *Stone Riprap Standard*. Place riprap stone on the slopes within the limits shown on the plans. Place stone for riprap on the filter fabric to produce a reasonably well-graded mass of riprap with the minimum practicable percentage of voids. Construct the riprap to the lines and grades shown on the plans or staked in the field. A tolerance of +6 in. and −0 in. from the slope line and grades shown on the plans is allowed in the finished surface of the riprap. Place riprap to its full thickness in a single operation. Avoid displacing the filter fabric. Ensure the entire mass of stones in their final position is free from objectionable pockets of small stones and clusters of larger stones. Do not place riprap in layers, and do not place it by dumping it into chutes, dumping it from the top of the slope, pushing it from the top of the slope, or any method likely to cause segregation of the various sizes. Obtain the desired distribution of the various sizes of stones throughout the mass by selective loading of material at the quarry or other source or by other methods of placement that will produce the specified results. Rearrange individual stones by mechanical equipment or by hand if necessary to obtain a reasonably well-graded distribution of stone sizes. Use the bedding thickness shown and place stone for riprap on the bedding material to produce a reasonably well-graded mass of riprap with the minimum practicable percentage of voids if required on the plans.

3.3. **Pneumatically Placed Concrete Riprap, Class II**. Meet Item 431, "Pneumatically Placed Concrete." Provide reinforcement following the details on the plans and Item 440, "Reinforcement for Concrete." Support reinforcement with approved supports throughout placement of concrete.

Give the surface a wood-float finish or a gun finish as directed. Cure the riprap with membrane-curing compound immediately after the finishing operation in accordance with Item 420, "Concrete Substructures."

3.4. **Cement-Stabilized Riprap**. Follow the requirements of the plans and the provisions for concrete riprap except when reinforcement is not required. The Engineer will approve the design and mixing of the cement-stabilized riprap.

3.5. **Special Riprap**. Construct special riprap according to the plans.

4. MEASUREMENT

This Item will be measured by the cubic yard of material complete in place. Volume will be computed on the basis of the measured area in place and the thickness and toe wall width shown on the plans.

If required on the plans, the pay quantity of the bedding material for stone riprap for protection to be paid for will be measured by the cubic yard as computed from the measured area in place and the bedding thickness shown on the plans.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Riprap" of the type, thickness, and void-filling technique (Dry, Grout, Mortar) specified, as applicable. This price is full compensation for furnishing, hauling, and placing riprap and for filter fabric, expansion joint material, concrete and reinforcing steel, grout and mortar, scales, test weights, equipment, labor, tools, and incidentals.

Payment for excavation of toe wall trenches, for all necessary excavation below natural ground or bottom of excavated channel, and for shaping of slopes for riprap will be included in the unit price bid per cubic yard of riprap.

When bedding is required for protection stone riprap, payment will be made at the unit price for "Bedding Material" of the thickness specified. This price is full compensation for furnishing, hauling, placing, and maintaining the bedding material until placement of the riprap cover is completed and accepted; excavation required for placement of bedding material; and equipment, scales, test weights, labor, tools, and incidentals. No payment will be made for excess thickness of bedding nor for material required to replace embankment material lost by rain wash, wind erosion, or otherwise.

Item 434
Bridge Bearings

1. DESCRIPTION

Furnish and install bearings for the support of bridge superstructure and substructure members. Bridge bearings under this specification consist of the 2 following categories and subcategories:

1.1. **Elastomeric Bridge Bearings:**

- **Plain Elastomeric Bearings**. Consisting of elastomer only.
- **Laminated Elastomeric Bearings**. Consisting of alternating individual layers of elastomer and steel laminates, with or without a steel top plate and special components (steel guide bars and bottom plate).
- **Sliding Elastomeric Bearings**. Consisting of a steel top (sole) plate with a stainless steel facing (upper component) bearing on a lower component. The lower component consists of a layer of polytetrafluoroethylene (PTFE) recessed and bonded to a steel plate that is vulcanized to the top of a laminated elastomeric bearing pad with or without special components (steel guide bars and bottom plate).

Plain and laminated elastomeric bridge bearings are designated by hardness (durometer), size, and configuration and, in the case of laminated bearings, by the thickness of the individual layers of elastomer and the size and position of any steel top plates.

1.2. **High Load Multi-Rotational (HLMR) Bearings:**

- **Disc Bearings**. Consisting of a polyether urethane disc contained between upper and lower steel bearing plates. The bearing has a shear resisting mechanism to prevent relative horizontal movement of the bearing plates and transmit horizontal loads.
- **Pot Bearings**. Consisting of a plain elastomeric disc confined by a shallow steel cylinder (pot) and a steel piston which engages the cylinder sufficiently to prevent their relative horizontal movement.

Provision for sliding movements (if required) uses a separate steel top plate with stainless steel facing (upper component) bearing on a lower component, and a lower component with a layer of PTFE bonded to the top of the upper steel bearing plate of the HLMR assembly. If required on the plans, restriction of lateral movement is provided by guide bars integrated with the steel top plate and interface components of the same stainless steel facing and PTFE layer.

HLMR bridge bearings are designated by configuration (fixed, multi-direction expansion, or guided expansion) and the vertical service reaction requirements. Fixed configurations allow rotation about the horizontal axis and prevent horizontal movement in all directions. Multi-direction expansion configurations allow rotation about the horizontal axis and horizontal movement in all directions. Guided expansion configurations allow rotation about the horizontal axis and horizontal movement in one direction as indicated on the plans, while guide bars and keyways restrict horizontal movement in the orthogonal direction. Provide either disc bearings or pot bearings unless a disc or pot bearing is specifically required on the plans. Provide a fabricator-designed HLMR bearing meeting the performance and dimensional criteria described on the plans and Section 434.2.3., "HLMR Bearings."

Bearings consisting of hinged steel bolster and rocker shoes, steel flat, cylindrical, or spherical bearings, and single/multiple steel roller bearings are not covered by this Item and must conform to Item 442, "Metal for Structures," unless shown otherwise on the plans.

2. MATERIALS

2.1. **Plain and Laminated Elastomeric Bearings**. Furnish bearings produced by a manufacturer from elastomer formulations approved by the Department. The Department's MPL has a list of approved bridge bearing elastomer formulations.

2.1.1. **Elastomer**. Provide elastomer for bearings formulated from previously unvulcanized 100% virgin polychloroprene rubber polymers meeting the physical properties, heat resistance, and compression set requirements of AASHTO M 251, Table X1.1, unless otherwise shown on the plans. Do not provide bearings containing previously vulcanized synthetic rubber or other synthetic rubber-like polymers. Perform material tests on the finished product in accordance with the applicable test methods. Do not use standard laboratory test slabs for this purpose. Prepare test specimens from the finished product in accordance with ASTM D3183.

Obtain approval for each elastomer formulation before use on Department projects. Submit certified test results to the Construction Division to prequalify and obtain approval of a particular formulation. Show actual test values obtained and the required values for the physical properties, heat resistance, and compression set of the elastomer when tested for compliance with the minimum requirements of AASHTO M 251, Table X1.1.

Forward samples (freight prepaid) to the Construction Division, Materials and Pavements Section, or their contracted testing laboratory when directed.

Submit only elastomer of the type or types to be supplied. Submit prequalification samples consisting of 2 finished bearings typical of the formulation and workmanship for Department projects. Submit 2 samples of each type when laminated and plain bearings are required. Laminated sample bearings may represent both plain bearings and laminated bearings for an elastomer formulation.

Plain sample bearings must measure 9 in. × 19 in. × 1 in. Laminated sample bearings must measure 9 in. × 14 in. × 1-1/2 in. with the following number of steel laminates:

- 50 durometer—3 steel laminates,
- 60 durometer—2 steel laminates, and
- 70 durometer—2 steel laminates.

Adhesion testing of laminated prequalification samples will be performed by the Department in accordance with Tex-601-J, Part I—Adhesion Test Method 1. Bond failure between the elastomer and steel laminates must occur as stated in this test method to constitute a passing test result. Presence of chlorinated compounds (neoprene) in the elastomer will be verified by the Department in accordance with Tex-601-J, Part IV—Chlorinated Compound Test Method.

Costs associated with testing elastomer formulations failing to conform to the requirements of this Item are borne by the bearings manufacturer. This cost will be assessed at the rate established by Construction Division at the time of testing.

Certify that the submitted samples are of the same basic elastomer formulation and of equivalent cure as the finished products to be furnished on Department projects.

Complete prequalification testing will be performed for each formulation at least once every 2 yr. and when necessary.

2.1.2. **Steel Laminates**. Provide steel laminates, for laminated bearings, of commercial grade steel strip or sheet with a thickness of 0.105 ±0.015 in.

2.1.3. **Steel Top Plates**. Provide steel top plates, when required for laminated bearings, in accordance with the plans.

2.1.4. **Special Components**. Provide steel guide bars and bottom plates, when required for laminated bearings, in accordance with the plans.

2.1.5. **Coatings**. Provide protective coatings for steel components materials in accordance with Item 445, "Galvanizing," or DMS-8104, "Paint, Shop Application for Steel Bridge Members," unless indicated otherwise on the plans.

2.2. **Sliding Elastomeric Bearings**.

2.2.1. **Lower Component**.

2.2.1.1. **PTFE**. Furnish PTFE materials that are pure virgin polytetrafluoroethylene fluorocarbon resin, unfilled. The finished materials must exhibit the physical properties shown in Table 1.

2.2.1.2. **Laminated Elastomeric Bearing Pad and Steel Plate**. Furnish laminated elastomeric bearing pads in accordance with Sections 434.2.1. and 434.3.1., "Plain and Laminated Elastomeric Bearings." Provide steel plates attached to laminated elastomeric bearing pads in accordance with the plans.

Table 1
Required PTFE Physical Properties

Physical Property	Test Method	Value (Unfilled)
Tensile strength, psi	ASTM D4894	2,800 Min
Elongation, %	ASTM D4894	200 Min
Melting point	ASTM D4894	622 ±4°F
Specific gravity	ASTM D792	2.16 ±0.03

2.2.2. **Upper Component**.

2.2.2.1. **Steel Top (Sole) Plates**. Provide steel top (sole) plates in accordance with the plans, and finished to ANSI #500 or better on the surface interfacing with the stainless steel sheet.

2.2.2.2. **Stainless Steel**. Provide Type 304 stainless steel sheet in accordance with ASTM A240. The thickness must be at least 1/16 in. unless otherwise shown on the plans.

2.2.3. **Special Components**. Provide steel guide bars and bottom plates, when required for sliding elastomeric bearings, in accordance with the plans.

2.2.4. **Coatings**. Provide coating materials as required in accordance with Item 445, "Galvanizing" and DMS-8104, "Paint, Shop Application for Structural Steel," unless indicated otherwise on the plans.

2.3. **HLMR Bearings**.

2.3.1. **Structural Design**. Provide a fabricator-developed design for the HLMR (disc or pot) bearings, meeting the service and factored vertical load capacity, service and factored horizontal load capacity, rotational capacity, and translation capacity requirements indicated on the plans and augmented by the requirements of this Item. Provide a bearing capable of transmitting 15% of the service vertical force as a factored horizontal load if no horizontal load capacity is provided on the plans. Provide a design that uses sole plate geometry or a grout interface to accommodate the longitudinal and transverse aspects of the bridge grade, and does not require the bearing to accommodate this in rotation unless indicated otherwise on the plans. If the bridge element supported by the bearing is cambered for dead load to be applied after the bearing is positioned, the dead load design rotation of the elastomer may be neglected provided the fabricator-developed design has checked the bearing for this temporary condition to ensure no damage occurs and there is no metal-to-metal contact. Provide a design that meets the current versions of the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*. Assume the plan rotations do not include requirements for uncertainties and construction tolerance stipulated in the AASHTO Specifications unless indicated on the plans.

2.3.2. **Maintenance Functionality**. Provide a fabricator-developed design that allows future removal with a maximum vertical jacking height of 1/4 in. after the load is removed. Provide a design with minimum 4-in. distance between the bottom of masonry plate and top of sole plate.

2.3.3. **Elements of HLMR Bearings**.

2.3.3.1. **Lower Component**.

2.3.3.1.1. **Polyether Urethane for Disc Bearings**. Furnish polyether urethane discs conforming to the material requirements of the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*, and the load and rotation demand indicated in Section 434.2.3.1., "Structural Design."

2.3.3.1.2. **Elastomeric Rotational Element for Pot Bearings**. Provide elastomer conforming to the material requirements of the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*, and the load and rotation demand indicated in Section 434.2.3.1., "Structural Design," with the exception that usage of virgin natural polyisoprene (natural rubber) is not allowed.

2.3.3.1.3. **PTFE**. For expansion HLMR bearings, furnish PTFE materials that are pure virgin polytetrafluoroethylene fluorocarbon resin, unfilled. The finished materials must exhibit the physical properties shown in Table 1. Provide PTFE that is bonded to the top steel bearing plate of the HLMR assembly in accordance with AASHTO LRFD *Bridge Construction Specifications*.

2.3.3.2. **Upper Component**.

2.3.3.2.1. **Steel Top Plates**. Provide steel top plates in accordance with the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*. Provide an ANSI #500 or better finish on the surface interfacing with the stainless steel sheet for expansion bearings. At the fabricator's option, the steel top plate may serve the function of the sole plate between the supported structure and the HLMR bearing assembly provided it matches geometric bevel requirements, plan dimensions, and minimum thickness for the sole plate depicted on the plans, while maintaining the performance requirements and avoiding damage due to installation. Otherwise, provide connectivity between the top plate and the sole plate or grouted interface as indicated on the plans. Coordinate any necessary adjustments to the sole plate geometry, connection method, or grouted interface with the Engineer to ensure compatibility with the structural design, before ordering any materials. Provide bolted connections for connection to steel trapezoidal box girder superstructures.

2.3.3.2.2. **Stainless Steel**. Provide Type 304 stainless steel sheet in accordance with ASTM A240. The thickness must be at least 1/16 in. unless otherwise shown on the plans.

2.3.3.3. **Miscellaneous Components**.

2.3.3.3.1. **Lateral Guides**. Provide guide bars integrated with the steel top plate and interface components of stainless steel facing and PTFE for guided HLMR expansion bearings. Submit alternate interface components to stainless steel and PTFE for review and approval. Provide details indicating guide bar, stainless steel, and PTFE attachment and design to sustain the lateral loads specified on the plans while maintaining unimpeded expansion capability.

2.3.3.3.2. **Piston**. Provide in accordance with the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*.

2.3.3.3.3. **Pot**. Provide in accordance with the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*.

2.3.3.3.4. **Sealing Rings**. Provide in accordance with the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*.

2.3.3.3.5. **Sealants**. Provide in accordance with the AASHTO LRFD *Bridge Design Specifications* and AASHTO LRFD *Bridge Construction Specifications*.

2.3.3.4. **Supporting Masonry Plate and Anchor Rods**. Coordinate any necessary adjustments to masonry plate geometry, connection method, or grout interface with the Engineer to ensure compatibility with the structure design before ordering any materials. Provide medium strength, mild steel or better type anchor rods in accordance with Item 449, "Anchor Bolts," including nuts and washers, unless indicated otherwise on the plans.

2.3.3.5. **Coatings**. Provide coating materials as required in accordance with Item 445, "Galvanizing," or DMS-8104, "Paint, Shop Application for Steel Bridge Members," unless indicated otherwise on the plans. Submit fabricator-preferred alternative coatings to the Engineer for review and approval.

3. CONSTRUCTION

3.1. **Plain and Laminated Elastomeric Bearings**. Electronically submit shop drawings for the complete assembly before fabrication of laminated elastomeric bearings with or without steel top plates or special components in accordance with the plans and Item 441, "Steel Structures." Provide a bearing layout with the shop drawings.

Mold together components of a laminated bearing to form an integral unit free of voids or separations in the elastomer or between the elastomer and the steel laminates or plates, unless otherwise shown on the plans. Provide well-vulcanized elastomer between the laminates or plates and on the outer surfaces of the bearing that is uniform and integral and resists separation by mechanical means into separate, definite, well-defined elastomeric layers. Evidence of this layered construction, either at the outer surfaces or within the bearing, will be cause for rejection. Repair of damaged elastomer on sides of laminated bearings is not allowed for product acceptance. Repair of damaged elastomer on top or bottom surfaces of laminated bearings is allowed when approved.

Cover edges of steel laminates with 1/8 in. to 1/4 in. of elastomer except exposure of the laminates will be permitted at approved laminate restraining devices and around holes entirely enclosed in the finished structure. Position laminates within 1/8 in. of plan location.

Plain bearings may be molded individually, cut from previously molded strips or slabs molded to the full thickness of the finished bearings, or extruded and cut to length. The finish of cut surfaces must be ANSI 250, or smoother. The finished bearings must have no voids or separations detectable either at the bearing surfaces or within the bearing. Plain elastomeric bearings must be well vulcanized, uniform, and integral units of such construction that the bearing is incapable of being separated by any mechanical means into separate, definite, well-defined elastomeric layers. Evidence of layered construction either at the outer surfaces or within the bearing will be cause for rejection.

The permissible variation from the dimensions and configuration shown on the plans for both plain and laminated bearings will be as listed in AASHTO M 251, Table 2. Flash tolerance, finish, and appearance must meet the requirements of the latest edition of the *Rubber Handbook* published by the Rubber Manufacturers Association, Inc., RMA F3 and T.063 for molded bearings and RMA F2 for extruded bearings.

Perform required welding in accordance with Item 441, "Steel Structures." Manufacture guide bars, when required, so adjacent top and bottom bar surfaces are parallel to within 1/16 in. in the assembled position. The tolerance for diameter of anchor bolt holes is +1/8 in., −0. The maximum deviation for flatness of steel plates is 1/16 in. in any 24 in. or as shown on the plans.

3.1.1. **Markings**. Mark the bearing type on the surface of each bearing as shown on the plans. The marking must remain legible until placement in the structure. Permanently mark, in addition, laminated bearings with:

- manufacturer's name or trademark,
- lot number,
- date of manufacture (month-year), and

- direction of slope.

Place this permanent marking on a face which is visible after erection of the bridge unless otherwise shown on the plans.

3.1.2. **Testing and Acceptance**. The sampling and testing of laminated bearing production, after prequalification approval, will be as follows:

3.1.2.1. **Laminated Bearings**. Subject each laminated bearing to a compression of 2,250 psi or a stress approved by the Engineer. Provide calibrated equipment per ASTM E4 for this compression testing. Each bearing will be acceptable if there is no visible evidence of bond failure or other damage and if the finished bearing meets other pertinent portions of this Item. Samples may be taken if the quality of production becomes questionable.

3.1.3. **Documentation**. Furnish certified laboratory test results on the elastomer properties of each batch or lot of compound for both plain and laminated bearings. Provide copies of certified mill test reports for laminated bearing steel top plates and any required steel special components.

3.1.4. **Storage**. Protect plain and laminated bearings from sunlight until placement in the structure.

3.1.5. **Field Methods**. Provide concrete surfaces for bearing areas under plain and laminated elastomeric bearings in accordance with Section 420.4.9., "Treatment and Finishing of Horizontal Surfaces."

Do not damage the elastomer when welding near bearings.

Damaged bearings will be subject to rejection and require replacement as directed.

3.2. **Sliding Elastomeric Bearings**. Electronically submit shop drawings for the complete assembly before fabrication of sliding elastomeric bearings in accordance with the plans and Item 441, "Steel Structures." Provide a bearing layout with the shop drawings.

Finish the steel top (sole) plate surface, interfacing with the stainless steel sheet, per Section 434.2.2.2.1., "Steel Top (Sole) Plates." Provide this finished surface flat to a tolerance of 1/32 in. Provide the remaining surface, outside the stainless steel sheet interface, flat to a tolerance of 1/16 in. in any 24 in.

Attach the stainless steel sheet to the steel top (sole) plate by continuous fillet-welding around the edges with an approved welding electrode. Do not extend the weld above the sliding surface. Protect the sliding surface from weld spatter. Polish the stainless steel sheet to a bright mirror finish less than 20 micro-in. rms, and solvent-clean to remove traces of polishing compound after attachment to the steel plate.

Fabricate the laminated elastomeric bearing pads according to Section 434.3.1., "Plain and Laminated Elastomeric Bearings." Vulcanize the laminated elastomeric bearing pad to the PTFE-faced steel plate. Machine the steel plate recessed surface flat to a tolerance of 1/32 in. and within 1/32 in. of required depth. Bond the PTFE material to the steel plate recessed surface with an approved adhesive. Fit the PTFE material into the recessed surface with not more than 1/32-in. gaps around the perimeter.

Perform required welding in accordance with Item 441, "Steel Structures." Manufacture guide bars when required so that adjacent top and bottom bar surfaces are parallel to within 1/16 in. in the assembled position. The tolerance for diameter of anchor bolt holes is +1/8 in., -0 in.

3.2.1. **Markings**. Mark the bearing type on the surface of each sliding elastomeric bearing. The marking must remain legible until placement in the structure. Permanently mark the laminated elastomeric bearing pad with the information specified in Section 434.3.1.1., "Markings."

3.2.2. **Testing and Acceptance**. Test a minimum of 10% of the sliding elastomeric bearing assemblies to a compressive strength of 2,250 psi or a stress approved by the Engineer. Provide calibrated equipment per

ASTM E4 for this compression testing. No tested sliding elastomeric bearing may show visible damage to the PTFE or stainless steel surfaces nor evidence of bond failure between the:

- PTFE-faced steel plate and laminated elastomeric bearing pad,
- steel laminates and elastomer within the laminated elastomeric bearing pad, and
- steel plate and PTFE.

Perform check tests if necessary on the steel, laminated elastomeric bearing pads, or PTFE material to verify the properties required under Section 434.2.2., "Sliding Elastomeric Bearings."

Bearings represented by test specimens passing the requirements of this Item will be approved for use in the structure subject to on-site inspection by the Engineer for visible defects.

3.2.2.1. **Lower Component**. Manufacture 1 additional bearing lower component per project for testing purposes. Notify the Construction Division, which will sample a bearing lower component at random from the lot, after bearings have been manufactured for a project. Forward selected samples (freight prepaid) to the Construction Division, or to their contracted testing laboratory when directed. Lower component samples will be tested to the following:

- Tex-601-J, Part II—Adhesion Test Method 2. Adhesion between the PTFE material and steel plate must meet a minimum 20 lb. per inch.
- Tex-601-J, Part III—Adhesion Test Method 3. Bond failure between the PTFE-faced steel plate and the laminated elastomeric bearing pad must occur as stated in this test method to constitute a passing test result.

Costs associated with testing sliding elastomeric bearing lower component project samples failing to conform to these requirements are borne by the bearings manufacturer. This cost will be assessed at the rate established by Construction Division at the time of testing.

3.2.2.2. **Documentation**. Furnish copies of certified mill test reports for the steel top (sole) plate, stainless steel, PTFE-faced steel plate, and any required steel special components. Provide a manufacturer's certification that the PTFE material meets the requirements of this Item. Furnish certified laboratory test results on the elastomer properties of each batch or lot of compound for laminated elastomeric bearing pads.

3.2.3. **Storage**. Store sliding elastomeric bearings horizontally in a dry, sheltered area. Provide moisture and dust-resistant wrapping maintained in good condition until installation. Lift bearings only from the undersides. Protect bearings from damage, dirt, oil, grease, and other foreign substances.

3.2.4. **Field Methods**. Provide concrete surfaces for bearing areas under sliding elastomeric bearings in accordance with Section 420.4.9., "Treatment and Finishing of Horizontal Surfaces."

Refer to the plans for temperature setting corrections for all bridges and bearing alignment relative to a chord for curved bridges. Perform such adjustments as directed if the plans do not address these requirements.

Exercise care in any field-welding required for the installation of a sliding elastomeric bearing to prevent damage to the elastomer, PTFE, or stainless steel surface. Repair damage to protective coating on the bearings and apply the final appearance coat in accordance with Item 446, "Field Cleaning and Painting Steel."

Damaged bearings will be subject to rejection and require replacement as directed.

3.3. **HLMR Bearings**. Electronically submit shop drawings for the complete assembly, before fabrication of HLMR bearings, in accordance with the plans. Provide a bearing layout with the shop drawings including geometric placement on substructure. Provide design calculations sealed by a licensed professional engineer.

3.3.1. **Markings**. Provide a permanent identification mark indicating each bearing's position in the structure and a direction arrow oriented in the forward station direction. Ensure the primary identification mark or a second such mark is provided at a visible location on the bearing after superstructure construction.

3.3.2. **Testing and Acceptance**. Coordinate arrangements for sampling and testing with the Construction Division before manufacturing all or a significant number of bearings for the project. Coordinate with the Construction Division, the number and type of tests that must be observed by a designated Construction Division representative. Perform testing in accordance with Section 18, "Bearing Devices," of the current AASHTO LRFD *Bridge Construction Specifications*. Use prequalification for certain tests only if approved by the Construction Division.

Disassemble bearings for visual inspection after testing. Replace or repair any bearings that reveal malfunction such as lift-off, galling between components, excessive deflection, yielding of steel, wrinkling of stainless steel, and flow or bond failure of PTFE. Perform testing to validate performance of replaced or repaired bearings as directed.

Costs associated with testing project samples failing to conform to these requirements are borne by the bearings manufacturer. This cost will be assessed at the rate established by Construction Division at the time of testing.

3.3.3. **Storage**. Store HLMR bearings horizontally in a dry, sheltered area. Provide moisture and dust-resistant wrapping maintained in good condition until installation. Lift bearings only from the undersides. Protect bearings from damage, dirt, oil, grease, and other foreign substances.

3.3.4. **Field Methods**. Provide concrete surfaces for bearing areas under HLMR bearings in accordance with Section 420.4.9., "Treatment and Finishing of Horizontal Surfaces," unless indicated otherwise on the plans or the HLMR bearing shop drawings.

Do not disassemble bearings unless otherwise approved by the Engineer with the guidance of the bearing fabricator. Clean any contaminated sliding surfaces as directed by the fabricator.

Place HLMR bearings on preformed fabric pads as indicated in Section 441.3.11.6., "Bearing and Anchorage Devices," unless indicated otherwise on the plans or the shop drawings. Refer to the plans for temperature setting corrections for all bridges and bearing alignment relative to a chord for curved bridges. Perform such adjustments as directed if the plans do not address these requirements.

Exercise care in any field-welding required for the installation of an HLMR bearing to prevent damage to the elastomer, disc element, PTFE, or stainless steel surface. Perform repair of damage to the prime coat on the bearings and apply the final appearance coat in accordance with Item 446, "Field Cleaning and Painting Steel."

Damaged bearings will be subject to rejection and require replacement as directed.

4. MEASUREMENT

4.1. **Plain and Laminated Elastomeric Bearings**. When plain and laminated elastomeric bearings are specified on the plans to be a pay item, measurement will be by each bearing.

4.2. **Sliding Elastomeric Bearings**. Sliding elastomeric bearings will be measured by each bearing.

4.3. **HLMR Bearings**. HLMR bearings will be measured by each bearing in a specified load range.

5. PAYMENT

5.1. **Plain and Laminated Elastomeric Bearings**. Plain and laminated elastomeric bearings used with precast prestressed concrete or rolled steel members will not be paid for directly but will be subsidiary to the pertinent Items.

For plain and laminated elastomeric bearings used with post-tensioned concrete superstructures, and with steel girders when specified as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Elastomeric Bearing" of the type specified. This price is full compensation for materials, including anchor bolts, top plates, steel special components; installation; and tools, equipment, labor, and incidentals.

5.2. **Sliding Elastomeric Bearings**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Sliding Elastomeric Bearing" of the type specified. This price is full compensation for the stainless steel faced top (sole) plate, the PTFE-faced steel plate vulcanized to the top of a laminated elastomeric bearing pad, the steel special components, the anchor bolts required to connect the bearing between superstructure and substructure; installation; and tools, equipment, labor, and incidentals.

5.3. **HLMR Bearings**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "HLMR Bearing" of the type specified. This price is full compensation for the stainless steel faced top (sole) plate, the PTFE-faced steel plate attached to the top bearing plate, the polyether urethane disc or elastomer layer, lateral guide components, shear restriction devices or outer cylinder pot, pot bearing seals, the anchor bolts required to connect the bearing to the supporting structure; installation; and tools, equipment, labor, and incidentals.

Item 438
Cleaning and Sealing Joints

1. DESCRIPTION

Clean and seal joints in new or existing rigid concrete pavements and bridge decks. Resize joints in rigid concrete pavements and approach slabs as shown on the plans.

2. MATERIALS

Use sealants of the class specified on the plans that meet the requirements of DMS-6310, "Joint Sealants and Fillers." Use primers recommended by the manufacturer of the sealant if required.

Provide backer rods that are circular and are 25% larger than the joint opening. Use backer rods compatible with the sealant that do not react or bond together.

3. EQUIPMENT

Use equipment that meets sealant manufacturer's recommendations. Use air compressors equipped with appropriate filters for removing oil and water from the air. Provide concrete saws with sufficient capacity to cut full depth of concrete pavement, approach slabs, and pan girder joints.

4. CONSTRUCTION

Submit information from the sealant manufacturer showing recommended equipment and installation procedures before starting work. All equipment and procedures will be subject to approval. If the equipment causes damage to dowels, reinforcing steel, concrete, base, sub-base, or subgrade, repair the damage and change the procedure and equipment to prevent further damage.

4.1. **Preparation**. Remove all debris, dirt, dust, saw-cuttings, and other foreign material from joint by an approved method. Collect and dispose of all the removed material.

Remove existing preformed bituminous fiber board material or other spacer material the full depth of the joint along with all other debris in the joint opening. Resize the joint sealant space by sawing to the width and depth shown on the plans to accommodate the type of sealant specified.

Clean debris from the diaphragm windows below the joints on concrete slab and girder bridges.

Abrasive blast clean the vertical faces of joints armored with steel to remove all visible rust, paint, mill scale, and other forms of contamination, leaving a white metal appearance. Clean concrete and other surfaces by method approved and in accordance with the manufacturer's specifications before placing sealant. Air blast the joint after cleaning to remove all dust.

Saw-cut concrete pavement and concrete approach slab full depth to provide joint opening as shown on the plans and as directed. Clean all debris out of the joint full depth of concrete pavement.

4.2. **Sealing**. Place the sealant in accordance with the manufacturer's recommended procedures. Apply the primer, when required, at the specified rate and time interval before applying the sealant. Apply the sealant to dry joint surfaces unless otherwise recommended by the sealant manufacturer. Tool any sealant material that is not self-leveling to force the sealant against the joint surfaces.

Place approved support spacers into joints as shown on the plans for concrete pavement. Place a backer rod in the joint opening to prevent the sealant from flowing through the joint and to hold the sealant at its required elevation unless directed otherwise. Set the top of the sealant and thickness of sealant as shown on the plans. Do not place sealant in an expansion-type joint if surface temperature is below 55°F or above 90°F.

5. MEASUREMENT

When specified on the plans to be a pay item, this Item will be measured by the foot of sealant placed.

6. PAYMENT

Unless otherwise specified on the plans, the work performed and materials furnished as this Item requires will not be paid for directly but will be subsidiary to bid items of the Contract.

When shown as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Cleaning and Sealing Existing Joints," "Cleaning and Sealing Joints" of the class, if specified, and "Cleaning Existing Joints," and "Resizing and Sealing Joints." This price is full compensation for furnishing all materials; sawing, routing, and cleaning and installing; disposing of debris; and equipment, labor, tools, and incidentals.

Item 440
Reinforcement for Concrete

1. DESCRIPTION

Furnish and place reinforcement of the type, size, and details shown on the plans.

2. MATERIALS

Use deformed steel bar reinforcement unless otherwise specified or allowed.

2.1. **Approved Mills**. Before furnishing steel, producing mills of reinforcing steel for the Department must be pre-approved in accordance with DMS-7320, "Qualification Procedure for Reinforcing Steel Producing Mills," by the Construction Division. The Department's MPL has a list of approved producing mills. Reinforcing steel obtained from unapproved sources will not be accepted.

Contact the Construction Division with the name and location of the producing mill for stainless reinforcing steel, low carbon/chromium reinforcing steel, or dual-coated reinforcing steel at least 4 weeks before ordering any material.

2.2. **Deformed Steel Bar Reinforcement**. Provide deformed reinforcing steel conforming to one of the following:

- ASTM A615, Grades 60, 75, or 80;
- ASTM A996, Type A, Grade 60;
- ASTM A996, Type R, Grade 60, permitted in concrete pavement only (Furnish ASTM A996, Type R bars as straight bars only and do not bend them. Bend tests are not required.); or
- ASTM A706, Grades 60 or 80.

Provide the grade of reinforcing steel shown on the plans. Provide Grade 60 if no grade is shown.

The nominal size, area, and weight of reinforcing steel bars this Item covers are shown in Table 1.

Table 1
Size, Area, and Weight of Reinforcing Steel Bars

Bar Size Number (in.)	Diameter (in.)	Area (sq. in.)	Weight per Foot (lbs.)
3	0.375	0.11	0.376
4	0.500	0.20	0.668
5	0.625	0.31	1.043
6	0.750	0.44	1.502
7	0.875	0.60	2.044
8	1.000	0.79	2.670
9	1.128	1.00	3.400
10	1.270	1.27	4.303
11	1.410	1.56	5.313
14	1.693	2.25	7.650
18	2.257	4.00	13.60

2.3. **Smooth Steel Bar Reinforcement**. Provide smooth bars for concrete pavement with a yield strength of at least 60 ksi and meeting ASTM A615. Provide steel conforming to ASTM A615 or meet the physical requirements of ASTM A36 for smooth bars that are larger than No. 3. Designate smooth bars by size number up to No. 4 and by diameter in inches above No. 4.

2.4. **Spiral Reinforcement**. Provide bars or wire for spiral reinforcement of the grade and minimum size or gauge shown on the plans.

Provide smooth or deformed wire conforming to ASTM A1064. Provide bars conforming to ASTM A615; ASTM A996, Type A; or ASTM A675, Grade 80, meeting dimensional requirements of ASTM A615.

2.5. **Weldable Reinforcing Steel**. Provide reinforcing steel conforming to ASTM A706 or with a maximum carbon equivalent (C.E.) of 0.55% if welding of reinforcing steel is required or desired. Provide a report showing the percentages of elements necessary to establish C.E. for reinforcing steel that does not meet ASTM A706, in order to be structurally welded. These requirements do not pertain to miscellaneous welds on reinforcing steel as defined in Section 448.4.2.1.1., "Miscellaneous Welding Applications."

Calculate C.E. using the following formula:

$$C.E. = \%C + \frac{\%Mn}{6} + \frac{\%Cu}{40} + \frac{\%Ni}{20} + \frac{\%Cr}{10} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

Do not weld stainless reinforcing steel without permission from the Engineer. Provide stainless reinforcing steel suitable for welding, if required, and submit welding procedures and electrodes to the Engineer for approval.

2.6. **Welded Wire Reinforcement**. Provide welded wire reinforcement (WWR) conforming to ASTM A1064. Observe the relations shown in Table 2 among size number, diameter in inches, and area when ordering wire by size numbers, unless otherwise specified. Precede the size number for deformed wire with "D" and for smooth wire with "W."

Designate WWR as shown in the following example: 6 × 12 – W16 × W8 (indicating 6-in. longitudinal wire spacing and 12-in. transverse wire spacing with smooth No. 16 wire longitudinally and smooth No. 8 wire transversely).

Table 2
Wire Size Number, Diameter, and Area

Size Number (in.)	Diameter (in.)	Area (sq. in.)
31	0.628	0.310
30	0.618	0.300
28	0.597	0.280
26	0.575	0.260
24	0.553	0.240
22	0.529	0.220
20	0.505	0.200
18	0.479	0.180
16	0.451	0.160
14	0.422	0.140
12	0.391	0.120
10	0.357	0.100
8	0.319	0.080
7	0.299	0.070
6	0.276	0.060
5.5	0.265	0.055
5	0.252	0.050
4.5	0.239	0.045
4	0.226	0.040
3.5	0.211	0.035
2.9	0.192	0.035
2.5	0.178	0.025
2	0.160	0.020
1.4	0.134	0.014
1.2	0.124	0.012
0.5	0.080	0.005

Note—Size numbers (in.) are the nominal cross-sectional area of the wire in hundredths of a square inch. Fractional sizes between the sizes listed above are also available and acceptable for use.

2.7. **Epoxy Coating**. Provide epoxy coated reinforcing steel as shown on the plans. Before furnishing epoxy coated reinforcing steel, an epoxy applicator must be pre-approved in accordance with DMS-7330, "Qualification Procedure for Reinforcing Steel Epoxy Coating Applicators." The Department's MPL has a list of approved applicators.

Furnish coated reinforcing steel meeting the requirements in Table 3.

Table 3
Epoxy Coating Requirements for Reinforcing Steel

Material	Specification
Bar	ASTM A775 or A934
Wire or WWR	ASTM A884 Class A or B
Mechanical couplers	As shown on the plans
Hardware	As shown on the plans

Use epoxy coating material and coating repair material that complies with DMS-8130, "Epoxy Powder Coating for Reinforcing Steel." Patch no more than 1/4-in. total length in any foot at the applicator's plant.

Maintain identification of all reinforcing steel throughout the coating and fabrication process and until delivery to the project site.

Furnish 1 copy of a written certification verifying the coated reinforcing steel meets the requirements of this Item and 1 copy of the manufacturer's control tests.

2.8. **Mechanical Couplers**. Use couplers of the type specified in DMS-4510, "Mechanical Couplers for Reinforcing Steel," Article 4510.5.A, "General Requirements" when mechanical splices in reinforcing steel bars are shown on the plans.

Furnish only couplers pre-qualified in accordance with DMS-4510, "Mechanical Couplers for Reinforcing Steel." Ensure sleeve-wedge type couplers are not used on coated reinforcing. Sample and test couplers for use on individual projects in accordance with DMS-4510, "Mechanical Couplers for Reinforcing Steel." Furnish couplers only at locations shown on the plans.

Furnish couplers for stainless reinforcing steel with the same alloy designation as the reinforcing steel.

2.9. **Fibers**. Supply fibers conforming to DMS-4550 "Fibers for Concrete" at the minimum dosage listed in the Department's MPL, when allowed by the plans. Use non-metallic fibers when shown on the plans.

2.10. **Stainless Reinforcing Steel**. Provide deformed steel bars of the types listed in Table 4 and conforming to ASTM A955, Grade 60 or higher when stainless reinforcing steel is required on the plans.

Table 4
Acceptable Types of Deformed Stainless Steel Bar

UNS Designation	S31653	S31803	S24100	S32304
AISI Type	316LN	2205	XM-28	2304

2.11. **Low Carbon/Chromium Reinforcing Steel**. Provide deformed steel bars conforming to ASTM A1035, Grade 100 when low carbon/chromium reinforcing steel is required on the plans.

2.12. **Dual-Coated Reinforcing Steel**. Provide deformed bars conforming to ASTM A1055, Grade 60 or higher when dual-coated reinforcing steel is required on the plans.

2.13. **Glass Fiber Reinforced Polymer Bars (GFRP)**. Provide bars conforming to the AASHTO LRFD *Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings*, Section 4, "Material Specifications" when GFRP bars are required on the plans. Provide sample certification demonstrating the GFRP bar supplier has produced bar that meets the Material Specifications 2 mo. before fabrication. Furnish certification upon shipment that the GFRP bar supplied meets the Material Specifications.

3. CONSTRUCTION

3.1. **Bending**. Fabricate reinforcing steel bars as prescribed in the CRSI *Manual of Standard Practice* to the shapes and dimensions shown on the plans. Fabricate in the shop if possible. Field-fabricate, if permitted, using a method approved by the Engineer. Replace improperly fabricated, damaged, or broken bars at no additional expense to the Department. Repair damaged or broken bars embedded in a previous concrete placement using a method approved by the Engineer.

Unless otherwise shown on the plans, the inside diameter of bar bends, in terms of the nominal bar diameter (d), must be as shown in Table 5.

Table 5
Minimum Inside Diameter of Bar Bends

Bend	Bar Size Number (in.)	Pin Diameter
Bends of 90° and greater in stirrups, ties, and other secondary bars that enclose another bar in the bend	3, 4, 5	4d
	6, 7, 8	6d
Bends in main bars and in secondary bars not covered above	3 through 8	6d
	9, 10, 11	8d
	14, 18	10d

Bend-test representative specimens as described for smaller bars in the applicable ASTM specification where bending No. 14 or No. 18 Grade 60 bars is required. Make the required 90° bend around a pin with a diameter of 10 times the nominal diameter of the bar.

Bend stainless reinforcing steel in accordance with ASTM A955.

3.2. **Tolerances**. Fabrication tolerances for bars are shown in Figure 1.

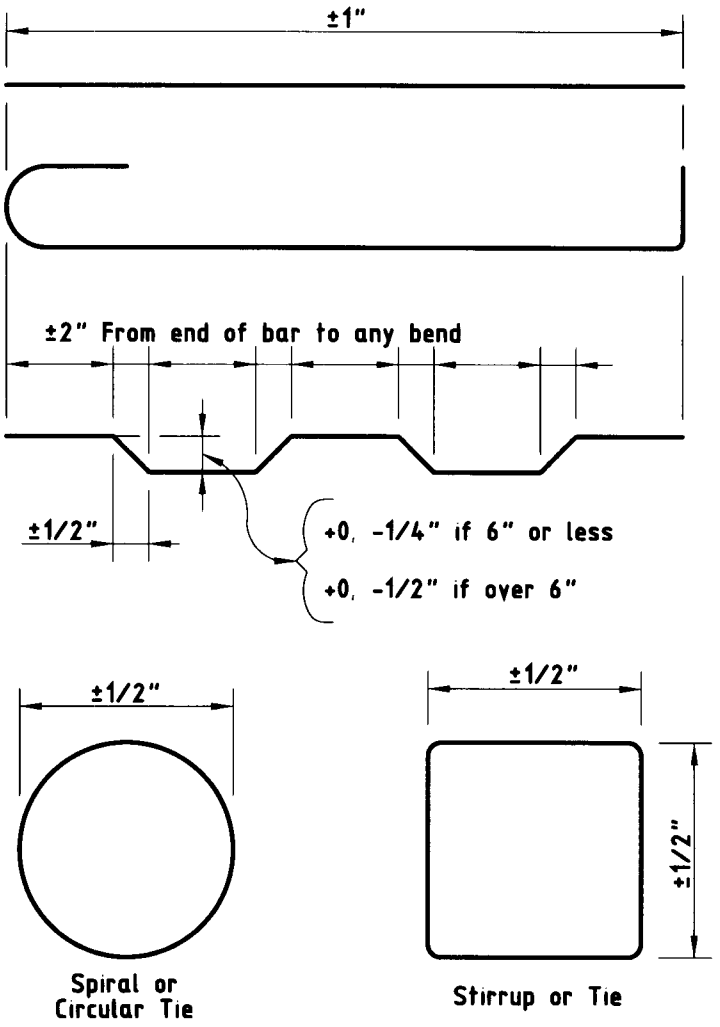


Figure 1
Fabrication Tolerances for Bars

3.3. **Storage**. Store reinforcement above the ground on platforms, skids, or other supports, and protect it from damage and deterioration. Ensure reinforcement is free from dirt, paint, grease, oil, and other foreign materials when it is placed in the work. Use reinforcement free from defects such as cracks and delaminations. Rust, surface seams, surface irregularities, or mill scale will not be cause for rejection if the minimum cross-sectional area of a hand wire-brushed specimen meets the requirements for the size of steel specified.

Do not allow stainless reinforcing steel to be in direct contact with uncoated reinforcing steel, nor with galvanized reinforcing steel. This does not apply to stainless steel wires and ties. Store stainless reinforcing steel separately, off the ground on wooden supports.

3.4. **Splices**. Lap-splice, weld-splice, or mechanically splice bars as shown on the plans. Additional splices not shown on the plans will require approval. Splices not shown on the plans will be permitted in slabs no more than 15 in. in thickness, columns, walls, and parapets.

- Do not splice bars less than 30 ft. in plan length unless otherwise approved. For bars exceeding 30 ft. in plan length, the distance center-to-center of splices must be at least 30 ft. minus 1 splice length, with no more than 1 individual bar length less than 10 ft. Make lap splices not shown on the plans, but otherwise

permitted, in accordance with Table 6. Maintain the specified concrete cover and spacing at splices, and place the lap-spliced bars in contact, securely tied together.

Table 6
Minimum Lap Requirements for Steel Bar Sizes through No. 11

Bar Size Number (in.)	Uncoated Lap Length	Coated Lap Length
3	1 ft. 4 in.	2 ft. 0 in.
4	1 ft. 9 in.	2 ft. 8 in.
5	2 ft. 2 in.	3 ft. 3 in.
6	2 ft. 7 in.	3 ft. 11 in.
7	3 ft. 5 in.	5 ft. 2 in.
8	4 ft. 6 in.	6 ft. 9 in.
9	5 ft. 8 in.	8 ft. 6 in.
10	7 ft. 3 in.	10 ft. 11 in.
11	8 ft. 11 in.	13 ft. 5 in.

- Do not lap No. 14 or No. 18 bars.
- Lap spiral steel at least 1 turn.
- Splice WWR using a lap length that includes the overlap of at least 2 cross wires plus 2 in. on each sheet or roll. Splices using bars that develop equivalent strength and are lapped in accordance with Table 6 are permitted.
- Lap the existing longitudinal bars with the new bars as shown in Table 6 for box culvert extensions with less than 1 ft. of fill. Lap at least 1 ft. 0 in. for extensions with more than 1 ft. of fill.
- Ensure welded splices conform to the requirements of the plans and of Item 448, "Structural Field Welding." Field-prepare ends of reinforcing bars if they will be butt-welded. Delivered bars must be long enough to permit weld preparation.
- Install mechanical coupling devices in accordance with the manufacturer's recommendations at locations shown on the plans. Protect threaded male or female connections, and ensure the threaded connections are clean when making the connection. Do not repair damaged threads.
- Mechanical coupler alternate equivalent strength arrangements, to be accomplished by substituting larger bar sizes or more bars, will be considered if approved in writing before fabrication of the systems.

3.5. **Placing**. Place reinforcement as near as possible to the position shown on the plans. Do not vary bars from plan placement by more than 1/12 of the spacing between bars in the plane of the bar parallel to the nearest surface of concrete. Do not vary bars from plan placement by more than 1/4 in in the plane of the bar perpendicular to the nearest surface of concrete. Provide a minimum 1-in. clear cover of concrete to the nearest surface of bar unless otherwise shown on the plans.

For bridge slabs, the clear cover tolerance for the top mat of reinforcement is −0, +1/2 in.

Locate the reinforcement accurately in the forms, and hold it firmly in place before and during concrete placement by means of bar supports that are adequate in strength and number to prevent displacement and keep the reinforcement at the proper distance from the forms. Provide bar supports in accordance with the CRSI *Manual of Standard Practice*. Use Class 1 supports, approved plastic bar supports, precast mortar, or concrete blocks when supports are in contact with removable or stay-in-place forms. Use Class 3 supports in slab overlays on concrete panels or on existing concrete slabs. Bar supports in contact with soil or subgrade must be approved.

Use Class 1A supports with epoxy coated reinforcing steel. Provide epoxy or plastic coated tie wires and clips for use with epoxy coated reinforcing steel.

Use mortar or concrete with a minimum compressive strength of 5,000 psi for precast bar supports. Provide a suitable tie wire in each block for anchoring to the bar.

Place individual bar supports in rows at 4-ft. maximum spacing in each direction. Place continuous type bar supports at 4-ft. maximum spacing. Use continuous bar supports with permanent metal deck forms.

The exposure of the ends of longitudinals, stirrups, and spacers used to position the reinforcement in concrete pipe and storm drains is not cause for rejection.

Tie reinforcement for bridge slabs and top slabs of direct traffic culverts at all intersections, except tie only alternate intersections where spacing is less than 1 ft. in each direction. Tie the bars at enough intersections to provide a rigid cage of reinforcement for reinforcement cages for other structural members. Fasten mats of WWR securely at the ends and edges.

Clean mortar, mud, dirt, debris, oil, and other foreign material from the reinforcement before concrete placement. Do not place concrete until authorized.

Stop placement until corrective measures are taken if reinforcement is not adequately supported or tied to resist settlement, reinforcement is floating upward, truss bars are overturning, or movement is detected in any direction during concrete placement.

3.6. **Handling, Placing, and Repairing Epoxy Coated Reinforcing Steel**.

3.6.1. **Handling**. Provide systems for handling coated reinforcing steel with padded contact areas. Pad bundling bands or use suitable banding to prevent damage to the coating. Lift bundles of coated reinforcement with a strongback, spreader bar, multiple supports, or a platform bridge. Transport the bundled reinforcement carefully, and store it on protective cribbing. Do not drop or drag the coated reinforcement.

3.6.2. **Placing**. Do not flame-cut coated reinforcement. Saw or shear-cut only when approved. Coat cut ends as specified in Section 440.3.6.3., "Repairing Coating."

Do not weld or mechanically couple coated reinforcing steel except where specifically shown on the plans. Remove the epoxy coating at least 6 in. beyond the weld limits before welding and 2 in. beyond the limits of the coupler before assembly. Clean the steel of oil, grease, moisture, dirt, welding contamination (slag or acid residue), and rust to a near-white finish after welding or coupling. Check the existing epoxy for damage. Remove any damaged or loose epoxy back to sound epoxy coating.

Coat the splice area after cleaning with epoxy repair material to a thickness of 7 to 17 mils after curing. Apply a second application of repair material to the bar and coupler interface to ensure complete sealing of the joint.

3.6.3. **Repairing Coating**. Use material that complies with the requirements of this Item and ASTM D3963 for repairing of the coating. Make repairs in accordance with procedures recommended by the manufacturer of the epoxy coating powder. Apply at least the same coating thickness as required for the original coating for areas to be patched. Repair all visible damage to the coating.

Repair sawed and sheared ends, cuts, breaks, and other damage promptly before additional oxidation occurs. Clean areas to be repaired to ensure they are free from surface contaminants. Make repairs in the shop or field as required.

3.7. **Handling and Placing Stainless Reinforcing Steel**. Handle, cut, and place stainless reinforcing steel bar using tools that are not used on carbon steel. Do not use carbon steel tools, chains, slings, etc. when handling stainless steel. Use only nylon or polypropylene slings. Cut stainless steel reinforcing using shears, saws, abrasive cutoff wheels, or torches. Remove any thermal oxidation using pickling paste. Do not field bend stainless steel reinforcing without approval.

Use 16 gauge fully annealed stainless steel tie wire conforming to the material properties listed in Section 440.2.10., "Stainless Reinforcing Steel." Support all stainless reinforcing steel on solid plastic, stainless steel, or epoxy coated steel chairs. Do not use uncoated carbon steel chairs in contact with stainless reinforcing steel.

3.8. **Bending, Handling, Repairing, and Placing GFRP Bars**. Fabricate, handle, repair, and place GFRP bars in accordance with the AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings, Section 5, Construction Specifications.

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be considered subsidiary to pertinent Items.

Item 441
Steel Structures

1. DESCRIPTION

Fabricate and erect structural steel and other metals used for steel structures or for steel portions of structures.

2. MATERIALS

2.1. **Base Metal**. Use metal that meets Item 442, "Metal for Structures."

2.2. **Approved Electrodes and Flux-Electrode Combinations**. Use only electrodes and flux-electrode combinations found on the Department's MPL. To request a product be added to this list or to renew an expired approval, electronically submit a current Certificate of Conformance containing all tests required by the applicable AWS A5 specification according to the applicable welding code (for most construction, AASHTO/AWS D1.5, *Bridge Welding Code*, or AWS D1.1, *Structural Welding Code—Steel*) to the Construction Division.

2.3. **High-Strength Bolts**. Use fasteners that meet Item 447, "Structural Bolting." Use galvanized fasteners on field connections of bridge members when ASTM A325 bolts are specified and steel is painted.

2.4. **Paint Systems**. Provide the paint system (surface preparation, primer, intermediate, and appearance coats as required) shown on the plans. Provide System IV if no system is specified.

2.4.1. **Standard Paint Systems**. Standard paint systems for painting new steel include the following:

2.4.1.1. **System III-B**. Provide paint in accordance with DMS-8101, "Structural Steel Paints-Performance." Provide inorganic zinc (IOZ) prime coat, epoxy intermediate coat, and urethane appearance coat for all outer surfaces except those to be in contact with concrete. Provide epoxy zinc prime coat for touchup of IOZ.

2.4.1.2. **System IV**. Provide paint in accordance with DMS-8101, "Structural Steel Paints-Performance." Provide IOZ prime coat and acrylic latex appearance coat for all outer surfaces except those to be in contact with concrete. Provide epoxy zinc prime coat for touchup of IOZ.

2.4.2. **Paint Inside Tub Girders and Closed Boxes**. Provide a white polyamide cured epoxy for all interior surfaces, including splice plate but excluding the faying surfaces, unless otherwise shown on the plans. Provide IOZ primer meeting the requirements of DMS-8101, "Structural Steel Paints—Performance," to all interior faying surfaces and splice plates.

2.4.3. **Special Protection System**. Provide the type of paint system shown on the plans or in special provisions to this Item. Special Protection Systems must have completed NTPEP Structural Steel Coatings (SSC) testing regimen as a complete system, with full data available through NTPEP.

2.4.4. **Galvanizing**. Provide galvanizing, as required, in accordance with Item 445, "Galvanizing."

2.4.5. **Paint over Galvanizing**. Paint over galvanized surfaces, when required, in accordance with Item 445, "Galvanizing."

2.4.6. **Field Painting**. Provide field paint, as required, in accordance with Item 446, "Field Cleaning and Painting Steel."

3. CONSTRUCTION

3.1. **General Requirements**.

3.1.1. **Applicable Codes**. Perform all fabrication of bridge members in accordance with AASHTO/NSBA Steel Bridge Collaboration S2.1. Follow all applicable provisions of the appropriate AWS code (D1.5 or D1.1) except as otherwise noted on the plans or in this Item. Weld sheet steel (thinner than 1/8 in.) in accordance with ANSI/AWS D1.3, Structural Welding Code—Sheet Steel. Unless otherwise stated, requirements of this Item are in addition to the requirements of S2.1 for bridge members. Follow the more stringent requirement in case of a conflict between this Item and S2.1. Perform all bolting in accordance with Item 447, "Structural Bolting."

Fabricate railroad underpass structures in accordance with the latest AREMA *Manual for Railway Engineering* and this Item. In the case of a conflict between this Item and the AREMA manual, the more stringent requirements apply.

3.1.2. **Notice of Fabrication**. Give adequate notice before commencing fabrication work as specified in Table 1. Include a schedule for all major fabrication processes and dates when inspections are to occur.

Table 1
Notice of Beginning Work

Plant Location	Notice Required
In Texas	7 days
In the contiguous United States	21 days
Outside the contiguous United States	60 days

Perform no Department work in the plant before the Engineer authorizes fabrication. The Contractor must bear all Department travel costs when changes to their fabrication or inspection schedules are not adequately conveyed to the Department.

When any structural steel is fabricated outside of the contiguous 48 states, the additional cost of inspection will be in accordance with Article 6.4., "Sampling, Testing, and Inspection."

3.1.3. **Bridge Members**. Primary bridge members include:

- web and flanges of plate, tub, and box girders;
- rolled beams and cover plates;
- floor beam webs and flanges;
- arch ribs and arch tie beams or girders;
- truss members;
- diaphragm members for curved plate girders or beams;
- pier diaphragm members for tub girders;
- splice plates for primary members; and
- any other member designated as "primary" or "main" on the plans.

Secondary bridge members include:

- bracing (diaphragms, cross frames, and lateral bracing); and
- all other miscellaneous bridge items not considered primary bridge members.

3.1.4. **Responsibility**. The Contractor is responsible for the correctness and completeness of shop drawings and for the fit of shop and field connections.

3.1.5. **Qualification of Plants and Personnel.**

3.1.5.1. **Plants.** Fabrication plants that produce bridge members must be approved in accordance with DMS-7370, "Steel Bridge Member Fabrication Plant Qualification." The Department's MPL has a list of approved bridge member fabrication plants.

Fabrication plants that produce non-bridge steel members listed below must be approved in accordance with DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification." The Construction Division maintains a list of approved non-bridge fabrication plants for the following items:

- Roadway Illumination Poles
- High Mast Illumination Poles
- High Mast Rings and Support Assemblies
- Overhead Sign Support Structures
- Traffic Signal Poles
- Intelligent Transportation System (ITS) Poles

The Department will evaluate non-bridge member fabrication plants for competence of the plant, equipment, organization, experience, knowledge, and personnel to produce acceptable work.

3.1.5.2. **Personnel.** Provide a QC staff qualified in accordance with the applicable AWS code. Provide an adequate number of qualified QC personnel for each specific production operation. QC must be on-site and independent of production personnel, as the Engineer determines. QC personnel must be proficient in utilizing the applicable plans, specifications, and test methods, and in verifying compliance with the plant QC and production procedures. Welding inspectors must be current AWS Certified Welding Inspectors for bridge member plants, and for non-bridge member plants requiring Department approval per DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification." The QC staff must provide inspection of all materials and workmanship before the Department's inspection. Provide the Department inspector with adequate personnel and equipment needed to move material for inspection access. QC is solely the Contractor's responsibility.

3.1.5.3. **Nondestructive Testing (NDT).** Personnel performing NDT must be qualified in accordance with the applicable AWS code and the employer's Written Practice. Level III personnel who qualify AS Level I and Level II inspectors must be certified by ASNT for which the NDT Level III is qualified. Testing agencies and individual third-party contractors must also successfully complete periodic audits for compliance, performed by the Department. In addition, ultrasound technicians must pass a hands-on test the Construction Division administers. This will remain current provided they continue to perform testing on Department materials as evidenced by test reports requiring their signature. A technician who fails the hands-on test must wait 6 months before taking the test again. Qualification to perform ultrasonic testing will be revoked when the technician's employment is terminated or when the technician goes 6 months without performing a test on a Department project. The technician must pass a new hands-on test to be re-certified.

3.1.5.4. **Welding Procedure Specifications Qualification Testing.** For bridge member fabrication, laboratories performing welding procedure specifications (WPSs) qualified by testing must be approved in accordance with DMS-7360, "Qualification Procedure for Laboratories Performing Welding Procedure Qualification Testing." The Department's MPL has a list of laboratories approved to perform WPS qualification testing.

3.1.6. **Drawings.**

3.1.6.1. **Erection Drawings.** Submit erection drawings prepared by a licensed professional engineer, including calculations, for approval in accordance with Item 5, "Control of the Work," at least 4 weeks before erecting any portion of field-spliced (welded or bolted) girders, railroad underpasses, trusses, arches, or other members for which erection drawings are required on the plans. Include drawings and calculations for any temporary structures used to support partially erected members. Erection drawings are not required for rolled I-beam units unless otherwise noted on the plans.

Prepare erection drawings following the procedures outlined in Section 2.2 of the AASHTO/NSBA Steel Bridge Collaboration S10.1. As a minimum, include:

- plan of work area showing structure location relative to supports and all obstructions;
- equipment to be used including allowable load information;
- erection sequence for all pieces;
- member weights and center of gravity location of pieces to be lifted;
- locations of cranes, holding cranes, and temporary supports (falsework), including when to release load from temporary supports and holding cranes;
- details of falsework including specific bracing requirements with maximum allowable design wind speed clearly indicated;
- girder lifting points;
- diaphragm and bracing requirements; and
- minimum connection requirements when more than the standard requirements.

Perform girder erection analyses using UT-Lift and UT-Bridge software available on the Department's website or other suitable commercial software. Ensure temporary stresses in members being erected will not cause permanent damage and that stability is maintained throughout the erection operations. Provide actual input files and output results from UT-Lift and UT-Bridge, or graphical and hard copy results from commercial software programs.

Do not proceed if site conditions differing from those depicted on the approved erection drawings could affect temporary support stresses, erected girders, or public safety in any manner. Revise erection drawings and resubmit to the Engineer for approval before proceeding if site conditions could affect these things.

3.1.6.2. **Shop Drawings**. Prepare and electronically submit shop drawings before fabrication for each detail of the general plans requiring the use of structural steel, forgings, wrought iron, or castings as documented in the *Guide to Electronic Shop Drawing Submittal* available on the Bridge Division website and as directed for other items the standard specifications require.

Indicate joint details on shop drawings for all welds. Provide a title block on each sheet in the lower right corner that includes:

- project identification data including federal and state project numbers,
- sheet numbering for the shop drawings,
- name of the structure or stream for bridge structures,
- name of owner or developer,
- name of the fabricator or supplier, and
- name of the Contractor.

Provide one set of 11 × 17-in. approved shop drawings in hardcopy to the Department for the inspector at the fabrication plant.

3.1.6.2.1. **Bridge Members**. Prepare drawings in accordance with AASHTO/NSBA Steel Bridge Collaboration G1.3, "Shop Detail Drawing Presentation" unless otherwise approved. Print a bill of material on each sheet, including the Charpy V-Notch (CVN) and fracture-critical requirements, if any, for each piece. Indicate fracture-critical areas of members.

3.1.6.2.2. **Non-Bridge Members**. Furnish shop drawings for non-bridge members when required by the plans or pertinent Items.

3.1.7. **Welding Procedure Specifications (WPSs)**. Submit WPSs and test reports in accordance with the applicable AWS code to the Construction Division before fabrication begins, and notify the Engineer which procedures will be used for each joint or joint type. Do not begin fabrication until the Engineer approves WPSs.

Post the approved WPSs for the welding being performed on each welding machine, or use another approved method of ensuring the welder has access to the procedure information at all times.

3.1.8. **Documentation**. Before beginning fabrication, provide a completed Material Statement Form 1818 (a.k.a. D-9-USA-1) with supporting documentation (such as mill test reports (MTRs)) that the producing mill issues and qualified personnel verifies. Ensure the documentation legibly reflects all information the applicable ASTM specifications require. Supply documents electronically to the Department.

Provide a copy of the shipping or storage invoice, as material is shipped or placed in approved storage, that reflects:

- member piece mark identification and calculated weight per piece from the contract drawings,
- number of pieces shipped or in storage,
- total calculated weight for each invoice per bid item, and
- the unique identification number of the shipping or storage invoice.

The inspector's acceptance of material or finished members will not prohibit subsequent rejection if the material or members are found to be damaged or defective. Replace rejected material promptly.

3.1.9. **Material Identification**. Assembly-mark individual pieces and issue cutting instructions to the shop using a system that will maintain identity of the original piece.

Identify structural steel by standard and grade of steel. Also differentiate between material toughness requirements (CVN, fracture-critical) as well as any other special physical requirements. In addition, identify structural steel for primary members by mill identification numbers (heat numbers). Use an approved identification system. Use either paint or low-stress stencils to make identification markings on the metal. Mark the material as soon as it enters the shop and carry the markings on all pieces through final fabrication. Transfer the markings before cutting steel for primary members of bridge structures into smaller pieces. Loss of identification marking on any piece, with no other positive identification, or loss of heat number identification on any primary member piece will render the piece unacceptable for use. Unidentifiable material may be approved for use after testing to establish acceptability to the satisfaction of the Engineer. Have an approved testing facility perform testing and a licensed professional engineer sign and seal the results.

3.2. **Welding**.

3.2.1. **Details**.

3.2.1.1. **Rolled Edges**. Trim plates with rolled edges used for webs by thermal cutting.

3.2.1.2. **Weld Tabs**. Use weld tabs at least 2 in. long for manual and semi-automatic processes, at least 3 in. long for automatic processes, and in all cases at least as long as the thickness of the material being welded. Use longer weld tabs as required for satisfactory work.

3.2.1.3. **Weld Termination**. Terminate fillet welds approximately 1/4 in. from the end of the attachment except for galvanized structures and flange-to-web welds, for which the fillet weld must run the full length of the attachment, unless otherwise shown on the plans.

3.2.1.4. **No-Paint Areas at Field-Welded Connections**. Keep surfaces within 4 in. of groove welds or within 2 in. of fillet welds free from shop paint.

3.2.1.5. **Galvanized Assemblies**. Completely seal all edges of tightly contacting surfaces by welding before galvanizing.

3.2.1.6. **Submerged-Arc Welding (SAW)**. Do not use hand-held semiautomatic SAW for welding bridge members unless altered to provide automatic guidance or otherwise approved.

3.2.1.7. **Tubular Stiffeners for Bridge Members**. Weld in accordance with AWS D1.5, using WPSs qualified based on tests on ASTM A709 Gr. 50W or Gr. 50 steel for non-weathering applications and ASTM A709 Gr. 50W steel for weathering applications.

3.2.1.8. **Non-Bridge Member Weathering Steel Welds**. Provide weld metal with atmospheric corrosion resistance and coloring characteristics similar to that of the base metal for weathering steel structures fabricated per AWS D1.1.

3.2.2. **Shop Splices**.

3.2.2.1. **Shop Splice Locations**. Keep at least 6 in. between shop splices and stiffeners or cross-frames. Obtain approval for shop splices added after shop drawings are approved.

3.2.2.2. **Grinding Splice Welds**. Grind shop groove welds in flange plates smooth and flush with the base metal on all surfaces whether the joined parts are of equal or unequal thickness. Grind so the finished grinding marks run in the direction of stress, and keep the metal below the blue brittle range (below 350°F). Groove welds in web plates, except at locations of intersecting welds, need not be ground unless shown on the plans except as required to meet AWS welding code requirements.

3.2.3. **Joint Restraint**. Never restrain a joint on both sides when welding.

3.2.4. **Stiffener Installation**.

3.2.4.1. **Flange Tilt**. Members must meet combined tilt and warpage tolerances before the installation of stiffeners. Cut stiffeners to fit acceptable flange tilt and cupping. Minor jacking or hammering that does not permanently deform the material will be permitted.

3.2.4.2. **Stiffeners Near Field Splices**. Tack weld intermediate stiffeners within 12 in. of a welded field splice point in the shop. Weld the stiffeners in the field in accordance with Item 448, "Structural Field Welding," after the splice is made.

3.2.5. **Nondestructive Testing (NDT)**. Perform magnetic particle testing (MT), radiographic testing (RT), or ultrasonic testing (UT) at the Contractor's expense as specified in D1.5 for bridge structures. The Engineer will periodically witness, examine, verify, and interpret NDT. Additional welds may be designated for NDT on the plans. Retest repaired groove welds per the applicable AWS code after repairs are made and have cooled to ambient temperature. Complete NDT and repairs before assembly of parts into a member, but after any heat-correction of weld distortion.

3.2.5.1. **Radiographic Testing**. Radiographs must have a density of at least 2.5 and no more than 3.5, as a radiographer confirms. The density in any single radiograph showing a continuous area of constant thickness must not vary in this area by more than 0.5. Use only ASTM System Class I radiographic film as described in ASTM E1815. Use low-stress stencils to make radiograph and location identification marks on the steel. The Engineer will examine and interpret all results of RT.

3.2.5.2. **Ultrasonic Testing**. Have UT equipment calibrated yearly by an authorized representative of the equipment manufacturer or by an approved testing laboratory.

3.2.5.3. **Magnetic Particle Testing**. Use half-wave rectified DC when using the yoke method unless otherwise approved. Welds may be further evaluated with prod method for detecting centerline cracking.

3.2.6. **Testing of Galvanized Weldments**. If problems develop during galvanizing of welded material, the Engineer may require a test of the compatibility of the combined galvanizing and welding procedures in accordance with this Section and may require modification of one or both of the galvanizing and welding procedures.

Prepare a test specimen with a minimum length of 12 in. using the same base material, with the same joint configuration, and using the welding procedure proposed for production work if testing is required. Clean and

galvanize this test specimen using the same conditions and procedure that will be applied to the production galvanizing.

Examine the test specimen after galvanizing. There must be no evidence of excessive buildup of zinc coating over the weld area. Excessive zinc coating buildup will require modification of the galvanizing procedure.

Remove the zinc from the weld area of the test specimen and visually examine the surface. There must be no evidence of loss of weld metal or any deterioration of the base metal due to the galvanizing or welding procedure. Modify the galvanizing or welding procedure as required if there is evidence of deterioration or loss of weld metal, and run a satisfactory retest on the modified procedures before production work. Report procedures and results on the galvanized weldment worksheet provided by the Department.

3.3. **Bolt Holes**. Detail holes on shop drawings 1/16 in. larger in diameter than the nominal bolt size shown on the plans unless another hole size is shown on the plans.

Thoroughly clean the contact surfaces of connection parts in accordance with Item 447, "Structural Bolting," before assembling them for hole fabrication. Make holes in primary members full-size (by reaming from a subsize hole, drilling full-size, or punching full-size where permissible) only in assembly unless otherwise approved.

Ream and drill with twist drills guided by mechanical means unless otherwise approved. If subpunching holes, punch them at least 3/16 in. smaller than the nominal bolt size. Submit the proposed procedures for approval to accomplish the work from initial drilling or punching through check assembly when numerically controlled (N/C) equipment is used. Use thermal cutting for holes only with permission of the Engineer. Permission for thermal cutting is not required for making slotted holes, when slotted holes are shown on the plans, by drilling or punching 2 holes and then thermally cutting the straight portion between them. Perform all thermal cutting in accordance with Section 441.3.5.1., "Thermal Cutting."

Slightly conical holes that naturally result from punching operations are acceptable provided they do not exceed the tolerances of S2.1. The tolerance for anchor bolt hole diameter for bridge bearing assemblies is +1/8 in., −0.

3.4. **Dimensional Tolerances**. Meet tolerances of the applicable AWS specifications and S2.1 except as modified in this Section.

3.4.1. **Rolled Sections**. Use ASTM A6 mill tolerances for rolled sections, except D1.5 camber tolerances apply to rolled sections with a specified camber.

3.4.2. **Flange Straightness**. Ensure flanges of completed girders are free of kinks, short bends, and waviness that depart from straightness or the specified camber by more than 1/8 in. in any 10 ft. along the flange. Rolled material must meet this straightness requirement before being laid out or worked. Plates must meet this requirement before assembly into a member. Inspect the surface of the metal for evidence of fracture after straightening a bend or buckle. The Engineer may require nondestructive testing.

3.4.3. **Alignment of Deep Webs in Welded Field Connections**. For girders 48 in. deep or deeper, the webs may be slightly restrained while checking compliance with tolerances of S2.1 for lateral alignment at field-welded connections. In the unrestrained condition, webs 48 in. deep or deeper must meet the tolerances of Table 2. Girders under 48 in. deep must meet the alignment tolerances of S2.1.

Table 2
Web Alignment Tolerances for Deep Girders

Web Depth (in.)	Maximum Web Misalignment (in.)
48	1/16
60	1/8
72	1/4
84	5/16
96	5/16
108	3/8
120	7/16
132	7/16
144	1/2

3.4.4. **Bearings**. Correct bearing areas of shoes, beams, and girders using heat, external pressure, or both. Grind or mill only if the actual thickness of the member is not reduced by more than 1/16 in. below the required thickness.

3.4.4.1. **I-Beams, Plate Girders, and Tub Girders**. The plane of the bearing area of beams and girders must be perpendicular to the vertical axis of the member within 1/16 in. in any 24 in.

3.4.4.2. **Closed Box Girders**. Meet these tolerances:

- The plane of the bearing areas of the box girder is perpendicular to the vertical axis of the girder within 1/16 in. across any horizontal dimension of the bearing.
- The planes of the beam supports on the box girder are true to the vertical axis of the supported beams or girders to 1/16 in. in any 24 in.

In the shop, verify the plane of all bearing areas with the box placed on its bearings to field grade, using an approved process for verification.

3.4.4.3. **Shoes**. Meet these tolerances:

- The top bolster has the center 75% of the long dimension (transverse to the girder) true to 1/32 in., with the remainder true to 1/16 in., and is true to 1/32 in. across its entire width in the short dimension (longitudinal to the girder).
- The bottom bolster is true to 1/16 in. across its diagonals.
- For a pin and rocker type expansion shoe, the axis of rotation coincides with the central axis of the pin.
- When the shoe is completely assembled, as the top bolster travels through its full anticipated range, no point in the top bolster plane changes elevation by more than 1/16 in. and the top bolster does not change inclination by more than 1 degree, for the full possible travel.

3.4.4.4. **Beam supports**. Fabricate beam support planes true to the box girder bearing to 1/16 in. in the short direction and true to the vertical axis of the nesting girders to 1/16 in.

3.4.5. **End Connection Angles**. For floor beams and girders with end connection angles, the tolerance for the length back to back of connection angles is ±1/32 in. Do not reduce the finished thickness of the angles below that shown on the shop drawings if end connections are faced.

3.5. **Other Fabrication Processes**.

3.5.1. **Thermal Cutting**. Use a mechanical guide to obtain a true profile. Hand-cut only where approved. Hand-cutting of radii for beam copes, weld access holes, and width transitions is permitted if acceptable profile and finish are produced by grinding. Provide a surface finish on thermal-cut surfaces, including holes, in accordance with D1.5 requirements for base metal preparation. Obtain approval before using other cutting processes.

3.5.2. **Oxygen-Gouging**. Do not oxygen-gouge quenched and tempered (Q&T), normalized, or thermo-mechanically controlled processed (TMCP) steel.

3.5.3. **Annealing and Normalizing**. Complete all annealing or normalizing (as defined in ASTM A941) before finished machining, boring, and straightening. Maintain the temperature uniformly throughout the furnace during heating and cooling so the range of temperatures at all points on the member is no more than 100°F.

3.5.4. **Machining**. Machine the surfaces of expansion bearings so the travel direction of the tool is in the direction of expansion.

3.5.5. **Camber**. Complete cambering in accordance with S2.1 before any heat-curving.

3.5.6. **Heat Curving**. Heat-curve in accordance with S2.1. The methods in the AASHTO bridge construction specifications are recommended. Attach cover plates to rolled beams before heat-curving only if the total thickness of one flange and cover plate is less than 2-1/2 in. and the radius of curvature is greater than 1,000 ft. Attach cover plates for other rolled beams only after heat-curving is completed. Locate and attach connection plates, diaphragm stiffeners, and bearing stiffeners after curving, unless girder shrinkage is accounted for.

3.5.7. **Bending of Quenched and Tempered Steels**. The cold-bending radius limitations for HPS 70W in S2.1 apply to all Q&T steels.

3.6. **Nonconformance Reports (NCRs)**. Submit an NCR to the Engineer for approval when the requirements of this Item are not met. Submit NCRs in accordance with the Construction Division's NCR guidelines document. Have readily available access to the services of a licensed professional engineer experienced in steel structures design and fabrication. This licensed professional engineer may be responsible for reviewing potentially structurally deficient members in accordance with the NCR guidelines document. Receive Department approval before beginning repairs. Perform all repair work in strict compliance with the approved NCR and repair procedure.

3.7. **Shop Assembly**.

3.7.1. **General Shop Assembly**. Shop-assemble field connections of primary members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, field connections of floor beams and stringers (including for railroad structures), field-bolted diaphragms for curved plate girders and railroad underpasses, and rigid frames. Field-bolted cross-frames and rolled-section diaphragms do not require shop assembly. Complete fabrication, welding (except for shear studs), and field splice preparation before members are removed from shop assembly. Obtain approval for any deviation from this procedure. The Contractor is responsible for accurate geometry.

Use a method and details of preassembly consistent with the erection procedure shown on the erection plans and camber diagrams. The sequence of assembly may start from any location in the structure and proceed in one or both directions. An approved method of sequential geometry control is required unless the full length of the structure is assembled.

Verify by shop assembly the fit of all bolted and welded field connections between bent cap girders and plate girders or between plate girders and floor beams.

Do not measure horizontal curvature and vertical camber for final acceptance until all welding and heating operations are completed and the steel has cooled to a uniform temperature. Check horizontal curvature and vertical camber in a no-load condition.

3.7.2. **Bolted Field Connections**. Each shop assembly, including camber, alignment, accuracy of holes, and fit of milled joints, must be approved before the assembly is dismantled.

Assemble with milled ends of compression members in full bearing. Assemble non-bearing connections to the specified gap. Ream all subsize holes to the specified size while the connections are assembled, or drill full size while the connections are assembled. Notify the Engineer before shipping if fill plates or shims are added. Adding or increasing the thickness of shims or fill plates in bearing connections requires approval. Use drift pins and snug-tight bolts during the drilling process to ensure all planes of the connection (webs and flanges) can be assembled simultaneously. Do not use tack welds to secure plates while drilling.

Secure parts not completely bolted in the shop with temporary bolts to prevent damage in shipment and handling. Never use tack welds in place of temporary bolts.

Match-mark connecting parts in field connections using low-stress stencils in accordance with the diagram in the erection drawings.

3.7.3. **Welded Field Connections**. Mill or grind bevels for groove welds. Do not cut into the web when cutting the flange bevel adjacent to the web. End preparation, backing, and tolerances for girder splices must be in accordance with Item 448, "Structural Field Welding." Details for all other field-welds must conform to the applicable AWS code unless otherwise shown on the plans.

In the shop, prepare ends of beams or girders to be field-welded taking into account their relative positions in the finished structure due to grade, camber, and curvature. Completely shop-assemble and check each splice. Match-mark the splice while it is assembled with low-stress stencils in accordance with the diagram in the erection drawings.

3.8. **Finish and Painting**.

3.8.1. **Shop Painting**. Perform shop painting as required in DMS-8104, "Paint, Shop Application for Steel Bridge Members." Grind corners on new steel items to be painted (except for the coatings on box and tub girder interiors) that are sharp or form essentially 90° angles to an approximately 1/16 in. flat surface before blast cleaning. (A corner is the intersection of 2 plane faces.) This requirement does not apply to punched or drilled holes. Do not omit shop paint to preserve original markings.

Ensure painted faying surfaces meet the required slip and creep coefficients for bolted connections as outlined in DMS-8104, "Paint, Shop Application for Steel Bridge Members."

Use a Class A slip (minimum slip coefficient of 0.33) if no slip coefficient or corresponding surface condition is specified Perform all required testing at no expense to the Department.

Surface preparation and painting the interiors of Tub Girders and Closed Boxes is in accordance with DMS-8104, "Paint, Shop Application for Steel Bridge Members."

3.8.2. **Weathering Steel**. Provide an SSPC-SP 6 blast in the shop to all fascia surfaces of unpainted weathering steel beams. Fascia surfaces include:

- exterior sides of outermost webs and undersides of bottom flanges of plate girders and rolled beams,
- all outer surfaces of tub girders and box girders,
- all surfaces of truss members,
- webs and undersides of bottom flanges of plate diaphragms,
- bottom surfaces of floor beams, and
- any other surfaces designated as "fascia" on the plans.

Do not mark fascia surfaces. Use one of the following methods as soon as possible to remove any markings or any other foreign material that adheres to the steel during fabrication and could inhibit the formation of oxide film:

- SSPC-SP 1, "Solvent Cleaning"
- SSPC-SP 2, "Hand Tool Cleaning"
- SSPC-SP 3, "Power Tool Cleaning"

- SSPC-SP 7, "Brush-off Blast Cleaning"

Do not use acids to remove stains or scales. Feather out touched-up areas over several feet.

3.8.3. **Machined Surfaces**. Clean and coat machine-finished surfaces that are in sliding contact, particularly pins and pinholes, with a non-drying, water-repellent grease-type material containing rust-inhibitive compounds. Ensure the coating material contains no ingredients that might damage the steel. Protect machined surfaces from abrasive blasting.

3.9. **Handling and Storage of Materials**. Prevent damage when storing or handling girders or other materials. Remove or repair material damaged by handling devices or improper storage by acceptable means in accordance with ASTM A6 and the applicable AWS code.

Place stored materials on skids or acceptable dunnage above the ground. Keep materials clean. Shore girders and beams to keep them upright and free of standing water. Place support skids close enough to prevent excessive deflection in long members such as columns. Do not stack completed girders or beams at the jobsite.

Protect structural steel from salt water or other corrosive environments during storage and transit.

3.10. **Marking and Shipping**. Mark all structural members in accordance with the erection drawings. If a surface is painted, make the marks over the paint. Do not use impact-applied stencils to mark painted surfaces.

Mark the weight directly on all members weighing more than 3 tons.

Keep material clean and free from injury during loading, transportation, unloading, and storage. Pack bolts of each length and diameter, and loose nuts or washers of each size, separately and ship them in boxes, crates, kegs, or barrels. Plainly mark a list and description of the contents on the outside of each package.

3.11. **Field Erection**. Do not lift and place any steel member, including girders and diaphragms, over an open highway or other open travel way unless otherwise approved. Do not allow traffic to travel under erected members until sufficiently stable as shown on approved erection drawings.

3.11.1. **Pre-Erection Conference**. Schedule and attend a pre-erection conference with the Engineer at least 7 days before commencing steel erection operations. Do not install falsework or perform any erection operations before the meeting.

3.11.2. **Methods and Equipment**. Do not tack-weld parts instead of using erection bolts. Do not tack-weld parts to hold them in place for bolting. Provide falsework, tools, machinery, and appliances, including drift pins and erection bolts. Provide enough drift pins, 1/32 in. larger than the connection bolts, to fill at least 1/4 of the bolt holes for primary connections. Use erection bolts of the same diameter as the connection bolts.

Securely tie, brace, or shore steel beams or girders immediately after erection as shown on the erection drawings. Maintain bracing or shoring until the diaphragms are in place and as specified in the erection drawings. Protect railroad, roadway, and marine traffic underneath previously erected girders or beams from falling objects associated with other construction activities.

Only welders certified or working directly under the supervision of a foreman certified in accordance with Item 448, "Structural Field Welding," may handle torches when applying heat to permanent structural steel members.

3.11.3. **Falsework**. Construct falsework in accordance with the erection plan. Construct foundations for shore towers as shown on erection drawings. Do not use timber mats with deteriorated timbers or soil to construct shore tower foundations. Notify the Engineer of completed falsework to obtain approval before opening roadway to traffic or starting girder erection activities. Ensure falsework is protected from potential vehicle impact.

Inspect and maintain falsework daily. Use screw jacks or other approved methods to control vertical adjustment of falsework to minimize the use of shims.

3.11.4. **Handling and Assembly**. Accurately assemble all parts as shown on the plans and the approved shop drawings. Verify match-marks. Handle parts carefully to prevent bending or other damage. Do not hammer if doing so damages or distorts members. Do not weld any member for transportation or erection unless noted on the plans or approved by the Engineer.

3.11.4.1. **Welded Connections**. Weld flange splices to 50% of their thickness and meet the minimum erection bracing and support requirements before releasing the erection cranes, as shown on the plans and on the approved erection plans. Field-weld in accordance with Item 448, "Structural Field Welding."

3.11.4.2. **Bolted Connections**. Before releasing the erection cranes:

- install 50% of the bolts in the top and bottom flanges and the web with all nuts finger-tight,
- meet the minimum erection bracing and support requirements shown on the plans and on the approved erection plans, and
- install top lateral bracing across the connection for tub girders, and fully tension the bolts connecting the bracing to the top flanges.

Install high-strength bolts, including erection bolts, in accordance with Item 447, "Structural Bolting." Clean bearing and faying surfaces for bolted connections in accordance with Item 447, "Structural Bolting." Clean the areas of the outside ply under washers, nuts, and bolt heads before bolt installation. Ensure the required faying surface condition is present at the time of bolting.

3.11.5. **Misfits**. Correct minor misfits. Ream no more than 10% of the holes in a plate connection (flange or web), and ensure no single hole is more than 1/8 in. larger than the nominal bolt diameter. Submit proposed correction methods for members with defects that exceed these limits or prevent the proper assembly of parts. Straighten structural members in accordance with S2.1. Make all corrections in the presence of the Engineer at no expense to the Department. Do not remove and reweld gusset plates without approval.

3.11.6. **Bearing and Anchorage Devices**. Place all bearing devices such as elastomeric pads, castings, bearing plates, or shoes on properly finished bearing areas with full and even bearing on the concrete. Place metallic bearing devices on 1/4 in.-thick preformed fabric pads manufactured in accordance with DMS-6160, "Water Stops, Nylon-Reinforced Neoprene Sheet, and Elastomeric Pads," to the dimensions shown on the plans. Provide holes in the pad that are no more than 1/4 in. larger than the bolt diameter.

Build the concrete bearing area up to the correct elevation once it has been placed below grade using mortar that meets Item 420, "Concrete Substructures," and provide adequate curing. Use only mortar for build-ups between 1/8 in. and 3/8 in. thick. Use galvanized steel shims or other approved shim materials in conjunction with mortar if the bearing area must be raised more than 3/8 in.

Provide at least 75% contact of flange to shoe with no separation greater than 1/32 in. for beams and girders. Make corrections using heat or pressure in accordance with S2.1, or with galvanized shims. Correct small irregularities by grinding.

Provide at least 85% contact between the rocker plate and the base plate. Adjust the location of slotted holes in expansion bearings for the prevailing temperature. Adjust the nuts on the anchor bolts at the expansion ends of spans to permit free movement of the span. Provide lock nuts or burr the threads.

Remove all foreign matter from sliding or machine-finished surfaces before placing them in the structure.

Restore distorted bearing pads or expansion bearings to an equivalent 70°F position after completion of all welded or bolted splices, using an approved method of relieving the load on the bearing devices.

3.11.7. **Erecting Forms**. Do not erect forms until all welding or bolting is complete and the unit is positioned and properly set on the bearings unless otherwise noted on the plans.

3.11.8. **Field Finish**. Paint in accordance with Item 446, "Field Cleaning and Painting Steel." Restore weathering steel that will remain unpainted to a uniform appearance by solvent cleaning, hand cleaning, power brush, or blast cleaning after all welding and slab concrete placement has been completed. Remove from all unpainted weathering steel fascia surfaces (see Section 441.3.8.2., "Weathering Steel,") any foreign material, including markings, that adheres to the steel and could inhibit formation of oxide film as soon as possible. Feather out touched-up areas over several feet. Do not use acids to remove stains or scales.

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 442
Metal for Structures

1. DESCRIPTION

Provide structural steel, high-strength bolts, forgings, steel castings, iron castings, wrought iron, steel pipe and tubing, aluminum castings and tubing, or other metals used in structures, except reinforcing steel and metal culvert pipe.

2. MATERIALS

Furnish mill test reports (MTRs), supplemental test documentation, and certifications required by this and other pertinent Items.

2.1. **Structural Steel**. The Engineer may sample and test steel in accordance with ASTM A370.

2.1.1. **Bridge Structures**. Provide the grade of ASTM A709 steel shown on the plans. Grade 50W, 50S, or HPS 50W may be substituted for Grade 50 at no additional cost to the Department. Use Zone 1 if no AASHTO temperature zone is shown on the plans.

2.1.2. **Non-Bridge Structures**.

2.1.2.1. **Steel Classifications**. Provide the types and grades of steel listed in this Section unless otherwise shown on the plans.

2.1.2.1.1. **Carbon Steel**. Meet ASTM A36.

2.1.2.1.2. **Low-Alloy Steel**. Meet the requirements of one of the following standards:

- ASTM A529 Grade 50;
- ASTM A572 Grade 50 or 55;
- ASTM A588;
- ASTM A709 Grade 50, 50S, 50W, or HPS 50W; or
- ASTM A992.

Specify ASTM A6 supplemental requirement S18, "Maximum Tensile Strength," for material used for sign, signal, and luminaire supports.

2.1.2.2. **Impact Testing**. Tension members and components of the following structure types, if more than 1/2 in. thick. Other members designated on the plans must meet the Charpy V-notch (CVN) requirements of Table 1:

- base plates for roadway illumination assemblies, traffic signal pole assemblies, high mast illumination poles, camera poles, and overhead sign supports;
- pole mounting plates, arm mounting plates, and clamp-on plates for traffic signal pole assemblies;
- arm stiffeners, pole gussets, and stiffeners for traffic signal pole long mast arm assemblies (50 ft. to 65 ft.);
- pole shafts, ground sleeves, and handhole frames for high mast illumination poles;
- W-columns, tower pipes, multiple-sided shafts, tower pipe and multiple-sided shaft connection plates, chord angles, chord splice plates or angles, and truss bearing angles for truss type overhead sign supports; and

- pipe posts, pipe arms, post and arm flange plates, and handhole frames for monotube overhead sign supports.

Table 1
CVN Requirements for Non-Bridge Steel

Material	Thickness	Minimum CVN Toughness
ASTM A36, A53, A242, A500, A501, A709 Gr. 36, any other steel with minimum specified yield point below 40 ksi	up to 4"	15 ft.-lb. at 70°F
ASTM A572,[1] A588,[1] A633,[1] any other steel with minimum specified yield point between 40 and 65 ksi, inclusive	up to 2"	15 ft.-lb. at 70°F
	over 2" to 4", mechanically fastened	15 ft.-lb. at 70°F
	over 2" to 4", welded	20 ft.-lb. at 70°F
Any steel with minimum specified yield point over 65 ksi and under 90 ksi[2]	up to 2-1/2"	20 ft.-lb. at 50°F
	over 2-1/2" to 4", mechanically fastened	20 ft.-lb. at 50°F
	over 2-1/2" to 4", welded	25 ft.-lb. at 50°F

1. Reduce the testing temperature by 15°F for each 10-ksi increment or fraction thereof above 65 ksi if the yield point of the material given on the MTR exceeds 65 ksi.
2. Reduce the testing temperature by 15°F for each 10-ksi increment or fraction thereof above 85 ksi if the yield point of the material given on the MTR exceeds 85 ksi.

Use the (H) frequency of testing for material with minimum specified yield point up to 50 ksi. Use the (P) frequency of testing for material with minimum specified yield point over 50 ksi. Ensure steel is sampled and tested in accordance with ASTM A673.

2.1.3. **Other Components**.

2.1.3.1. **Miscellaneous Bridge Components**. Provide steel that meets ASTM A36, A709 Grade 36, or A500 Grade B for members such as steel bearing components not bid under other Items, steel diaphragms for use with concrete bridges, and armor and finger joints, unless otherwise shown on the plans.

2.1.3.2. **Shear Connectors and Anchors**. Provide cold-drawn bars for stud shear connectors, slab anchors, and anchors on armor and finger joints that meet the requirements of ASTM A108, Grade 1010, 1015, 1018, or 1020, either semi-killed or killed, and have the tensile properties given in Table 2 after drawing or finishing. Determine tensile properties in accordance with ASTM A370.

Table 2
Minimum Tensile Properties for Bar Stock

Tensile strength	60 ksi
Yield strength	50 ksi
Elongation	20% (2")
Reduction of area	50%

Provide certification from the manufacturer that the studs or anchors as delivered have the required material properties.

2.1.3.3. **Fasteners**. Provide high-strength bolts that meet ASTM A325 or A490 as shown on the plans. The Department may sample high-strength bolts, nuts, and washers for structural connections in accordance with Tex-719-I.

Follow the requirements of Item 447, "Structural Bolting," for tests, test reports, and supplemental requirements for high-strength bolts, nuts, and washers.

Use bolts that meet ASTM A307 and nuts that meet ASTM A563 when ASTM A325 or A490 bolts are not shown on the plans.

2.1.3.4. **Slip-Resistant Deck Plates**. Furnish steel for deck plates that meets ASTM A786 and one of A242, A588, or A709 Gr. 50W. State the type and trade name of material to be used on the shop drawings.

2.1.3.5. **Rail Posts**. Provide material for rail posts that meets ASTM A36 or ASTM A709 Grade 36 unless otherwise shown on the plans.

2.2. **Steel Forgings**. Provide steel forgings for pins, rollers, trunnions, or other forged parts that meet ASTM A668, Class C, D, F, or G, as shown on the plans. For pins 4 in. or smaller in diameter for non-railroad structures, material that meets ASTM A108, Grades 1016 to 1030, with a minimum yield strength of 36 ksi, may be used instead.

2.3. **Steel Castings**. Provide steel castings that meet ASTM A27, Grade 70-36.

2.4. **Iron Castings**. Provide iron castings that are true to pattern in form and dimensions; free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended; and meet the standards shown in Table 3.

Table 3
Standards for Iron Castings

Casting Material	ASTM Standard	Grade or Class
Gray iron	A48	35B
Malleable iron	A47	32510
Ductile iron	A536	70-50-05

2.5. **Steel Tubing**. Provide steel tubing that meets ASTM A500, Grade B unless otherwise shown on the plans. Tubing that meets API Standard 5L, Grade X52 may be used if produced by a mill listed in the standard API specifications as authorized to produce pipe with the API monogram. Hydrostatic tests are not required for API 5L steel, and instead of an MTR, the manufacturer may furnish a certificate for each lot or shipment certifying the tubing meets the requirements of this Section.

2.6. **Pipe Rail**. "Pipe" includes special extruded and bent shapes. Provide pipe that is rolled, extruded, or cold-pressed from a round pipe or flat plate, and of the section shown on the plans.

Ensure the design of the cold press and dies results in a pipe of uniform section-free from die marks. Cut the pipe to the lengths required once it has been formed to the required section. Make the end cuts and notches at the angles to the axis of the pipe required to produce vertical end faces and plumb posts when required by the plans. Provide a neat and workmanlike finish when cutting and notching pipe.

2.7. **Aluminum**. Provide aluminum materials that meet the standards shown in Table 4 unless otherwise shown on the plans.

Table 4
Aluminum Standards

Material	ASTM Standard	Alloy-Temper
Castings	B108	A444.0-T4
Extrusions	B221	6061-T6
Sheet or plate	B209	6061-T6

When testing is required, cut test specimens from castings from the lower 14 in. of the tension flange, but not at the junction of the rib or base. Flatten the curved surfaces before machining. Provide standard test specimens in conformance with ASTM E8.

3. CONSTRUCTION

3.1. **Fabrication, Erection, and Painting**. Fabricate, weld, and erect structural metal in accordance with Item 441, "Steel Structures," Item 447, "Structural Bolting," Item 448, "Structural Field Welding," and the applicable AWS welding code. Paint in accordance with Item 446, "Field Cleaning and Painting Steel." Aluminum or galvanized steel members do not require painting unless otherwise shown on the plans.

3.2. **Galvanizing**. Galvanize fabricated steel items, steel castings, bolts, nuts, screws, washers, and other miscellaneous hardware in accordance with Item 445, "Galvanizing." Galvanizing is not required unless specified.

4. MEASUREMENT

This Item will be measured by the pound of structural metal furnished and placed in a complete structure not including the weight of erection bolts, paint, or weld metal.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

The maximum percent variance from the plans quantity will be as given in Table 5.

Table 5
Percent Variance

Quantity	Variance
Over 1,000,000 lb.	1/2%
100,000 through 1,000,000 lb.	1%
Under 100,000 lb.	1-1/2%

If the requests for increases in sizes or weights of members are approved, measurement will be made on the sizes or weights shown on the plans.

Castings, bearing plates, anchor bolts, drains, deck plates, armor and finger joints, and other metal for which no separate measurement is specified will be included in the total quantity of structural steel.

The weights of rolled materials (such as structural shapes and plate) will be computed on the basis of nominal weights and dimensions using measurements shown on the plans. Deductions will not be made for material that is removed for copes, clips, planing, or weld preparation. The weight of castings will be computed from the dimensions shown on the approved shop drawings. Shoes will be measured by the weights shown on the plans.

Weight of high-strength fasteners will be based on Table 6. Weight of other metal will be based on Table 7.

Splices will be measured as follows:

- No additional weight will be allowed for weld metal in a welded splice.
- Where a bolted splice is permitted as an alternate for a welded splice, measurement will be made on the basis of a welded splice.
- Where a bolted splice is required, the weight of the splice material, bolt heads, washers, and nuts will be measured with no deduction for holes.

Table 6
Pay Weight for High-Strength Fasteners, Pounds per Hundred Units

Diameter	Item		
	Bolt heads	Nuts	Washers
3/4"	15	19	4.8
7/8"	23	30	7.0
1"	32	43	9.4
1-1/8"	45	59	11
1-1/4"	64	79	14

Table 7
Pay Weight for Metals

Material	Weight (lb./cu. in.)
Steel	0.2836
Cast iron	0.2604
Wrought iron	0.2777

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Structural Steel" of the type (Rolled Beam, Plate Girder, Tub Girder, Box Girder, Railroad Through-Girder, Railroad Deck-Girder, Miscellaneous Bridge, Miscellaneous Non-Bridge) specified. This price is full compensation for materials, fabrication, transportation, erection, paint, painting, galvanizing, equipment, tools, labor, and incidentals.

Item 445
Galvanizing

1. DESCRIPTION

Galvanize or repair galvanizing on metal items.

2. MATERIALS

Provide galvanized metal items that meet the standards in Table 1.

Table 1
Galvanizing Standards

Item	Standard
Fabricated items, rolled, pressed, or forged steel shapes, plates, pipes, tubular items, and bars	ASTM A123
Steel or iron castings	ASTM A153, Class A
Bolts, nuts, screws, washers, and other miscellaneous hardware	ASTM A153, Class C or D or ASTM B695, Class 50
Miscellaneous fasteners	ASTM B633, Class Fe/Zn 8
Rail elements for metal beam guard fence or bridge railing	AASHTO M 180
Permanent metal deck forms, supporting angles, and incidental items	ASTM A653, Coating Designation G165

3. CONSTRUCTION

3.1. **General**. Provide for proper filling, venting, and draining during cleaning and galvanizing if fabricated members or assemblies are required to be hot-dip galvanized. Provide drain holes or slots as required, except where prohibited by the plans. Provide a surface finish on the thermal-cut drain holes or slots in accordance with AWS D1.1 requirements for base metal preparation. Drain to the small end of tapered sections that are assembled using slip-joint splices. Ensure cleaning and galvanizing does not produce hydrogen embrittlement.

Remove weld flux, weld slag, and any other weld residue or impurities before galvanizing. Before galvanizing material 1/4 in. or greater in thickness:

- remove all sharp burrs and
- chamfer to approximately 1/16 in. all edges.

3.2. **Painting Galvanized Materials**. Provide a paint system if painting is specified on galvanized materials in accordance with DMS-8102 "Paint Systems for Galvanized Steel." Follow all manufacturer instructions for surface preparation and application including the following:

3.2.1. **Surface Preparation**. Do not water-quench or chromate-quench galvanized surfaces to be painted. Prepare the surface in accordance with ASTM D6386. Apply coating within 12 hr. of cleaning. Re-clean the surface if more than 12 hr. elapse before initial painting.

3.2.2. **Coating Application**. Ensure the coating is smooth, even, continuous, and free of drips, runs, sags, holidays, wrinkles, or other coating defects. Ensure the coating has a uniform appearance within all portions of the painted piece and all related pieces and components of a project. Ensure all repairs are smooth, even, and visually match the remainder of the coated piece by use of feathering and other appropriate techniques to avoid sharp transitions.

3.3. **Galvanizing Weldments**. If problems develop during galvanizing of welded material, the Engineer may require a compatibility test of the combined galvanizing and welding procedures in accordance with Section 441.3.2.6., "Testing of Galvanized Weldments," and may require modification of one or both of the galvanizing and welding procedures.

3.4. **Workmanship**.

3.4.1. **Coverage**. Bare spots no more than 1/8 in. across are acceptable unless numerous. Repair larger bare spots in accordance with Section 445.3.5., "Repairs." Local runs or drips of zinc coating are acceptable unless they interfere with the intended use of the product. Carefully remove plainly visible excessive zinc accumulations.

3.4.2. **Adhesion**. Tap the coated area with a small hammer to test coating adhesion. The coating is acceptable if it is not brittle and does not scale or flake.

3.4.3. **Appearance**.

3.4.3.1. **White Rust**. A white powdery residue indicates moisture. Remove heavy layers of white rust that have caused the coating to pit. Light coatings may remain unless the Engineer requires chemical removal. Remove white rust from articles that will be in direct contact with soil.

3.4.3.2. **Red Rust**. Red rust on galvanized items indicates uncoated areas. See Section 445.3.4.1., "Coverage," for acceptance criteria.

3.4.3.3. **Alligator Cracking or Spider Webbing**. The composition of the base metal may cause dark lines resembling alligator skin. See Section 445.3.4.2., "Adhesion," to determine whether the coating is acceptable.

3.4.3.4. **Dull Gray Coating**. The composition of the base metal can cause a dull gray color. See Section 445.3.4.2., "Adhesion," to determine whether the coating is acceptable.

3.4.4. **Coating Thickness**. Galvanize to the thickness specified. Use Tex-728-I to determine coating thickness.

3.5. **Repairs**. Use zinc-based solders, sprayed zinc, or zinc-rich paints for repairs in accordance with this Section.

3.5.1. **Materials**.

3.5.1.1. **Zinc-Based Solders**. Solders used in rod form or as powders:

- zinc-tin-lead alloys with liquidus temperatures in the range of 446°F to 500°F or
- zinc-cadmium alloys with liquidus temperatures in the range of 518°F to 527°F.

3.5.1.2. **Sprayed Zinc (Metallizing)**. Zinc coating applied by spraying with droplets of molten metal using wire, ribbon, or powder processes.

3.5.1.3. **Organic Zinc-Rich Paints**. Zinc-rich paints based on organic binders that meet the requirements of DMS-8103, "Galvanizing Repair Paints." The Department's MPL has a list of approved repair paints for galvanized coatings.

3.5.2. **Repair Processes**.

3.5.2.1. **Zinc-Based Solders**. Remove moisture, oil, grease, dirt, corrosion products, and welding slag or flux from surfaces to be repaired. Clean surface to white metal by wire-brushing, light grinding, or mild blasting extending into the surrounding undamaged galvanized coating. Preheat cleaned areas to at least 600°F, but not more than 750°F. Wire-brush while heating and evenly distribute a layer of zinc solder. Flush the repaired area with water or wipe with a damp cloth to remove flux residue when repair is completed.

3.5.2.2. **Sprayed Zinc (Metallizing)**. Remove oil, grease, corrosion products, and any welding slag or flux from surfaces to be repaired, and ensure the surfaces are dry. Clean surface to white metal by wire-brushing, light grinding, or mild blasting extending into the surrounding undamaged galvanized coating. Apply coating by metal-spraying pistols fed with either zinc wire, ribbon, or powder. Provide a coating that is uniform and free of lumps, coarse areas, or loose particles.

3.5.2.3. **Organic Zinc-Rich Paints**. Remove oil, grease, corrosion products, and welding slag or flux from surfaces to be repaired, and ensure the surfaces are clean and dry. Clean surface to near-white metal by wire-brushing, light grinding, or mild blasting extending into the surrounding undamaged coating to provide a smooth repair. Spray or brush-apply the paint to the prepared area in accordance with the paint manufacturer's instructions to attain the required dry-film thickness. Provide multiple passes when using spray application.

3.6. **Repair Coating Thickness**. Measure thickness in the repaired area using Tex-728-I after completing repair and cooling or curing. The minimum thickness required is the same as that required for the specified galvanizing. However, if the repair uses zinc-rich paints, the minimum coating thickness is 50% higher than the specified galvanizing thickness but not greater than 4.0 mils.

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be considered subsidiary to pertinent Items.

Item 446
Field Cleaning and Painting Steel

1. DESCRIPTION

Prepare steel surfaces for painting and apply paint.

2. MATERIALS

Provide the paint system (surface preparation, primer, intermediate, and appearance coats as required) shown on the plans. Provide System II if no system specified. Provide a concrete gray appearance coat (Federal Standard 595C, color 35630,) unless otherwise shown on the plans. Use differing colors for each individual coat with enough contrast between colors to distinguish the various steps in the painting process, including differing the color of the stripe coat relative to the primer and intermediate coat.

2.1. **Paint Systems**. Standard paint systems for painting new and existing steel include the following:

2.1.1. **System I-A (Overcoating, One Coat)**. Provide an overcoating system in accordance with DMS-8105, "Paint, One Coat Overcoat," and the manufacturer's specifications.

2.1.2. **System I-B (Overcoating, High Corrosion Environment)**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide a penetrating sealer, intermediate prime coat on bare steel areas, and an appearance coat in accordance with manufacturer's specifications.

2.1.3. **System II**. Provide #810 Prime Coat meeting DMS-8100, "Structural Steel Paints—Formula," and acrylic latex appearance coat meeting DMS-8101, "Structural Steel Paints—Performance."

2.1.4. **System III-A**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide organic zinc (OZ) prime coat, epoxy intermediate stripe coat, epoxy intermediate full coat and urethane appearance coat.

2.1.5. **System III-B**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide inorganic zinc (IOZ) prime coat, epoxy intermediate, and urethane appearance coat. Provide epoxy zinc prime coat, as recommended by the IOZ manufacturer, for touchup of IOZ.

2.1.6. **System IV**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide IOZ prime coat and acrylic latex appearance coat. Provide epoxy zinc prime coat, as recommended by the IOZ manufacturer, for touchup of IOZ.

2.2. **Paint Inside Tub Girders and Closed Boxes**. In accordance with Item 441, "Steel Structures."

2.3. **Paint over Galvanizing**. In accordance with Item 445, "Galvanizing."

2.4. **Special Protection System**. Provide the type of paint system shown on the plans or in special provisions to this Item. Special Protection System paints must have completed NTPEP Structural Steel Coatings (SSC) testing regimen as a complete system, with full data available through NTPEP unless specified otherwise.

3. EQUIPMENT

Ensure spray equipment:

- has adequate capacity and sufficient gauges, filters, agitators, regulators, and moisture separators to ensure delivery of clean dry air at the proper pressure and volume;
- is adequate for the type of paint being used;
- has spray heads that provide a smooth, uniform coat of paint;
- will remove moisture from air stream in contact with the paint; and
- has no dried coatings, solvents, or other foreign matter on surfaces that paint is likely to contact.

Maintain all equipment and accessories in good working order.

Keep paint pots no more than 20 ft. above or below the level of spray application of paint during painting operations. Do not allow fluid hoses to sag more than 10 ft. below the level of the bottom of the paint pot or actual spraying operations, whichever is the lowest point. Keep hoses serviceable with no cracks or deterioration. Equip paint pots (or other containers from which the paint is dispensed) with agitators that operate whenever paint is in the pot.

3.1. **Airless Spray Equipment**. Use regulator and air or fluid pressure gauges. Use fluid hoses with at least 1/4-in. inside diameter (I.D.) and a maximum length of 75 ft.

3.2. **Conventional Spray Equipment**. Use independent fluid pressure and atomization pressure regulators and gauges. Use fluid and air hoses with at least 1/2-in. I.D. and a maximum length of 75 ft.

4. CONSTRUCTION

4.1. **Qualification**. Certification of the cleaning and painting contractor, subcontractor, or fabricator is required as follows:

Submit to the Engineer documentation verifying SSPC QP 1 certification for work requiring the removal or application of coatings. Additionally, submit to the Engineer documentation verifying SSPC QP 2 Cat A certification when work requires removal of coatings containing hazardous materials. Maintain certifications throughout the project. No work may be performed without current and active certifications unless otherwise shown on the plans. The Engineer may waive QP 1 certification for minor, touch-up repair work and coating steel members repaired in accordance with Item 784, "Steel Member Repair."

The Engineer may waive certification requirements, when stated on the plans, for the purpose of qualification in the SSPC QP program if the SSPC has accepted the project as a qualification project as part of the process for obtaining SSPC QP1 or QP2 Cat A certification. Submit SSPC QP applications and proof of acceptance before beginning work or provide SSPC QP 7 certification when required on the plans.

Inform the Engineer within 1 business day of all scheduled or unannounced inspections or audits by SSPC, OSHA, EPA, TCEQ, or other agencies or organizations. Furnish the Engineer a complete copy of all inspection and audit reports and any SSPC DAC actions within 7 days of receipt.

4.2. **Responsibility for Hazards**. Comply with Section 6.10., "Hazardous Materials." Handle all paints and cleaning products in accordance with the information provided by the manufacturer and all applicable federal and state regulations.

4.3. **Access**. Provide safe access to all parts of the work for proper inspection. Do not place rigging, scaffolds, etc., in contact with previously painted surfaces until the previously applied coating has fully cured. Protect previously painted and cured surfaces with an approved padding to minimize damage when rigging, scaffolds, etc., will be placed on or hung from those surfaces. Avoid and minimize coating damage to the extent possible. Repair all coating damaged as a result of rigging or scaffolding as directed.

Remove tree limbs, bushes, grass, and other items that will interfere with the cleaning and painting operations as directed. Remove vertical clearance signs, and erect and maintain temporary ground-mounted signs matching the content and letter size on the existing sign unless otherwise directed. Re-attach permanent clearance signs as directed.

4.4. **Steel to be Painted**. Clean and paint all structural steel except weathering steel that is to remain unpainted, unless otherwise shown on the plans. Structural steel includes all main members, bearing apparatus, diaphragms, floor beams, rivets, bolts, lateral bracing, etc., where applicable. Paint the rolling faces of rockers and base plates, all surfaces of bearing plates, and all surfaces of iron or steel castings, whether or not the surfaces are milled unless otherwise shown on the plans or exempted in this Item. Perform the initial cleaning and application of required prime and intermediate coatings on new steel before shipment of the steel to the jobsite unless otherwise provided in the Contract or approved in writing.

4.5. **Special Protection System**. Apply paint as shown on the plans.

4.6. **Cleaning and Painting New Steel**. Clean and prime new steel in accordance with Item 441, "Steel Structures," before erection or installation of repair pieces. Clean and paint unpainted areas of newly erected steel, including bolts, nuts, washers, and areas where the shop-applied paint has been damaged or fails to meet specification requirements, in accordance with the method required under the paint system specified and Section 446.4.7.3.1., "General Preparation." Water blast exposed surfaces of all newly erected steel. Provide Tool Cleaning surface preparation to all repair areas. Prepare all unpainted areas with Abrasive Blast Cleaning. Repair primer coat and apply remaining coats after erection and maintenance work is complete. Prevent paint and overspray from coming in contact with passing traffic, private and public property, and areas of the bridge not designated to be painted.

4.7. **Cleaning and Painting Existing Steel**.

4.7.1. **Hold Points**. No work may proceed beyond the listed hold point until the Engineer has reviewed and given provisional approval. Provide the following hold points at a minimum:

- at containment completion,
- following any surface preparation,
- immediately before each coating application,
- after coating application,
- after each coat has cured, and
- after preparation of areas for repair.

4.7.2. **Containment**. Submit a plan that details the procedures and type and size of equipment proposed to keep public property, private property, and the environment from being adversely affected by the cleaning and painting operations. Approval of the plan is required before cleaning and painting operations begin. Containment is not required for painting newly erected, shop primed steel other than to comply with Section 446.4.6., "Cleaning and Painting New Steel."

When required on the plans, submit a containment plan and engineering analysis showing the loads, including wind loads, added to the existing structure by the containment system and waste materials. Verify the forces and stresses induced in the members from these loads do not result in overstress of the members. Have a licensed professional engineer sign, seal, and date the submittal.

Provide containment during all cleaning and painting operations of existing steel structures. Obtain approval of the constructed containment system before beginning cleaning and painting.

Unless otherwise shown on the plans, construct and maintain a structure meeting the following minimum requirements:

- SSPC Guide 6, Class 1A, Level 1 Emissions;
- ability to withstand winds up to 30 mph;
- enclosure of all sides of area with air-impenetrable walls;
- illumination meeting SSPC Guide 12;
- rigid, watertight floor formed from minimum 20 gauge steel;
- overlapping seams and entryways; and
- exhaust air filtration system capable of creating negative pressure inside the enclosure causing the sides of the containment to have a concave appearance and demonstrating minimum 100 ft. per minute cross draft air flow and minimum 50 ft. per minute downdraft air flow in all areas within the containment.

In place of a full containment structure, a modified containment system may be proposed for the following situations:

- when using abrasive blasting equipment equipped with negative pressure able to contain all blast refuse. Demonstrate, for approval, the equipment's ability to contain all blast refuse.
- when using hand tools for spot cleaning only, provide a system that will contain all removed paint, rust, and other debris. Place an airtight membrane below the member being cleaned to collect all falling debris.
- when using power hand tools for spot cleaning only that are equipped with high-efficiency particulate air (HEPA) filter vacuums that will capture all removed paint, rust, and other debris. Otherwise, provide an airtight membrane below the member being cleaned to collect all falling debris.

Provide a system meeting SSPC Guide 6, Class 1W, when using water blasting.

Store, characterize, and dispose of all recovered debris in accordance with 30 TAC 335, "Industrial Solid Waste and Municipal Hazardous Waste." Alternatively, Universal Waste rules may be used. Discharge liquids in accordance with the TCEQ Texas Pollution Discharge Elimination Program (30 TAC 305, "Effluent Guidelines and Standards for TPDES Permits") and Texas Surface Water Quality Standards (30 TAC 307). Alternatively, liquids may be captured, stored, and characterized for disposal at an authorized facility in accordance with 30 TAC 315, "Pretreatment Regulation for Existing and New Sources of Pollution," or 30 TAC 335, "Industrial Solid Waste and Municipal Hazardous Waste."

Use a skimmer when cleaning and painting over bodies of water. Remove any blast or paint material the skimmer collects the day the release occurs. Correct the containment problem that allowed the release before continuing work.

Ensure air is clear of dust and remove all blast refuse from cleaned members before the inspector enters the containment to inspect the cleaned surfaces. Remove all blast refuse from the containment before ending work for the day.

4.7.3. **Preparation of Surfaces**. Prepare surfaces before applying paint.

4.7.3.1. **General Preparation**. Clean far enough into any shop-applied paint to ensure removal of all contaminants. Feather edges of sound paint around cleaned areas.

Ensure all surfaces to be painted are completely free of oil, grease, moisture, dirt, sand, overspray, welding contamination (slag or acid residue); loose or flaking mill scale, rust, or paint; weld spatter; and any other conditions that will prevent the paint from forming a continuous, uniform, tightly adhering film. Remove all hackles, splinters weld spatter, sharp edges, fins, slag, or other irregularities which may interfere with proper paint adhesion to the steel. Remove all steel splinters (hackles) raised or evident during cleaning. Reblast areas from which hackles are removed when abrasive blast cleaning is required.

Before other cleaning operations, remove grease-like contaminants with clean petroleum solvents or other approved methods. Contain solvents and removed material as approved. Dispose of properly or reuse solvents as approved. This requirement applies to all coats.

When abrasive blast cleaning is required, blast all flame-cut edges to produce a visible anchor pattern over the entire flame-cut surface.

Completely remove, as directed, the protective coating on machined surfaces and pins.

Do not damage adjacent materials such as concrete during surface preparation or painting.

Feather all sound, tightly adhered coating edges surrounding cleaned or repaired areas a minimum of 1 in. and ensure a smooth, blended transition.

Round all corners and edges to a 1/16-in. radius. Reblast as needed. Remove pack rust to depth of at least 0.5 in.

4.7.3.2. **Classes of Cleaning**. The requirements of Section 446.4.7.3.1., "General Preparation," apply whether or not a class of cleaning is specified. Use an approved abrasive for abrasive blasting. Do not use steel shot. Use an abrasive recycling system with an approved recyclable abrasive when abrasive blast cleaning is used to remove existing paint containing lead or chromium. Abrasive will be considered recyclable if it is separated from the dust and paint debris before being reused. All abrasives must meet SSPC-AB1, AB2, or AB3 as appropriate.

All paint systems require water blasting to remove contaminants before any other surface preparation. Both System I-A and I-B require tool cleaning for defective areas of disbonded coating or rust. All other paint systems require abrasive blast cleaning unless otherwise shown on the plans.

4.7.3.2.1. **Abrasive Blast Cleaning**. Meet the surface preparation requirements of SSPC-SP 10 unless otherwise shown on the plans. Ensure a minimum profile of 1.5 mils. Do not add depth to existing profile when the surface profile exceeds 4.0 mils. Measure surface profile in accordance with ASTM D4417, Method C, "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel." Containment mounting points and other repair areas under 1 sq. ft. may be tool-cleaned to SSPC SP-11 with at least a minimum 2 mil profile when approved by the Engineer.

4.7.3.2.2. **Tool Cleaning**. Meet the requirements of SSPC-SP2 or SP3 unless otherwise shown on the plans. Probe the perimeter of peeled areas of paint with a putty knife to ensure remaining paint is tightly adhered.

4.7.3.2.3. **Water Blasting**. Meet the requirements of SSPC-SP WJ-4. Tight mill scale and tightly adhered rust and paint are permitted. Probe the perimeter of peeled areas of paint with a putty knife to ensure remaining paint is tightly adhered.

4.7.3.3. **Tape Test**. Perform the tape test, as necessary to determine cleanliness, on any surface before painting as follows:

- Press a strip of filament tape onto the surface by rubbing with moderate thumb pressure 4 times, leaving approximately 2 in. of one end of the tape free from the surface.
- Grasp the free end and remove the tape from the surface with a sharp pull.

The surface will be considered to be contaminated and not adequately cleaned if visible particles cling to the tape.

4.7.4. **Painting**.

4.7.4.1. **Paint Condition**. Thoroughly mix and strain paints to be applied. Mix by mechanical methods. Provide continuous mechanical agitation during painting operations to prevent settling. Ensure the paint is a completely homogeneous mixture free of lumps, skins, and agglomerates and contains all pigments, vehicle

solids, and thinners required in the original formulation. Keep paint containers tightly covered and protected from weather when not in use.

4.7.4.2. **Thinning**. Adjust paint to the correct application consistency by using suitable thinners or by using properly applied heat up to 150°F. Using heat to thin paints may decrease their useful pot life.

4.7.4.3. **Paint System Requirements**. Ensure all coatings in the paint system, including shop-applied coats, are from the same manufacturer.

4.7.4.4. **Stripe Coat**. All stripe coat, when specified, will be unthinned and worked in by brush to achieve a contiguous film over all edges, corners, bolts, nuts, threads, rivets, and weld seams, extending at least 1 in. onto adjacent steel.

4.7.4.5. **Paint Systems**.

4.7.4.5.1. **System I-A (Overcoating, One Coat)**. Apply at least 4.0 mils dry film thickness (DFT) maintenance overcoat to all surfaces to be painted.

4.7.4.5.2. **System I-B (Overcoating, High Corrosion Environment)**.

- **Penetrating Sealer**. Apply 0.5–1.0 mil DFT of penetrating sealer to all surfaces to be painted.
- **Prime Coat**. Apply 4.0–8.0 mils DFT of primer to areas that have received tool cleaning and to other areas where there is no existing primer.
- **Appearance Coat**. Apply 2.0–6.0 mils DFT of appearance coat.

4.7.4.5.3. **System II**.

- **Prime Coat**. Apply 3.5–10.0 mils DFT of primer in at least 2 coats.
- **Appearance Coat**. Apply 2.0–5.0 mils DFT of appearance coat.

4.7.4.5.4. **System III-A**.

- **Prime Coat**. Apply at least 3.5 mils DFT of epoxy zinc primer.
- **Stripe Coat**. Apply stripe coat of epoxy intermediate coating.
- **Intermediate Coat**. Apply at least 2.0 mils DFT of epoxy intermediate coating.
- **Appearance Coat**. Apply at least 2.0 mils DFT of appearance coating.

4.7.4.5.5. **System III-B**.

- **Prime Coat**. Apply at least 3.0 mils DFT of inorganic zinc primer to new steel in accordance with Item 441, "Steel Structures." Spot-clean all damaged and unpainted areas in accordance with Section 446.4.6., "Cleaning and Painting New Steel." Apply at least 3.0 mils DFT of epoxy zinc primer to the spot cleaned areas.
- **Stripe Coat**. Apply stripe coat of epoxy intermediate coating.
- **Intermediate Coat**. Apply at least 2.0 mils DFT of epoxy intermediate coating.
- **Appearance Coat**. Apply at least 2.0 mils DFT of appearance coat.

4.7.4.5.6. **System IV**.

- **Prime Coat**. Apply at least 3.0 mils DFT of inorganic zinc primer to new steel in accordance with Item 441, "Steel Structures." Spot-clean all damaged and unpainted areas in accordance with Section 446.4.6., "Cleaning and Painting New Steel." Apply at least 3.0 mils DFT of epoxy zinc primer to the spot cleaned areas.
- **Appearance Coat**. Apply at least 2.0 mils DFT of appearance coat.

4.7.4.5.7. **Special Protection System**. Apply paint as shown on the plans.

4.7.4.6. **Temperature**. Do not apply #810 Prime Coat when the steel or air temperature is below 50°F or when the steel or air temperature is expected to drop below 50°F within 2 hr. after application. Follow product data sheets for temperature requirements for all other paints.

4.7.4.7. **Application**. Clean steel surfaces or surfaces of previously applied coats of paint immediately before painting by blowing with clean compressed air, brushing, or both to remove traces of dust or other foreign particles. Wash the surfaces of previously applied coatings either with clean, fresh water or with a mild detergent and water mixture followed by a complete and thorough rinse with clean, fresh water when directed.

Do not apply paint to any surface with discernible moisture. Do not apply paint to any surface when steel is within 5°F of the dewpoint. Do not apply any paint when impending weather conditions might result in injury to fresh paint.

Provide environmental controls such as dehumidification, heaters, or additional containment measures as needed to control and maintain favorable atmospheric conditions in all areas of the containment. Provide environmental controls at no additional cost to the Department.

Apply each coat of paint to clean, dry, firm surfaces complying with all specification requirements. Ensure surfaces to be painted are free of all forms of contamination. Ensure each coat fully cures to form a smooth, continuous, tightly adhering film of uniform thickness and appearance, free of sags, runs, pinholes, holidays, overspray, or other defects before applying the next coat. Apply all coats by spray, except brush-applied stripe coats. Obtain Engineer approval for alternative methods of application to paint inaccessible areas.

Repair all runs, sags, and other defects in each coat of paint before application of subsequent coats.

Measure the dry film thickness of coatings in accordance with Tex-728-I.

If, in the opinion of the Engineer, there is an objectionable amount of dust in the atmosphere, discontinue painting or take necessary precautions to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before the paint is applied.

Provide full coverage of the steel with the concrete surface when painting steel that is in contact with concrete. Do not extend the paint more than 4 in. onto the concrete surfaces or as directed. Ensure when painting is complete the only visible paint on concrete surfaces is the finish coat. Remove excessive or objectionable paint on concrete surfaces in an approved manner.

Cure the primer, when System II is specified, in accordance with Table 1 before applying appearance coat.

Table 1
System II Primer Cure Times

Temperature	Days Cure, Min
77°F and above	2
65–77°F	3
55–65°F	4
40–55°F	5

Clean coated surfaces by an approved method that does not damage the paint to remove all dirt, grease, concrete, overspray, and any other substance that may impair adhesion before the application of the next coat.

Provide an even and uniform appearance throughout the painted portion of the structure.

4.7.4.8. **Workmanship**. Perform all painting with skilled painters who can adjust equipment and application techniques as dictated by the type of paint, weather conditions, environment, and size and shape of the surface being painted. Painters who, in the opinion of the Engineer, do not adjust equipment to apply coatings in a uniform, full wet coat free of runs, sags, holidays, and overspray will not be considered skilled painters.

Apply sprayed coatings essentially 90° to the surface and between 10 and 18 in. from the surface as necessary to apply a full wet coat of paint free of overspray, runs, sags, and holidays. Any spray painter who does not consistently spray in this manner or extends the spraying stroke so paint is applied to the surface at an angle of less than 80° will not be allowed to spray paint. Brush application for touchup is acceptable as long as the paint is mixed in the appropriate proportions by weight and is agitated continuously during the painting operation.

4.7.5. **Handling and Shipping**. Pad the blocks, chains, slings, braces, clamps, etc., used for handling, moving, storing, and shipping painted members so the paint will not be damaged.

4.8. **Paint Improperly Applied**. To uncover evidence of improperly applied paint, the Engineer may at any time during construction explore underneath the surface of any paint coats already applied. Repair these areas of investigation at no additional expense to the Department. Whenever unsatisfactory conditions are found, the Engineer may require remedial measures.

Repair or completely remove and replace all paint that has been applied improperly, has been applied to improperly cleaned surfaces, fails to dry and harden properly, fails to adhere tightly to underlying metal or other paint film, or does not have a normal, workmanlike appearance in conformance with this Item. When the final field coat does not have a uniform color and appearance throughout the structure, correct it by the use of whatever additional coats or other corrective measures are required. Remove freshly applied paint that has not yet set with the use of suitable solvents. Remove dried paint films with blast cleaning, scraping, or flame torches, as approved.

4.9. **Storage and Disposal**. Collect all waste generated by cleaning and painting operations as necessary to prevent release into the environment. At a minimum, collect all waste before leaving the jobsite each day. Handle and store the waste as if it was hazardous or Universal Waste until classification is made. Follow the requirements of 30 TAC 335 for on-site handling of the waste. Store waste collected in containers that comply with 49 CFR 178. Seal containers containing waste each day before leaving the jobsite.

Test a representative sample of waste using EPA Test Method 1311, "Toxicity Characteristic Leaching Procedure" (TCLP), to determine existing metal and organic content. Handle and dispose of non-hazardous waste as a "Special Waste" as defined in 30 TAC 330.2 or as directed. Provide documentation showing disposal of the waste was done in a suitable landfill holding permits to handle this type of material. Dispose of hazardous waste in compliance with applicable waste rules and regulations. Transport hazardous waste using a permitted transporter and dispose of in an authorized hazardous waste facility.

When the plans specify the existing coating to be removed contains hazardous materials and steel grit is used as the abrasive, the waste generated is classified as hazardous or Universal Waste regardless of the results of the TCLP. For manifesting purposes, the Department is considered the waste generator for paint removal wastes generated from structures owned or controlled by the State. Dispose of this waste in compliance with applicable waste rules and regulations as specified above and by the Contract.

Provide copies of all test reports and transportation manifests to the Engineer before shipping waste. Provide signed original manifests to the Engineer verifying all steps of the handling and disposal process were correctly handled.

4.10. **Miscellaneous**. Notify the Engineer of any condition that may require the repair or replacement of any portion of the bridge.

Stencil on the exterior face of the outside beam the control, section, and structure number upon completion of the painting operations for each structure as directed. Stencil on the interior face of the outside beam the completion date of the painting operation. Do this work at each end of the structure where painting is specified.

5. MEASUREMENT

When this Item is specified on the plans to be a pay item, it will be measured by the lump sum or by each structure, structure unit, or group of structures as shown on the plans.

6. PAYMENT

When this Item is specified as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the price bid for "Cleaning and Painting Existing Structures," "Cleaning and Painting Existing Railing," or "Cleaning and Painting Existing Piling" for the system specified and, when paid by each, for the structure description by reference number. "Cleaning and Painting Existing Structures" includes painting of railing and piling unless otherwise shown on the plans. This price is full compensation for paint; cleaning, spot painting, and painting; removal of vegetative obstructions; containment systems; traffic protection and scaffolding; disposal of waste; and materials, equipment, labor, tools, and incidentals.

Item 447
Structural Bolting

1. DESCRIPTION

Furnish and install high-strength bolts for structural connections.

2. MATERIALS

2.1. **General**. Use the same supplier for bolts and nuts to ensure proper fit. Have the manufacturer or distributor perform rotational-capacity (R-C) tests in accordance with Tex-452-A on all bolt, nut, and washer assemblies. Test each combination of bolt production lot, nut lot, and washer lot as an assembly and assign an R-C lot number to each lot tested. Test 2 samples from each assigned R-C lot.

Furnish a manufacturer's certified test report (MCTR) or a distributor's certified test report (DCTR) for each R-C lot supplied. Include in the MCTR or DCTR:

- results of the R-C tests,
- R-C lot number,
- manufacturing location for assembly components,
- date and location of tests, and
- a statement that the materials represented by the test report conform to the specifications.

2.2. **Bolt Assemblies**. Provide bolts, nuts, and washers meeting the type, grade, and finish requirements in Table 1.

Use ASTM A325 or A490 Type 3 plain (uncoated) bolts for weathering steel as indicated and ASTM A325 Type 1 galvanized bolts for coated steel.

Provide bolts long enough for the installed bolt end to be flush with or outside the face of the nut.

Ensure galvanized nuts are lubricated with a lubricant containing a dye of a color that contrasts with the color of the galvanizing. Order ASTM A563 nuts with supplemental requirement S2 if they will be galvanized.

Table 1
ASTM Type, Finish, and Grade for Structural Bolts, Nuts, and Washers

	ASTM Designation	Bolt Type	Bolt Finish	ASTM A563 Nut Grade and Finish	ASTM F436 Washer Type and Finish
Heavy-Hex Bolts	A325	1	Galvanized	DH,[1] galvanized and lubricated	1; galvanized
	A325	3	Plain	C3 and DH3; plain	3; plain
	A490	3	Plain	DH3; plain	3; plain
Tension-Control Bolts			Galvanized	DH,[1] galvanized and lubricated	1; galvanized
		3	Plain	C3 and DH3; plain	3; plain
	F2280	3	Plain	DH3; plain	3; plain

1. ASTM A194 Heavy Hex Grade 2H nuts may be substituted.

2.3. **Washer-Type Indicating Devices**. Use compressible-washer-type direct tension indicators that meet ASTM F959 if allowed. Alternative washer-type indicating devices must be approved by Engineer. Provide detailed testing, installation, and inspection requirements prepared by the manufacturer.

2.4. **Storage**. Protect all bolts and nuts from dirt and moisture at the jobsite. Remove from protected storage only those bolts and nuts anticipated to be installed during a workday. Return unused fasteners to protected

storage at the end of the day. Do not clean fasteners of lubricant present in the as-delivered condition. Perform a field R-C test at the Contractor's expense in accordance with Tex-452-A on any lot of fasteners that shows signs of rust, dirt, or loss of lubrication as directed. Apply additional lubrication and rerun the R-C test before installing bolts if the fasteners fail the R-C test. Replace any fasteners that cannot be re-lubricated to pass the field R-C test. Tension control bolts may only be re-lubricated by the manufacturer.

2.5. **Sampling and Testing**. Sample high-strength bolts, nuts, and washers in accordance with Tex-719-I. Perform field R-C tests as directed in accordance with Tex-452-A. Perform installation verification tests required in Section 447.4.1., "Verification Testing."

2.6. **Fitup Bolts and Erection Pins**. Provide heavy-hex fitup bolts of the same diameter as the connection bolts. Do not use washer-type indicating devices for fitups. Do not reuse galvanized bolts or ASTM A490 bolts that have been used as fitup bolts. Provide a sufficient number of erection or drift pins, 1/32 in. larger than the bolt diameter.

2.7. **Paint Markers**. Provide white or yellow paint markers for marking bolts or nuts for wrench calibration, R-C Tests, and bolt installation.

3. EQUIPMENT

3.1. **Testing Equipment**. Provide a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent), calibrated torque wrench, and other accessories necessary to perform the installation verification test and the R-C test and to calibrate hydraulic or electric torque wrenches.

3.2. **Wrenches**. Furnish either of the following types of wrenches.

3.2.1. **Air-Driven Impact Wrenches**. Furnish air-driven impact wrenches, air compressors, and related accessories of sufficient capacity to properly tension high-strength bolts. Impact wrenches should be of sufficient size and capacity to be able to tension fully a bolt in less than 15 sec. Repair or replace any wrenches that are unable to apply full tension to a bolt within this time.

3.2.2. **Calibrated Torque Wrenches**. Furnish calibrated hydraulic or electric torque wrench and related accessories capable of properly tensioning high-strength bolts. Calibrate the wrench to stall out or cut out completely when the bolt tension reaches 1.05 times the tension specified in Table 2. Calibrate the wrench by tensioning 3 bolts of each size in a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent). Mark each bolt and verify the rotation from snug-tight when calibrating the wrench as specified in Section 447.4.5.3.1., "Turn-of-the-Nut Method." Calibrate the wrench at least once each working day or as directed. Recalibrate the wrench for changes in bolt diameter; changes in bolt length greater than 2 bolt diameters; significant differences in the surface condition of the bolts, threads, nuts, or washers; or changes in the equipment or hose length.

4. CONSTRUCTION

4.1. **Verification Testing**. Have each member of the bolting crew that will perform the actual work complete an acceptable pre-installation verification test in the presence of the Engineer. Only crewmembers that have demonstrated proper workmanship via verification testing may perform production bolting work.

4.1.1. **Air-Driven Impact Wrench**. Perform an installation verification test on 3 complete fastener assemblies of each combination of diameter, length, grade, and lot to be installed before beginning bolting. Follow the bolt-tensioning procedures in Section 447.4.5.3., "Tension Bolts." Use a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent) to verify and demonstrate that the method for estimating the snug-tight condition and controlling the turns from snug-tight develops a tension greater than 1.05 times the tension specified in Table 2. The snug-tight condition is defined as the tightness that exists when the plies of the joint are in firm contact.

4.1.2. **Calibrated Torque Wrench**. Calibrate the wrench before beginning bolting in accordance with Section 447.3.2.2., "Calibrated Torque Wrenches." Use the bolting crew that will perform the actual work for the calibration and calibrate the wrench in the presence of the Engineer. Follow the bolt-tensioning procedures in Section 447.4.5.3., "Tension Bolts."

4.1.3. **Direct-Tension Indicator**. Use a calibrated tension-measuring device for compression-type indicators to verify the gap is not less than 0.015 in. or the job inspection gap specified by the manufacturer when tension in the bolt reaches 1.05 times the tension specified in Table 2.

Follow the manufacturer's instructions for pre-installation verification testing methods and frequency for alternative washer-type indicating devices deemed acceptable.

4.2. **Workmanship**. The Engineer will disqualify any crewmembers not adhering to proper installation methods during production work. Disqualified crew may not perform further bolting work until they complete an additional pre-installation verification test suitable to the Engineer.

4.3. **General**. Ensure all material within the grip of the bolt is steel. Do not allow any compressible material such as gaskets or insulation within the grip. Ensure the slope of parts in contact with the bolt head or nut does not exceed 1:20 with respect to a plane normal to the bolt axis. Prepare all joint surfaces, including those in contact with the bolt heads, nuts, or washers, so that the surfaces are free of dirt, loose rust, loose mill scale, burrs, and other matter that would prevent solid seating of the parts.

Replace any bolts and nuts installed for shipping purposes unless the shop drawings indicate the shop-installed bolts are to be fully tensioned in the shop. Do not tension bolts that have been installed snug-tight in the shop. Remove any bolts installed snug-tight in the shop and replace them with new bolts. Inspect and prepare the joint surfaces after removing shop-installed bolts that are not fully tensioned in the shop.

Provide a hardened washer for heavy-hex and tension-control bolts under either the nut or the bolt head, whichever is turned during tensioning. Install hardened washers under both the nut and bolt head of ASTM A490 bolts when the outer plies being fastened have a yield strength less than 40 ksi.

Install an ASTM F436 washer for direct tension indicators as follows:

- under the nut when the nut is turned and the direct tension indicator is located under the bolt head;
- between the nut and the direct tension indicator when the nut is turned and the direct tension indicator is located under the nut;
- under the bolt head when the bolt head is turned and the direct tension indicator is located under the nut; and
- between the bolt head and the direct tension indicator when the bolt head is turned and the direct tension indicator is located under the bolt head.

Tension all bolts to provide the minimum bolt tension values given in Table 2.

Erect steel in conformance with Item 441, "Steel Structures." Do not tack-weld any parts to eliminate fitup bolts or to hold parts together while bolting.

Remove lubricant from bolt assemblies on painted structures after tensioning and before coating the connections.

Re-tighten the nuts or tack weld the nuts to the bolts when bolts are used to temporarily support welded diaphragms after completing the welding operations if the diaphragms are over vehicular or pedestrian traffic.

Table 2
Bolt Tension

Nominal Bolt Size, in.	Minimum Tension (kips)	
	ASTM A325 Bolts	ASTM A490 Bolts
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1-1/8	56	80
1-1/4	71	102
1-3/8	85	121
1-1/2	103	148

4.4. **Preparation of Faying Surfaces**. Perform blast cleaning or painting of faying surfaces in accordance with Item 441, "Steel Structures." Provide an SSPC-SP 10 blast cleaning before shipment for weathering steel. Do not wire-brush weathering steel faying surfaces.

Roughen galvanized faying surfaces by hand wire-brushing. Do not use power wire brushes to roughen galvanized faying surfaces.

4.5. **Bolt Installation**. Use the following procedure for bolt installation of a complete connection:

4.5.1. **Fair-Up Holes**. Use a minimum number of erection or drift pins, as directed, in the holes to "fair-up" all holes.

4.5.2. **Install Bolts**. Install bolts in all remaining holes of the connection. Do not use excessive force, which results in damage to the threads, to install the bolts. Increase the number of erection or drift pins as necessary to align the holes if force is required to install the bolts. Do not ream the holes unless approved. Ream the holes in accordance with Section 441.3.11.5., "Misfits," if approved. Remove the erection or drift pins and install bolts in these holes. Bring the connection to a full snug-tight condition by snugging systematically from the most rigid part of the connection to the free edges. The snug-tight condition is defined as the tightness that exists when the plies of the joint are in firm, full contact and all of the bolts in the joint have been tightened sufficiently to prevent the removal of the nuts without the use of a wrench. A snug-tight condition can usually be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench as demonstrated in the installation verification test. As necessary, re-snug previously snugged bolts that may have relaxed as a result of the subsequent snugging of adjacent bolts to ensure all bolts are simultaneously snug-tight and the connection plates are in full contact.

Fully tighten a minimum number of bolts as directed until the plies are in full contact if snugging does not bring the plies of the joint into full contact. Mark these bolts as fitup bolts. Use a non-galvanized ASTM A325 bolt of the same diameter as a fitup bolt in connections requiring the use of galvanized ASTM A325 bolts. Re-snug all remaining bolts.

Do not use washer-type indicating devices to bring the connection to a snug-tight condition. Rather, install heavy-hex bolt assemblies in a sufficient number of holes (approximately 20%) to attain firm, full contact between plies. Remove the heavy-hex bolts and install the washer-type indicating device assemblies after firm contact is established by connections in surrounding bolt holes.

4.5.3. **Tension Bolts**. Loosen all fitup bolts after tensioning all the other bolts in the connection. Ungalvanized ASTM A325 bolts used as fitup bolts may be reused in a connection using this type of bolt. Replace all galvanized bolts and ASTM A490 bolts used as fitup bolts. Tension these remaining untensioned bolts in accordance with this paragraph. Ensure the element not turned by the wrench (bolt head or nut) does not rotate.

4.5.3.1. **Turn-of-the-Nut Method**. Match-mark the nuts and the protruding bolt ends after the bolts have been brought up to snug-tight condition and before final tensioning so that actual rotation can be determined.

Tension all bolts in the connection to their final tension by the amount of rotation specified in Table 3. Start final tensioning at the center or most rigid part of the connection and progress toward the free edges.

4.5.3.2. **Calibrated Wrench Method**. Use a calibrated hydraulic torque wrench to tension all bolts to 1.05 times the tension given in Table 1 after they have been brought to the snug-tight condition. Calibrate the wrench in accordance with Section 447.3.2.2., "Calibrated Torque Wrenches." Start tensioning at the most rigid part of the connection and proceed to the free edges. Return the wrench to re-tension previously tensioned bolts that may have relaxed as a result of the subsequent tensioning of adjacent bolts. Place marks on the socket at one-third points so the amount of rotation can be visually determined.

4.5.3.3. **Washer-Type Indicating Devices**.

4.5.3.3.1. **Compressible-Washer-Type Direct Tension Indicators**. Ensure the direct-tension indicator arches are oriented away from the work and that they bear against the hardened bearing surface. Confirm the appropriate feeler gage is 1) accepted in at least half the spaces between protrusions before tensioning, and 2) refused entry in at least half the spaces between protrusions after tensioning.

4.5.3.3.2. **Alternative Washer-Type Indicating Devices**. Follow the procedures prepared by the manufacturer and approved by the Engineer. Verify proper installation after tensioning.

4.5.4. **Bolt Reuse**. Do not reuse ASTM A490 or galvanized ASTM A325 bolts. Ungalvanized ASTM A325 bolts may be reused one time if the threads have not been damaged. Re-tensioning previously tensioned bolts loosened by the tensioning of adjacent bolts is not considered to be reuse.

Tension all bolts in a connection within 10 days of installation. Bolts not tensioned within 10 days of installation are subject to field R-C testing. Re-lubricate or replace any installed bolts that do not have sufficient lubrication as determined by the field R-C test.

Table 3
Nut Rotation from Snug-Tight Condition[1]

Bolt length (underside of head to end of bolt)	Disposition of Outer Face of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped less than 1:20 (beveled washer not used)	Both faces sloped less than 1:20 from bolt axis (beveled washer not used)
Up to and including 4 bolt diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 bolt diameters up to and including 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 bolt diameters up to and including 12 diameters[2]	2/3 turn	5/6 turn	1 turn

1. Nut rotation is relative regardless of the element (nut or bolt) being turned. The tolerance is –0°, +30° for bolts installed by 1/2 turn or less and –0°, +45° for bolts installed by 2/3 turn or more.
2. Determine the required rotation for bolt lengths greater than 12 diameters using the installation verification test in a simulated connection of solidly fitted steel.

5. MEASUREMENT AND PAYMENT

Installation and testing of bolts will not be paid for directly but will be subsidiary to the pertinent Items requiring the use of high-strength bolts.

When payment for the structure associated with the bolts is made under Item 442, "Metal for Structures," bolts, nuts, and washers will be paid for in accordance with Item 442, "Metal for Structures."

Item 448
Structural Field Welding

1. DESCRIPTION

Field-weld metal members using the shielded metal arc or flux cored arc welding processes.

2. MATERIALS

Provide electrodes for shielded metal arc welding (SMAW) conforming to the requirements of the latest edition of ANSI/AWS A5.1 or ANSI/AWS A5.5.

Provide electrodes for flux cored arc welding (FCAW) conforming to the requirements of the latest edition of ANSI/AWS A5.20 or ANSI/AWS A5.29.

Provide electrodes and flux-electrode combinations named on the Department's MPL. To request that a product be added to this list or to renew an expired approval, the Contractor or the consumable manufacturer must submit certified reports of all tests required by the applicable AWS A5 specification according to the applicable welding code to the Construction Division. For most structural steel construction, the applicable welding code is AASHTO/AWS D1.5 or ANSI/AWS D1.1. For reinforcing steel, the applicable code is ANSI/AWS D1.4. Tests must be conducted on electrodes of the same class, size, and brand and manufactured by the same process and with the same materials as the electrodes to be furnished. Resubmit electrodes or flux-electrode combinations every 12 months for renewal.

Table 1 shows the classes of electrodes required. Use electrodes with the type of current, with the polarity, and in the positions permitted by AWS A5.1 and A5.5 for SMAW. AWS A5.20 and A5.29 specifications govern for FCAW. Obtain approval for electrode use on steel not listed in Table 1.

Table 1
Classification of Electrodes Permitted

Type of Steel (ASTM Standards)	Electrode Specification	Process	Filler Metal Requirements
Steel piling Armor joints A500 A501	AWS A5.1 or A5.5	SMAW	E60XX E70XX or E70XX-X
	AWS A5.20 or A5.29	FCAW	E6XTX-X E7XTX-X (except -2, -3, -10, -GS)
A36 A572 Gr. 50 A588 A242 A709 Gr. 36. 50, or 50S	AWS A5.1 or A5.5	SMAW	E7016 E7018 E7028
	AWS A5.20 or A5.29	FCAW	E7XT-1 E7XT-5 E7XT-6 E7XT-8
Weathering steel A588 A242 A709 Gr. 50W	AWS A5.5	SMAW	E8018-W E8016-C3 E8018-C3 E8016-C1 E8018-C1 E8016-C2 E8018-C2
	AWS 5.29	FCAW	E8XT1-W E8XTX-Ni1 E8XTX-Ni2 E8XTX-Ni3
A709 Gr. HPS 70W	AWS A5.5	SMAW	E9018-M-H8R
Reinforcing steel Grade 40	AWS A5.1 or A5.5	SMAW	E70XX
Reinforcing steel Grade 60	AWS A5.5	SMAW	E90XX
Permanent metal deck forms	AWS A5.1 or A5.5	SMAW	E6010 E6011 E6013 E7018

Note—Low-hydrogen electrodes applicable to the lower strength base metal may be used in joints involving base metals of different yield points or strengths.

E7010 and E8010 electrodes may be used when welding the root passes of beam and girder splices if the requirements of Section 448.4.3.5.1., "High-Cellulose Electrodes for Root Passes," are met.

Use electrodes meeting the diffusible hydrogen requirements for fracture-critical welding in AASHTO/AWS D1.5 when welding fracture-critical applications.

Use gas or gas mixtures that are welding grade and have a dew point of −40°F or lower for gas-shielded FCAW. Furnish certification to the Engineer that the gas or gas mixture is suitable for the intended application and will meet the dew point requirements.

3. EQUIPMENT

Provide electrode drying and storing ovens that can maintain the required temperatures specified in Section 448.4.3.1., "Electrode Condition." Each oven must have a door that is sealed and can be latched. Each oven must have a small port that may be opened briefly to insert a thermometer or the oven must be equipped with a thermometer that allows for direct reading of temperature inside the oven without opening the oven. Provide equipment able to preheat and maintain the temperature of the base metal as required and as shown on the plans. Provide approved equipment (e.g., temperature indicator sticks or infrared thermometer) for checking preheat and interpass temperatures at all times while welding is in progress.

Provide welding equipment meeting the requirements of the approved welding procedure specifications (WPS), if required, and capable of making consistent high-quality welds.

4. CONSTRUCTION

4.1. **Procedure Qualification**. Use the proper classification and size of electrode, arc length, voltage, and amperage for the thickness of the material, type of groove, welding positions, and other circumstances of the work.

Submit WPSs for FCAW, qualified in accordance with AASHTO/AWS D1.5 for approval before any field welding on a project.

4.2. **Welder Qualification**. Provide Department certification papers for each welder and for each welding process to be used before welding, except for miscellaneous welds described in Section 448.4.2.1.1., "Miscellaneous Welding Applications." Certification is issued by the Department as described in Section 448.4.2.2., "Certified Steel Structures Welder."

4.2.1. **Miscellaneous Welding**. A qualified welder is an experienced welder who is capable of making welds of sound quality but does not have Department certification papers. The Engineer will check the welder's ability by conducting a jobsite test in accordance with Section 448.4.2.1.2., "Miscellaneous Weld Qualification Test," before welding begins. Furnish all materials and equipment necessary for this test.

4.2.1.1. **Miscellaneous Welding Applications**. A welder certified for structural or reinforcing steel or a qualified welder may make miscellaneous welds of the following types:

- splicing reinforcing steel to extend bars in the bottom of a drilled shaft;
- attaching chairs to the reinforcing steel cage of a drilled shaft;
- armor joints and their supports;
- screed rail and form hanger supports where permitted on steel units;
- reinforcing steel to R-bars for lateral stability between prestressed beams, spirals, or bands to reinforcing bars in drilled shaft cages;
- permanent metal deck forms;
- additional steel added in railing when slip-form construction is used; and
- other similar miscellaneous members that have no load-carrying capacity in the completed structure.

4.2.1.2. **Miscellaneous Weld Qualification Test**. A qualified welder must pass a jobsite Miscellaneous Weld Qualification Test before welding:

- Make a single-pass fillet weld of 1/4 in. maximum size in the vertical position approximately 2 in. long on 1/2-in. plate in the location shown in Figure 1. Use the same electrode proposed for the work.
- The Engineer will visually inspect the fillet weld for a reasonably uniform appearance and then rupture the weld as shown in Figure 2 with a force or by striking it with a hammer.
- The fractured surface of the weld will be inspected to ensure complete penetration into the root of the joint, complete fusion to the base metal, and no inclusion or porosity larger than 3/32 in. in its greatest dimension.

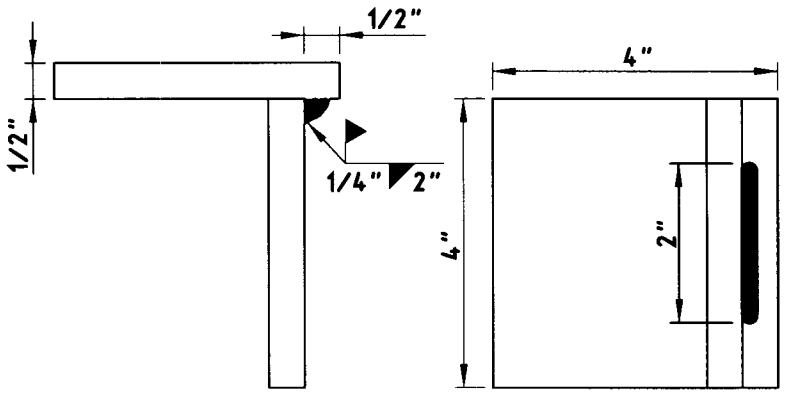


Figure 1
Miscellaneous Qualification—Fillet Weld Break Specimen

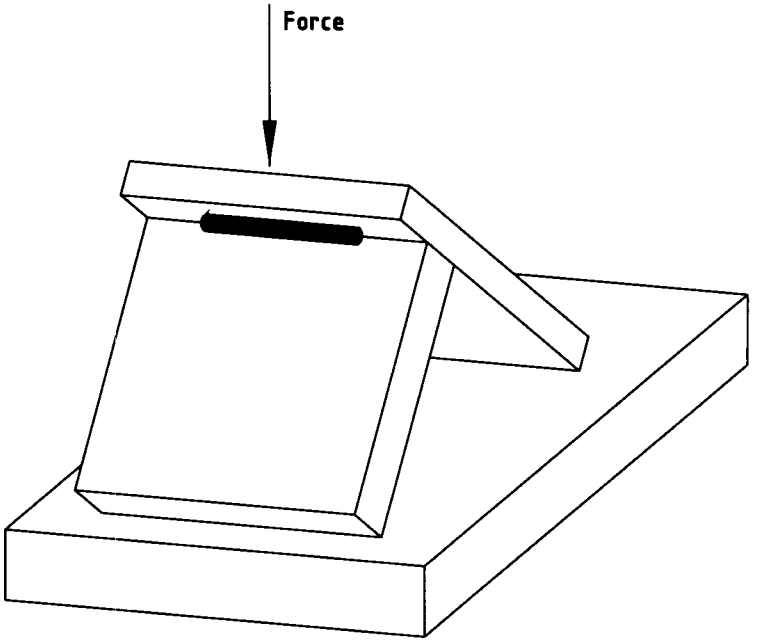


Figure 2
Miscellaneous Qualification—Method of Rupturing Specimen

A welder who fails the Miscellaneous Weld Qualification Test may take a retest under the following conditions:

- The retest occurs immediately and consists of 2 test welds as described above with both test specimens meeting all of the requirements.
- The retest occurs after 30 days if the welder provides evidence of further training or practice. In this case the test consists of a single test weld.

Qualification by the Miscellaneous Weld Qualification Test is effective immediately upon satisfactory completion of the test and remains in effect for the duration of a project.

4.2.2. **Certified Steel Structures Welder**. Before making non-miscellaneous welds on structural steel, a welder must pass the AASHTO/AWS D1.5 qualification test for groove welds for plates of unlimited thickness in the vertical (3G) and overhead (4G) positions with the following additional requirements:

- Use metal for test plates that meets Item 442, "Metal for Structures," with a minimum yield point of 36 ksi. The minimum width of test plate must be sufficient to accommodate the radiograph inspection of 5-1/4 continuous inches of the weld, not counting the ends of the weld.
- Use approved electrodes meeting the required class in accordance with Table 1 and, in the case of FCAW, in accordance with the approved WPS.
- Have a radiographic inspection performed on the weld on each test plate. Any porosity or fusion-type discontinuity with greatest dimension larger than 1/16 in. found in the weld will result in failure of the test. Discontinuities with greatest dimension less than 1/16 in. are acceptable provided the sum of their greatest dimensions does not exceed 3/8 in. in any inch of weld.
- Have 2 side-bend specimens prepared, tested, and inspected for each test plate.

The test must be administered by an approved laboratory and welding observed by laboratory personnel. Submit 2 copies of the certification issued by the laboratory, all accompanying test papers, and the radiographic films to the Bridge Division for review. The Bridge Division issues Department certification papers if the laboratory's certification is approved. A welder must also demonstrate to the Engineer a thorough knowledge of the required welding procedures together with the ability and desire to follow them and make welds of sound quality and good appearance. The certification issued by an approved laboratory is accepted for 1 mo. from the time of certification, during which time the welder may work on Department projects if the work is satisfactory. Certification papers issued by the Department remain in effect as long as the welder performs acceptable work as determined by the Bridge Division. The certification may be cancelled at any time if the welder's work is not acceptable.

For SMAW, a welder certified using EXX18 electrodes is qualified to weld with all approved SMAW electrodes up to E90XX to join metals with a maximum specified yield strength of 65 ksi.

4.3. **Welding Steel Structures**.

4.3.1. **Electrode Condition**.

4.3.1.1. **SMAW**. For electrodes with low-hydrogen coverings in conformance with AWS A5.1, dry to the manufacturer's written drying instructions or dry for at least 2 hours between 450°F and 500°F. For electrodes with low-hydrogen coverings conforming to AWS A5.5, dry for at least 1 hour between 700°F and 800°F or as specified by the electrode manufacturer. If using electrodes from a newly opened undamaged hermetically sealed container, drying is not required. Store electrodes in ovens held at a temperature of at least 250°F immediately after drying or removal from hermetically sealed container. Elapsed time permitted between removal of an electrode from the storage oven or hermetically sealed container and use of the electrode is given in Table 2. If the electrodes have the moisture resistance designator "R" and are being used on steel with minimum specified yield strength of 50 ksi or less, exposure time may be increased up to 9 hr.

Table 2
SMAW Electrode Exposure Limits

Electrode Type	Exposure Time (hr.)
E70	4
E80	2
E90	1

Leave electrodes in the holding oven for at least 4 hr. at 250°F before reusing if they are placed back in it before the times given in Table 2 have lapsed. The Engineer may reduce times allowed for use without re-drying in humid atmospheres. Do not redry electrodes more than once. Do not use electrodes with flux that has been wet, cracked, or otherwise damaged.

4.3.1.2. **FCAW**. Protect or store welding wire coils removed from the original package to keep their characteristics or welding properties intact. Do not use coils or portions of coils that are rusty.

4.3.1.3. **Special Applications**. Dry electrodes for fracture-critical applications or when welding steel not shown in Table 1 in accordance with the manufacturer's specifications and AASHTO/AWS D1.5.

4.3.2. **Environmental Conditions**. Do not weld when the air temperature is lower than 20°F; when surfaces are wet or exposed to rain, snow, or wind; or when operators are exposed to inclement conditions. Provide wind breaks to protect welding operations from winds greater than 5 mph.

4.3.3. **Assembly and Fitup**. Verify that ends of members to be welded are prepared in accordance with the welded joint detail specified. See Figures 3, 4, and 5 for proper end preparation and weld details of girder splices.

Bring the parts to be joined by fillet welds into as close contact as possible, not separated more than 3/16 in. Increase the leg of the fillet weld by the amount of the separation if the separation is 1/16 in. or more. Keep the separation between faying surfaces of lap joints and of butt joints landing on backing strips to no more than1/16 in.

Make suitable allowance for shrinkage, and never restrain the joint on both sides in any welding process.

Use the following fitup procedure for groove welds for butt joints:

- Align splices of beams and girders joined by groove welds with the center of gravity of both cross-sections coinciding or each flange vertically offset equally. Fit beams and girders with offset webs with the webs aligned and the flanges offset laterally. Make the joint with a smooth transition between offset surfaces and with a slope of no more than1:4 when flanges are offset or abutting parts differ in thickness or width by more than 1/8 in.
- Space members to provide a 3/16-in. root opening at the nearest point. At other points of the joint when the spacing provides up to a 7/16-in. opening, correction may be made by buildup up to 1/8 in. on each bevel nose. Rebevel openings exceeding 7/16 in. and move the parts to be joined closer together to bring the joint within the maximum buildup limits. Allow buildups to cool to the maximum preheat and interpass temperatures before welding the joint.
- Bring all members into correct alignment and hold them in position by acceptable clamps while welding.

Complete all butt splices before welding diaphragms or sway bracing in a particular section of a unit. Diaphragms and sway bracing may be welded in a unit behind the splice welding to provide stability except where such welding interferes with butt splice adjustments, such as at a drop-in segment of a continuous unit. Complete all splices before welding beams or girders to shoes.

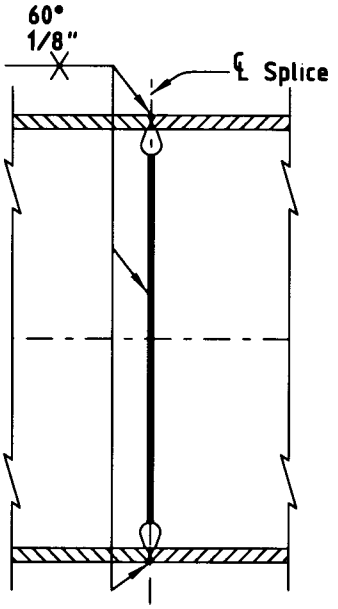


Figure 3
Girder Splice Details

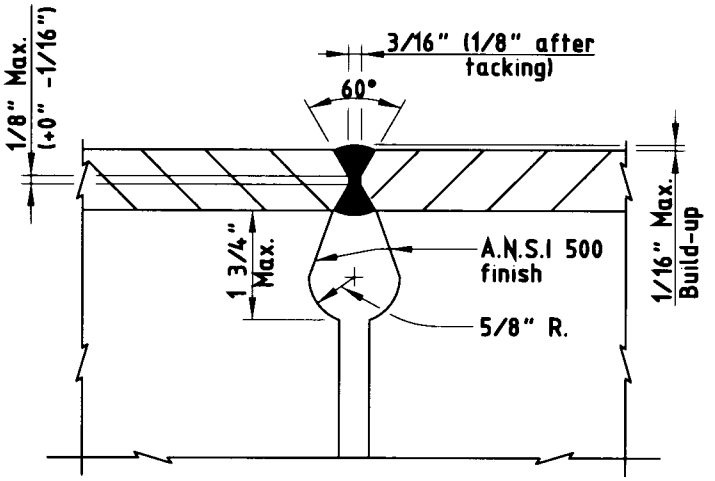


Figure 4
Girder Splice Details (Flange)

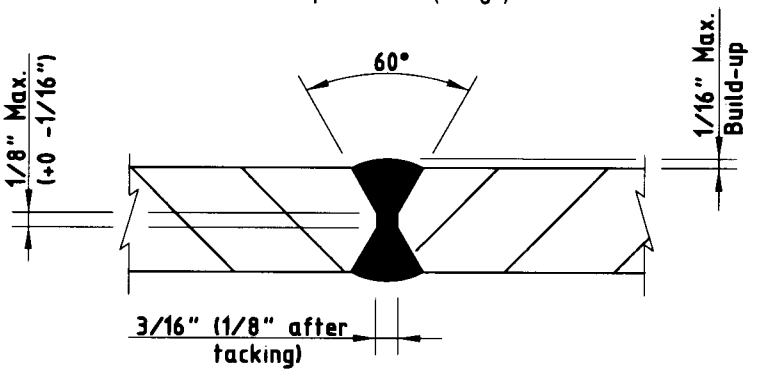


Figure 5
Girder Splice Details (Web)

4.3.4. **Preheat**. Preheat ahead of welding both groove and fillet welds (including tack welding) to the temperatures shown in Table 3. Keep preheat and interpass temperatures high enough to prevent cracks. The preheat

temperatures shown in Table 3 are minimums, and higher preheats may be necessary in highly restrained welds. Preheat the base metal when it is below the required temperature so that parts being welded are not cooler than the specified temperature within 3 in. of the point of welding.

Measure preheat temperature on the side opposite to which the heat is applied at points approximately 3 in. away from the joint.

Completely weld a joint before allowing it to cool below the specified temperature. Always deposit enough weld to prevent cracking before allowing a joint to cool. Do not allow preheat and interpass temperatures to exceed 400°F for thickness up to 1-1/2 in. and 450°F for greater thicknesses.

Table 3
Minimum Preheat and Interpass Temperature for Welding with Low-Hydrogen Electrodes

Thickest Part at Point of Welding	Temperature
Up to 3/4 in., inclusive	50°F
More than 3/4 in. up to 1-1/2 in., inclusive	70°F
More than 1-1/2 in. up to 2-1/2 in., inclusive	150°F
More than 2-1/2 in.	225°F

Preheat the material in accordance with Table 4 when E7010 or E8010 electrodes are used for tacking or temporary root pass.

Table 4
Minimum Preheat Temperature for Welding with E7010 or E8010 Electrodes

Thickest Part at Point of Welding	Temperature
1/2 in. and less	150°F
9/16 in. through 3/4 in.	200°F
13/16 in. through 1-1/2 in.	300°F
More than 1-1/2 in.	400°F

Use preheat and interpass temperatures for the thicker plate thickness when joining steels of different thickness.

Preheat base metal to at least 70°F when the base metal temperature is below 32°F. and maintain this minimum temperature during welding. Preheat base metal to 200°F before starting to weld if it is moist.

Preheat fracture-critical applications in accordance with AASHTO/AWS D1.5.

4.3.5. **Welding Practice**. Use an approved procedure to control shrinkage and distortion. Weld FCAW in accordance with an approved WPS. Weld as required by the Contract or erection drawings. Do not change the location or size of welds without approval. Do not make temporary welds for transportation, erection, or other purposes on main members except as shown on the plans or approved. Use a crayon, paint, or other approved method to mark each groove weld to identify the welder who performed the work.

Use the stringer-bead technique where possible for groove welds. Progress upward in vertical welding passes using a back-step sequence keeping the end of the low-hydrogen electrode contained within the molten metal and shield of flux unless the electrode manufacturer's specifications indicate otherwise.

Begin and terminate groove welds at the ends of a joint on extension bars. Make edge preparation and thickness of extension bars the same as that of the member being welded but extending at least 2 in. beyond the joint. Remove extension bars with a cutting torch or arc-air gouging, and grind the flange edges smooth after the weld is completed and cooled. Clean any defects exposed by the grinding, fill them with weld metal, and regrind them to a uniform finish. Grind so that grind marks are parallel to the flange, and avoid excess grinding of the parent metal. Clean and fuse tack welds thoroughly with the final weld. Remove defective, cracked, or broken tack welds.

Gouge, chip, or otherwise remove the root of the initial weld to sound metal for all groove welds, except those produced with the aid of backing or those on steel piling or armor joints, before welding is started on the second side. Clean the back side thoroughly before placing the backup pass. Fuse the weld metal

thoroughly with the backing, and use backing that is continuous for the full length of the weld. Make a continuous length of backing by welding shorter sections together only under the following conditions:

- All splices in the backing are complete joint penetration (CJP) groove welds made with the same controls as similar CJP groove welds in the structure.
- The welds are radiographed and examined as described in Section 448.4.3.7., "Radiographic Inspection" to ensure weld soundness.
- All welding and testing of the backing is complete before the backing is used to make the structural weld.

4.3.5.1. **High-Cellulose Electrodes for Root Passes**. E7010 and E8010 electrodes may be used when welding the root passes of beam and girder splices if the work is preheated in accordance with Table 4. Remove the E7010 or E8010 electrode pass completely by arc-air gouging, and replace it using a low-hydrogen electrode after the root passes are backed up.

4.3.5.2. **Welding Sequence**. Make beam and girder splices using the sequences shown in Figure 6. (Some members will require fewer or more passes than Figure 6 shows.) Alternate welds from flat to overhead to prevent heat buildup along bevel edge. Arrange the passes between the top and bottom flange to maintain balance and symmetry.

Place passes 1, 2, and 3 in the top flange, followed by passes 4, 5, and 6 in the bottom flange (see Figure 6) for rolled I-beams and built-up girders. Gouge out and replace passes 1 and 4, which always are placed in the overhead position. Next, place passes 7, 8, and 9 in the top flange, followed by passes 10, 11, and 12 in the bottom flange. Continue with placing passes 13–17 in the top flange, followed by passes 18–22 in the bottom flange. Continue to alternate welding between top and bottom flange with a maximum of 5 passes per flange until the flange splices are complete. Tack weld web after aligning girder webs with short tacks as required to obtain proper alignment. Place pass 23 and pass 24 on the web. Gouge out and replace pass 23. Finish web splice with pass 25.

Remove all slag for each layer, bead, and the crater area, and clean the weld and adjacent base metal before welding over previously deposited metal. Avoid arc strikes, and if they occur, grind resulting cracks and blemishes out to a smooth contour, checking them visually to ensure soundness.

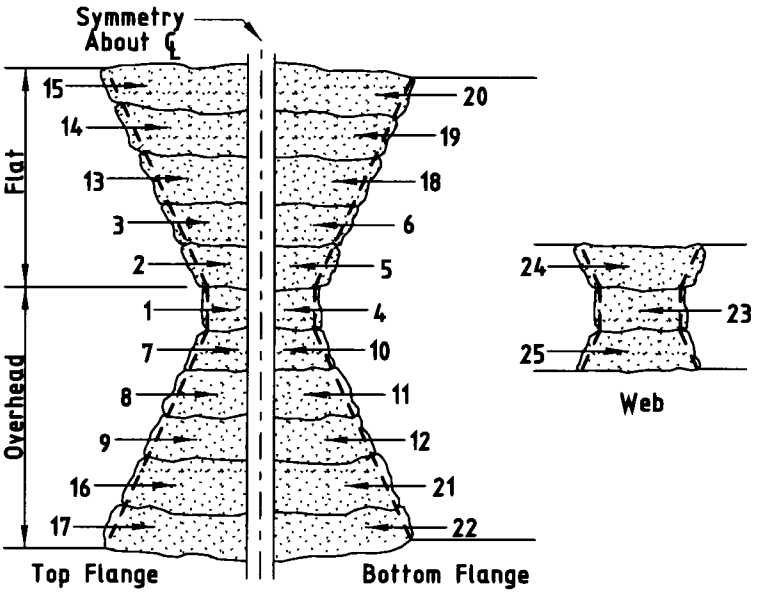


Figure 6
Welding Sequence for Splices for Material up to 50,000-psi Yield Strength.

Deviation from the above sequence of weld passes requires approval. Obtain approval from the Bridge Division for welding procedures and sequences for special connections.

4.3.5.3. **Electrode Size and Weld Layer Thickness**.

4.3.5.3.1. **SMAW**.

4.3.5.3.1.1. **Electrode Size**. Use electrodes with the following maximum size:

- 1/4 in. for all welds made in the flat position except root passes,
- 1/4 in. for horizontal fillet welds,
- 1/4 in. for root passes of fillet welds made in the flat position and of groove welds made in the flat position with backing and with a root opening of 1/4 in. or more,
- 5/32 in. for welds made with low-hydrogen electrodes in the vertical and overhead positions, and
- 3/16 in. for all other welds.

4.3.5.3.1.2. **Weld Size and Layer Thickness**. Make the root pass large enough to prevent cracking. Make layers subsequent to the root pass in fillet welds and all layers in groove welds of the following maximum thickness:

- 1/4 in. for root passes of groove welds;
- 1/8 in. for subsequent layers of welds made in the flat position; and
- 3/16 in. for subsequent layers of welds made in the vertical, overhead, and horizontal positions.

Make fillet welds passes using no larger than:

- 3/8 in. in the flat position,
- 5/16 in. in the horizontal or overhead positions, and
- 1/2 in. in the vertical position.

4.3.5.3.2. **FCAW**.

4.3.5.3.2.1. **Electrode Size**. Use electrodes with the following maximum size:

- 5/32 in. for the flat and horizontal positions,
- 3/32 in. for the vertical position, and
- 5/64 in. for the overhead position.

4.3.5.3.2.2. **Weld Size and Layer Thickness**. Make weld layers, except root and surface layers, no thicker than 1/4 in. Use a multiple-pass split-layer technique when the root opening of a groove weld is 1/2 in. or wider. Use the split-layer technique to make all multiple-pass welds when the width of the layer exceeds 5/8 in.

Ensure each pass has complete fusion with adjacent base metal and weld metal and that there is no overlap, excessive porosity, or undercutting.

Do not use FCAW with external gas shielding in a draft or wind. Furnish an approved shelter of material and shape to reduce wind velocity near the welding to a maximum of 5 mph.

Make fillet weld passes using no larger than:

- 1/2 in. in the flat position,
- 3/8 in. in the horizontal or overhead positions, and
- 5/16 in. in the vertical position.

4.3.6. **Weld Quality**. Provide welds that are sound throughout with no cracks in the weld metal or weld pass. Completely fuse the weld metal and the base metal and each subsequent pass. Keep welds free from overlap, and keep the base metal free from undercut more than 1/100 in. deep when the direction of undercut is transverse to the primary stress in the part that is undercut. Fill all craters to the full cross-section of the welds.

4.3.7. **Radiographic Inspection**. Conduct radiographic testing (RT) as required in the field at the expense of the Contractor by an agency or individual registered and licensed to perform industrial radiography. Follow all applicable rules and regulations for radiographic operations. Testing includes furnishing all materials, equipment, tools, labor, and incidentals necessary to perform the required testing. The Department may require further tests in accordance with Article 5.10., "Inspection," and may perform additional testing, including other methods of inspection.

Perform RT in accordance with AASHTO/AWS D1.5. The Engineer will examine and interpret the resulting radiographs in accordance with AASHTO/AWS D1.5. All radiographs become the property of the Department and remain with the Engineer.

Radiographically inspect the full flange width of all flange splices and the top and bottom 1/6 of the web at each splice for field-welds of splices in beams or girders. Radiographically retest repaired welds. Make necessary repairs before any further work is done. Additional RT required because of unacceptable welding or poor radiograph quality is at the Contractor's expense. RT of particular welds required by the plans is in addition to the RT required by this Item.

Meet the requirements specified in Section 441.3.2.5.1., "Radiographic Testing" for radiograph film quality.

4.3.8. **Corrections**. When welding is unsatisfactory or indicates inferior workmanship, the Engineer will require corrective measures and approve the subsequent corrections.

Use oxygen gouging or arc-air gouging when required to remove part of the weld or base metal. Back-gouge splices in beams and girders or cut out defective welds using arc-air gouging by a welder qualified to make beam and girder splices.

Slope the sides of the area to be welded enough to permit depositing new metal were corrections require depositing additional weld metal.

Use a smaller electrode than that used for the original weld where corrections require depositing additional weld metal. Clean surfaces thoroughly before re-welding.

Remove cracked welds completely and repair. Remove the weld metal for the length of the crack if crack length is less than half the length of the weld plus 2 in. beyond each end of the crack, and repair.

Restore the original conditions where work performed after making a deficient weld has made the weld inaccessible or has caused new conditions making the correction of the deficiency dangerous or ineffectual by removing welds, members, or both before making the necessary corrections; otherwise, compensate for the deficiency by performing additional work according to a revised and approved design.

Cut apart and re-weld improperly fitted or misaligned parts.

Straighten members distorted by the heat of welding using mechanical means or the carefully supervised application of a limited amount of localized heat. Do not let heated areas exceed 1,200°F as measured by temperature-indicating crayons or other approved methods for steel up to 65,000-psi yield strength. Do not let heated areas exceed 1,100°F for higher-strength steels. Keep parts to be heat-straightened substantially free of stress from external forces except when mechanical means are used with the application of heat. Before straightening, submit a straightening procedure to the Engineer for approval.

Correct defective or unsound welds either by removing and replacing the entire weld or as follows:

4.3.8.1. **Excessive Convexity**. Reduce to size by grinding off the excess weld metal, leaving a smooth profile.

4.3.8.2. **Shrinkage Cracks, Cracks in Base Metal, Craters, and Excessive Porosity**. Remove defective portions of base and weld metal down to sound metal, and replace with additional sound weld metal.

4.3.8.3. **Undercut, Undersize, and Excessive Concavity**. Clean and deposit additional weld metal.

4.3.8.4. **Overlap and Incomplete Fusion**. Remove and replace the defective portion of weld.

4.3.8.5. **Slag Inclusions**. Remove the parts of the weld containing slag, and replace them with sound weld metal.

4.3.8.6. **Removal of Base Metal during Welding**. Clean and form full size by depositing additional weld metal using stringer beads.

4.4. **Shear Stud Welding**. Weld shear studs to steel surfaces and perform preproduction and production tests as required in AASHTO/AWS D1.5.

4.5. **Welding Reinforcing Steel**. Splice reinforcing steel by welding only at locations shown on the plans.

4.5.1. **Base Metal**. Provide weldable reinforcing steel in conformance with Item 440, "Reinforcement for Concrete."

4.5.2. **Preheat and Interpass Temperature**. Minimum preheat and interpass temperatures are shown in Table 5. Preheat reinforcing steel when it is below the listed temperature for the size and carbon equivalency range of the bar being welded so that the cross-section of the bar is above the minimum temperature for at least 6 in. on each side of the joint. Allow bars to cool naturally to ambient temperature after welding is complete. Do not accelerate cooling.

Table 5
Minimum Preheat and Interpass Temperature for Reinforcing Steel

Carbon Equivalent Range (%)	Size of Reinforcing Bar (no.)	Temperature (°F)
Up to and including 0.40	Up to 11 inclusive	None
	14 and 18	50
0.41 through 0.45 inclusive	Up to 11 inclusive	None
	14 and 18	100
0.46 through 0.55 inclusive	Up to 6 inclusive	None
	7 to 11 inclusive	50
	14 and 18	200
Unknown	Up to 18 inclusive	500

Base the preheat and interpass temperatures for widening projects on the existing reinforcing steel and the requirements of Table 5.

4.5.3. **Joint Types**. Use butt splices for all No. 7 and larger bars. Use lap splices for No. 6 and smaller bars.

Make groove welds in lap splices at least 4 in. long, and weld them on each side of the lap joint as shown in Figure 7. For No. 5 and smaller bars, weld from one side of the lap when it is impractical to weld from both sides of the joint if approved by the Engineer, but in this case make the weld at least 6 in. long.

Make all butt splices in the flat position. Make all welds for butt splices, except horizontal welds on vertical bars, as shown in Figures 8 and 9. The back-up strip is required when access to the splice is from the top only. When bars can be rotated or access to the splice is available from 2 sides, the double bevel splice may be used, and this type weld requires gouging out the root pass similar to a flange splice on structural steel. The root pass may be made using E7010 or E8010 electrodes for all double beveled splices. Preheat the steel to 400°F, if using E7010 or E8010 electrodes, and then completely remove the root pass before welding the opposite side. Make horizontal splices on vertical bars as shown in Figure 10. Provide alignment strips as shown in Figures 9 and 10 to hold bars during welding operation. Trim alignment strips after welding is complete.

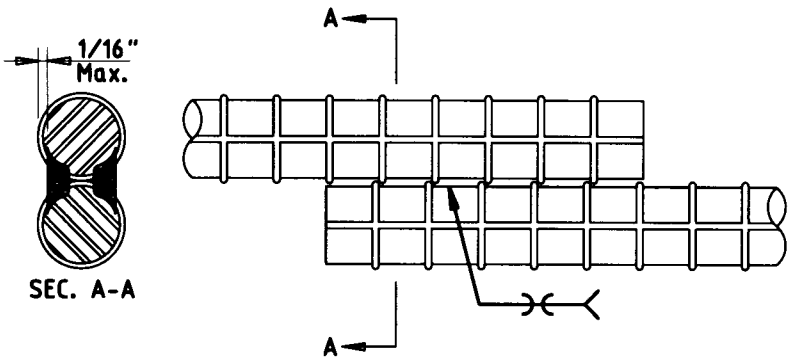


Figure 7
Direct Lap Joint with Bars in Contact

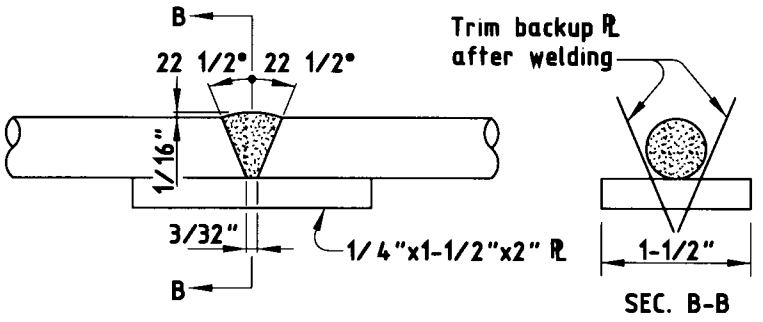


Figure 8
Single Bevel V-Groove Weld in Horizontal Position

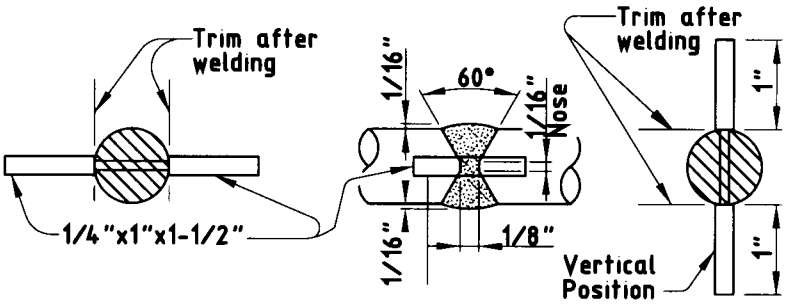


Figure 9
Double Bevel V-Groove Weld in Horizontal Position

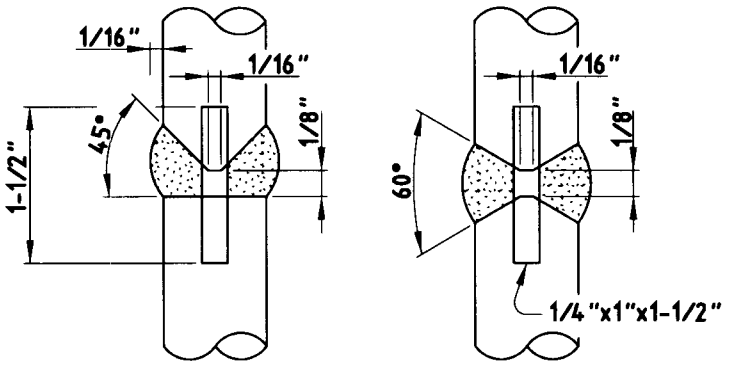


Figure 10
Double Bevel V-Groove Weld in Vertical Position

4.5.4. **Radiographic Inspection**. Radiograph welded butt splices at the expense of the Contractor when designated on the plans. Follow all applicable rules and regulations for radiographic operations. Ensure welds have no cracks and that the sum of the greatest dimensions of porosity and fusion-type defects do not exceed 1/10 of the nominal bar diameter.

The Engineer will examine and interpret the resulting radiographs, which become the property of the Department and remain with the Engineer.

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 449
Anchor Bolts

1. DESCRIPTION

Fabricate and install anchor bolts to be embedded in or attached to concrete. Anchor bolts are also referred as anchor rods.

2. MATERIALS

2.1. **Bolts and Nuts**. Provide bolts and nuts that meet the standards given in Table 1.

Table 1
Bolt and Nut Standards

Specified Anchor Bolt Category	Bolt Standards	Nut Standards
Mild steel	ASTM A307 Gr. A, F1554 Gr. 36, or A36	ASTM A563
Medium-strength, mild steel	ASTM F1554 Gr. 55 with supplementary requirement S1	ASTM A194 Gr. 2 or A563 Gr. D or better
High-strength steel	ASTM A325 or A449[1]	ASTM A194 or A563, heavy hex
Alloy steel	ASTM A193 Gr. B7 or F1554 Gr. 105	ASTM A194 Gr. 2H or A563 Gr. DH, heavy hex

1. If headed bolts are specified, ASTM A449 bolts must be heavy hex head.

Provide a mill test report or manufacturer's certification indicating the material conforms to these requirements. For alloy steel anchor bolts, provide a test report or certification attesting to the heat-treating process if applicable. If no specific bolt category is indicated on the plans, provide mild steel anchor bolts and nuts that meet the standards given in Table 1.

2.2. **Washers**. Use washers that meet ASTM F436.

2.3. **Threads**. Provide anchor bolts with rolled or cut threads of UNC or 8UN series in accordance with ASME B1.1. Anchor bolts 1-3/4 in. in diameter and larger must have UNC series threads. If bolts have rolled threads, ensure the diameter of the unthreaded portion of bolts with rolled threads is neither less than the minimum pitch diameter nor more than the maximum major diameter of the threads. If bolts have cut threads, ensure the diameter of the unthreaded portion is not less than the minimum major diameter of the threads. Ensure all threads for bolts and nuts have Class 2 fit tolerances in accordance with ASME B1.1.

3. CONSTRUCTION

3.1. **Fabrication**. Welded splicing of anchor bolts is not permitted.

Provide an anchorage device with each anchor bolt consisting of a standard bolt head, a threaded bolt with nuts, or, if shown on the plans, a 90° bend. Make the inside-bend diameter approximately 2 times the anchor bolt diameter, but at no point along the bend greater than 3 times the bolt diameter. Hot bending is permissible provided the temperature does not exceed 1,100°F.

If the anchor bolts will be installed in a template embedded in concrete, tack weld the anchorage nuts to the template in the shop. Perform this welding with appropriate jigs to ensure the anchor bolt is perpendicular to the template.

When embedded templates are not specified and nuts are welded to the end of anchor bolts for anchorage, weld only on the nut face at the unstressed end of the bolt. Ensure no welding, arc, or other potential notch-producing effects occur in the stressed portion of the bolt.

Shipping of the anchor bolt cage in its assembled condition is not required.

3.2. **Finish**. Galvanize in accordance with Item 445, "Galvanizing."

3.2.1. **Anchor Bolts Embedded in Concrete**. Galvanize the exposed end of the thread length plus a minimum of 6 in. unless otherwise shown on the plans.

3.2.2. **Anchor Bolts Extending Through Concrete**. Galvanize the complete length of the bolt.

3.2.3. **Nuts**. Galvanize exposed nuts. Galvanize the untapped blanks before cutting the threads.

3.2.4. **Washers**. Galvanize exposed washers.

3.3. **Installation**. Hold the anchor bolt and template assembly rigidly in position during concrete placement. Use wood templates or other positive means to ensure correct positioning of anchor bolts not requiring steel templates. Positioning devices may be tack welded to the steel templates but not to any portion of the anchor bolts.

3.3.1. **Anchor Bolt Thread Lubricant Coating**. Coat anchor bolt threads before installing nuts with an electrically conducting lubricant compound described in Section 449.3.3.2.1., "Definitions," for traffic signal poles, roadway illumination poles, high mast illumination poles, and overhead sign support structures. Coat anchor bolt threads for other structures with pipe joint compound or beeswax. After installing nuts, repair galvanizing damage on bolts, nuts, and washers in accordance with Section 445.3.5., "Repairs."

3.3.2. **Anchor Bolt Tightening Procedure**. Tighten anchor bolts for traffic signal poles, shoe base and concrete traffic barrier base roadway illumination poles, high mast illumination poles, and overhead sign support structures in accordance with this Section. This procedure covers the tightening of nuts on a double-nut anchor bolt system using anchor bolts with 55 ksi or 105 ksi minimum yield strength and UNC or 8UN thread series to secure structures to drilled shaft foundations.

3.3.2.1. **Definitions**. The following definitions apply to the anchor bolt tightening procedure:

- **Double-Nut Anchor Bolt System**. An anchor bolt with 2 nuts that sandwich the structure's base plate. The bottom nut is positioned under the base plate to level, support, and provide the reaction for the force applied by tightening the top nut positioned above the base plate.
- **Electrically Conducting Lubricant**. A compound commonly used in the electrical industry to coat threads of field-cut rigid metal conduit and suitable for exposure to weather.
- **Impact Tightening**. The tightening of nuts with a box end "slug" or "knocker" wrench and a sledgehammer. The wrench, matching the size of the nut to be tightened, is driven with the sledgehammer to rotate the nut.
- **Static Tightening**. The tightening of nuts with a "spud" wrench and a pipe or extension handle. The wrench, matching the size of the nut to be tightened, may be turned with more than one worker to rotate the nut.
- **Snug-Tight**. The condition when the nut is in full contact with the base plate. It may be assumed the full effort of a worker on a 12-in. wrench results in a snug-tight condition.
- **Turn-of-the-Nut Method**. The tightening of top nuts to snug-tight condition then establishing reference positions by marking one flat on each nut with a corresponding reference mark on the base plate at each bolt. Each nut is then turned to the prescribed rotation from the referenced snug-tight position.

3.3.2.2. **Anchor Bolt Tightening**. Perform the following procedure:

- Coat the threads of the anchor bolts with electrically conducting lubricant.

- Install the bottom nuts on the bolts, 1 on each bolt.
- Level the top template (using it as a guide) by adjusting the bottom nuts so the template rests on each nut and the distance between the top of the concrete shaft and the bottom surface of the bottom nut is approximately 1/2 in.
- Remove the template.
- Coat the bearing surfaces of the bottom nuts and washers with electrically conducting lubricant.
- Install bottom washers on bolts, 1 on each bolt.
- Erect and plumb the structure as specified. Adjust the bottom nuts so each is bearing equally on the washer or base plate. The truss for cantilever overhead sign support structures and the mast arm for traffic signal poles must be removed during anchor bolt tightening.
- With the plumbed structure supported by a crane, coat the bearing surfaces of the top nuts and washers with electrically conducting lubricant. Install 1 washer and 1 top nut on each bolt. Turn the top nuts onto the bolts so each is hand-tight against the washer or base plate.
- Turn each bottom nut to a snug-tight condition using a wrench.
- Verify the structure is still plumb and still supported by the crane. Begin turn-of-the-nut method by turning each top nut down to the same snug-tight condition. Prevent rotation of the bottom leveling nut during all top nut tightening. Establish reference marks for turn-of-the-nut method once snug-tight condition is achieved, and then tighten the top nuts by turning each nut 1/12 turn (1/2 of a nut flat) past snug-tight using either static or impact tightening. Turn each top nut an additional 1/12 turn until each nut has been tightened 1/6 total turn past snug-tight.

4. MEASUREMENT AND PAYMENT

Top or bottom templates, washers, lock washers, nuts, lock nuts, and other devices used for installing anchor bolts are considered part of the anchor bolt assembly. All work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 454
Bridge Expansion Joints

1. DESCRIPTION

Furnish and install bridge expansion joints.

2. MATERIALS

Provide materials in accordance with the requirements of the following Items.

- Item 442, "Metal for Structures"
- DMS-6140, "Polymer Concrete for Bridge Joint Systems"
- DMS-6310, "Joint Sealants and Fillers"
- ASTM D5973

Use primers recommended by the manufacturer of the sealant when required. Use backer rods compatible with the sealant that do not react or bond together.

3. CONSTRUCTION

Place expansion joints to conform to the finished grade of the roadway surface. Set the joint opening at the dimension shown on the plans for 70°F, adjusted for the temperature at the time of installation. Place the seal for the full length of the joint for sealed joint openings and, when required, extend it into the parapet wall on the low side or sides of the bridge.

3.1. **Sealed Expansion Joint (SEJ)**. Choose an approved joint system that conforms to the joint type and the design requirements shown on the plans. Secure each side of the joint by welding it to the adjacent reinforcing steel or other attachments as approved. Remove any connection holding the joint halves together immediately after each joint half is secured in place. Install the neoprene seal as a continuous piece to form a watertight seal.

3.2. **Armor Joint**. Place steel armor plates as shown on the plans. Secure each side of the joint by welding it to adjacent reinforcing steel or other attachments as approved. Remove any connection holding joint halves together immediately after each joint half is secured in place.

Seal the joint when specified. Abrasive blast clean the vertical faces of the steel plates where the sealant will be in contact to remove all visible rust, paint, mill scale, and other forms of contamination, leaving a white metal appearance. Clean the concrete in contact with the sealant by an approved method in accordance with the manufacturer's specifications before placing sealant. After cleaning, air blast the joint to remove all dust. Place sealant in accordance with the manufacturer's specifications and as shown on the plans. Repair damage to paint protection system above the seal when shown on the plans for steel armor plates to be painted.

3.3. **Header-Type Expansion Joint**. Meet with the manufacturer's representative and the Engineer to discuss the required installation procedures of the materials before beginning the work. Perform the work in accordance with the manufacturer's printed instructions and as discussed in the meeting. Additionally, the Engineer may request the presence of the manufacturer's representative for additional training if work personnel are not adequately following manufacturer's installation directions.

3.3.1. **Header**. Provide an approved polymer concrete from DMS-6140, "Polymer Concrete for Bridge Joint Systems." Create the required void in the concrete surface or asphalt overlay to accept the header material

in accordance with the details shown on the plans. Extend the depth of the void in the asphalt overlay to sound concrete. Remove any unsound steel or concrete and repair concrete in accordance with Item 429, "Concrete Structure Repair," and Item 785, "Bridge Joint Repair or Replacement." Use header material as repair material only when approved. Clean the voided region of all materials that could inhibit the bond between the header material and concrete or steel. Form the joint opening to the required width shown on the plans.

Place materials once approved. Place material on a clean, sound, and dry base when the ambient temperature is at least 45°F and rising or as required by the manufacturer. Do not place material on wet substrate or when raining.

Cure for the duration required by the manufacturer's data sheets before opening to traffic.

Tool or grind the upper corner of the header adjacent to the opening to a 1/4-in. radius.

3.3.2. **Sealant**. Provide an approved Class 1 or Class 7 joint sealant from DMS-6310, "Joint Sealants and Fillers" unless otherwise shown on the plans. Clean the joint opening of forming material, existing seal, and other material that will inhibit the bond between the header material and the sealant. Abrasive blast clean surfaces in contact with the sealant. Place an approved backer rod and the sealant as shown on the plans. Place sealant primer and sealant when ambient temperature is rising and is between 55°F and 85°F to provide for adequate joint opening and compression of the sealant during curing.

4. MEASUREMENT

Sealed expansion joints and armor joints will be measured by the foot. Header-type expansion joints will be measured by the foot or by the cubic foot of header material and foot of sealant. Length measurement will be along the centerline of the joint at the surface of the roadway and up into the parapet. Calculate volume for header-type expansion joints using the length and width shown on the plans and the header depth measured in place.

Sealed expansion joints and armor joints are a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Sealed Expansion Joint" of the size (minimum total movement capacity) and designation specified, "Armor Joint," "Armor Joint (With Seal)," and "Header-Type Expansion Joint." Sealing the joint will be subsidiary to these items with the exception of the header-type expansion joint when the header is paid for by volume measurement. This price is full compensation for furnishing and installing the joint systems including steel; and for materials, tools, equipment, labor, and incidentals.

If volume measurement for the header material is specified, the header material will be paid for at the unit price bid for "Header-Type Expansion Joint" and the sealant will be paid for at the unit price bid for "Joint Sealant." This price is full compensation for furnishing and installing the joint systems and for materials, tools, equipment, labor, and incidentals.

Item 460
Corrugated Metal Pipe

1. DESCRIPTION

Furnish and install corrugated metal pipes, materials for constructing corrugated metal pipe culverts, or corrugated metal storm drain mains, laterals, stubs, and inlet leads.

2. MATERIALS

2.1. **Fabrication**. Furnish corrugated metal pipe in accordance with Table 1.

Table 1
Specifications for Corrugated Metal Pipe

Pipe Type	AASHTO Specification
Galvanized steel and aluminized steel	M 36
Aluminized Type 2	M 36
Polymer Coated	M 36 & M 245
Asphalt Coated	M 36
Aluminum	M 196

The pipe type and corresponding AASHTO designations are shown in Table 2.

Table 2
Corrugated Metal Pipe Types

Pipe Type	AASHTO Classification
Circular	Type I
Circular, smooth-lined	Type IA
Circular, spiral rib	Type IR
Arch	Type II
Arch, smooth-lined	Type IIA
Arch, spiral rib	Type IIR

Provide corrugated metal pipe of all types with annular corrugations, helical corrugations, or spiral ribs (corrugations) projecting outward. Provide pipe with helical end corrugations only when necessary to join new pipe to existing pipe with helical end corrugations.

Provide a minimum polymer coating thickness of 10 mils on each side for pre-coated galvanized steel pipe. Galvanized metal sheets and coils used for galvanized corrugated metal pipe may be sampled and tested in accordance with Tex-708-I.

Repair damaged galvanized coating in accordance with Section 445.3.5., "Repairs." Repair damaged aluminized or polymer coating in accordance with AASHTO M 36 and M 245 respectively.

2.2. **Protective Coating**. Furnish bituminous coating, when required, that meets AASHTO M 190 and that tightly adheres to the metal, does not chip off in handling, and protects the pipe from deterioration as evidenced by samples prepared from the coating material successfully meeting the Shock Test and Flow Test in accordance with Tex-522-C.

Coat the pipe uniformly inside and out to a minimum thickness of 0.05 in. measured on the crests of the corrugations. Coat the pipe with additional material applied to the full inner circumference to form a smooth inside lining with a minimum thickness of 1/8 in. above the crest of the corrugations when smooth lining is specified.

2.3. **Design**. The diameter, permissible corrugations, and required gauges for full-circle pipe will be shown. The design size and permissible corrugations for pipe arch will be shown. The required gauges of the shell and the liner for smooth lined pipe will also be shown. Furnish the shape and minimum gauge for steel pipe arch in accordance with Tables 3, 4, 5, or 6 for the specified design size and corrugation. Use Table 7 or 8 for aluminum pipe arch. Refer to U.S. Standard Gauge for uncoated sheets where reference is made to gauge of metal.

Measure dimensions from the inside crests of the corrugations. A tolerance of ±1 in. or 2% of the equivalent circular diameter, whichever is greater, is allowed for span and rise.

Table 3
Steel Pipe Arch
2-2/3 × 1/2-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
1	17	13	12	16	0.064	15
2	21	15	12	16	0.064	18
2A	23	19	12	16	0.064	21
3	28	20	12	16	0.064	24
4	35	24	12	16	0.064	30
5	42	29	12	14	0.079	36
6	49	33	12	14	0.079	42
7	57	38	12	12	0.109	48
8	64	43	12	12	0.109	54
9	71	47	12	10	0.138	60

Table 4
Steel Pipe Arch
3 × 1-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
7	53	41	12	14	0.079	48
8	60	46	12	14	0.079	54
9	66	51	12	14	0.079	60
10	73	55	12	14	0.079	66
11	81	59	12	14	0.079	72
12	87	63	12	14	0.079	78
13	95	67	12	12	0.109	84
14	103	71	18	12	0.109	90
15	112	75	18	12	0.109	96
16	117	79	18	12	0.109	102
17	128	83	24	10	0.138	108
18	137	87	24	10	0.138	114
19	142	91	24	10	0.138	120

Table 5
Steel Pipe Arch
5 × 1-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
11	81	59	12	12	0.109	72
12	87	63	12	12	0.109	78
13	95	67	12	12	0.109	84
14	103	71	18	12	0.109	90
15	112	75	18	12	0.109	96
16	117	79	18	12	0.109	102
17	128	83	24	10	0.138	108
18	137	87	24	10	0.138	114
19	142	91	24	10	0.138	120

Table 6
Steel Pipe Arch, Spiral Rib
7-1/2 × 3/4 × 3/4-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
2	20	16	12	16	0.064	18
2A	23	19	12	16	0.064	21
3	27	21	12	16	0.064	24
4	33	26	12	16	0.064	30
5	40	31	12	14	0.064	36
6	46	36	12	12	0.064	42
7	53	41	12	12	0.079	48
8	60	46	12	12	0.079	54
9	66	51	15	12	0.079	60

Table 7
Aluminum Pipe Arch
2-2/3 × 1/2-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
1	17	13	12	16	0.060	15
2	21	15	12	16	0.060	18
2A	23	19	12	16	0.060	21
3	28	20	12	14	0.075	24
4	35	24	12	14	0.075	30
5	42	29	18	12	0.105	36
6	49	33	18	12	0.105	42
7	57	38	18	10	0.135	48
8	64	43	18	10	0.135	54
9	71	47	18	8	0.164	60

Table 8
Aluminum Pipe Arch, Spiral Rib
7-1/2 × 3/4 × 3/4-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
2	20	16	12	16	0.064	18
2A	23	19	12	16	0.064	21
3	27	21	15	16	0.064	24
4	33	26	18	16	0.064	30
5	40	31	18	14	0.075	36
6	46	36	18	12	0.105	42
7	53	41	21	12	0.105	48
8	60	46	18	10	0.135	54
9	66	51	21	10	0.135	60

2.4. **Coupling Bands**. Furnish coupling bands and other hardware for galvanized or aluminized steel pipe in accordance with AASHTO M 36 for steel pipe and AASHTO M 196 for aluminum pipe. Use coupling bands that are no more than 3 nominal sheet thicknesses lighter than the thickness of the pipe to be connected or no lighter than 0.052 in. for steel or 0.048 in. for aluminum. Provide coupling bands made of the same base metal and coating as the pipe.

3. CONSTRUCTION

3.1. **Designation of Type**. The types of pipes will be indicated on the plans by the following descriptions:

- Pipe type: Corrugated metal pipe (CMP), corrugated metal pipe arch (CMP ARCH), spiral rib corrugated metal pipe (SRCMP), or spiral rib corrugated metal pipe arch (SRCMP ARCH);
- Type of material: Galvanized steel, aluminum-coated (Type 2), or aluminum;
- Pipe coating: Bituminous coated or polymer coated;
- Special requirements: Paved invert or smooth lining; and
- Pipe size: Diameter or design number.

Furnish any of the material types specified above when pipe is designated as "Corrugated Metal Pipe" without a type of material or pipe coating designation.

3.2. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," except where jacking, boring, or tunneling methods are shown on the plans or permitted. Jack, bore, or tunnel in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

Provide uniform backfill material and uniformly compacted density throughout the length of the structure so equal pressure is provided. Allow no heavy earth-moving equipment over the structure until a minimum of 4 ft. of compacted fill (permanent or temporary) has been placed over the top of the structure unless otherwise shown on the plans or permitted in writing. Inspect the inside periphery of the structure for local or unequal deformation caused by improper construction methods before adding each new layer of loose backfill material. Continue inspections until a minimum of 24 in. of cover is obtained. Evidence of such deformation will be reason for corrective measures as directed. Remove and replace pipe damaged by the Contractor at no additional cost to the Department.

3.3. **Laying Pipe**. Lay pipes on the bedding from the outlet end and join the separate sections firmly together with outside laps of annular joints pointing upstream and longitudinal laps on the sides unless otherwise authorized. Coat any metal in joints not protected by galvanizing or aluminizing with a suitable asphalt paint. Lower sections of pipe into the trench without damaging the pipe or disturbing the bedding and the sides of the trench. Remove and re-lay, without extra compensation, pipe that is not in alignment or shows excessive settlement after laying.

Lay multiple installations of corrugated metal pipe and pipe arches with the centerlines of individual barrels parallel. Maintain the clear distances between outer surfaces of adjacent pipes given in Table 9 unless otherwise indicated on the plans.

Table 9
Required Pipe Clear Distances

Diameter Full-Circle Pipe (in.)	Pipe Arch Design Size	Clear Distance Between Pipes (Full-Circle Pipe and Pipe Arch)
18	2	1 ft. 2 in.
21	2A	1 ft. 3 in
24	3	1 ft. 5 in.
30	4	1 ft. 8 in.
36	5	1 ft. 11 in.
42	6	2 ft. 2 in.
48	7	2 ft. 5 in.
54	8	2 ft. 10 in.
60 to 84	9	3 ft. 2 in.
90 to 120	10 and over	3 ft. 5 in.

3.4. **Jointing**. Provide field joints that maintain pipe alignment during construction and prevent infiltration of side material during the life of the installation. Provide one of the following jointing systems unless otherwise shown on the plans.

3.4.1. **Coupling Bands**. Use coupling bands with annular corrugations only with pipe with annular corrugations or with helical pipe or spiral rib pipe in which the ends have been rerolled to form annular corrugations. Provide bands with corrugations that have the same dimensions as the corrugations in the pipe end or are designed to engage the first or second corrugation from the end of each pipe. The band may also include a U-shaped channel to accommodate upturned flanges on the pipe.

Field-join pipe with helically corrugated bands or bands with projections (dimples) when helical end corrugations are allowed.

Coupling bands with projections may be used with pipe that has annular or helical end corrugations or spiral ribs. Provide bands formed with the projections in annular rows with 1 projection for each corrugation of helical pipe or spiral rib pipe. Provide 2 annular rows for bands 10-1/2 in. or 12 in. wide and 4 annular rows of projections for bands 16-1/2 in. or 22 in. wide.

Use a coupling band width that conforms to Table 10. Connect the bands using suitable galvanized devices in accordance with AASHTO M 36. Lap coupling bands equally on each of the pipes to form a tightly closed joint after installation. Provide at least the minimum coupling band width recommended by the manufacturer for corrugations not shown in Table 10.

Table 10
Coupling Band Width Requirements

Nominal Corrugation Size[1] (in.)	Nominal Pipe Inside Diameter[2] (in.)	Minimum Coupling Band Width (in.)		
		Annular Corrugated Bands	Helically Corrugated Bands	Bands with Projections
2-2/3 by 1/2	12 to 36	7	12	10-1/2
	42 to 72	10-1/2	12	10-1/2
	78 to 84[3]	10-1/2	12	16-1/4
3 by 1	36 to 72	12	14	10-1/2
	78 to 120	12	14	16-1/4
5 by 1	36 to 72	20	22	12
	78 to 120	20	22	22
7-1/2 by 3/4 by 3/4	18 to 60	10-1/2	12	10-1/2
	66 to 102	10-1/2	12	16-1/4

1. For helically corrugated pipe or spiral rib pipe with rerolled ends, the nominal size refers to the dimensions of the end corrugations in the pipe.
2. Equivalent circular diameter for Type II pipe.
3. Diameter through 120 in. for annular corrugated bands used on rerolled ends of helically corrugated pipe or spiral rib pipe.

The minimum diameter of bolts for coupling bands is 3/8 in. for pipe diameters 18 in. and less and 1/2 in. for pipe diameters 21 in. and greater. Provide at least 2 bolts for bands 12 in. wide or less. Provide at least 3 bolts for bands wider than 12 in.

Provide galvanized hardware in accordance with Item 445, "Galvanizing."

3.4.2. **Bell and Spigot**. Attach the bell to one end of the corrugated metal pipe at the manufacturing plant before shipment. Provide a bell with a minimum 6-in. stab depth. Install the gasket on the spigot end and apply lubricant in accordance with the manufacturer's recommendations. Provide gaskets that meet ASTM F477 with Type A Shore durometer hardness of 45 ±5. Do not use thermoplastic elastomer as the basic polymer. Push the spigot end of the pipe into the bell end of the previously laid pipe during laying of the pipe.

3.4.3. **Pipe Connections and Stub Ends**. Make connections of pipe to existing pipe or appurtenances as shown on the plans or as directed. Mortar or concrete the bottom of the existing structure, if necessary, to eliminate any drainage pockets created by the new connection.

Insulate portions of aluminum pipe that are to be in contact with metal other than aluminum by a coating of bituminous material meeting the requirements of Section 460.2.2., "Protective Coating." Extend the coating a minimum of 1 ft. beyond the area of contact.

Restore any damage that results from making the connection when connecting pipe into existing structures that will remain in service. Seal stub ends for connections to future work not shown on the plans by installing watertight plugs into the free end of the pipe.

4. MEASUREMENT

This Item will be measured by the foot. Pipe will be measured between the ends of the barrel along the flow line, not including safety end treatments. Safety end treatments will be measured in accordance with Item 467, "Safety End Treatment." Pipe that is required to be jacked, bored, or tunneled will be measured in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box." Where spurs, branches, or connections to existing pipe lines are involved, measurement of the spur or new connecting pipe will be made from the intersection of the flow line with the outside surface of the pipe into which it connects. Where inlets, headwalls, catch basins, manholes, junction chambers, or other structures are included in lines of pipe, the length of pipe tying into the structure wall will be included for measurement but no other portion of the structure length or width will be included.

For multiple pipes, the measured length will be the sum of the lengths of the barrels.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Corrugated Metal Pipe," "Corrugated Metal Pipe Arch," "Spiral Rib Corrugated Metal Pipe," or "Spiral Rib Corrugated Metal Pipe Arch" of the type, size, and coating specified. This price is full compensation for furnishing, hauling, placing, and joining of pipes; jointing materials; all connections to new or existing structures; breaking back, removing, and disposing of portions of the existing structure; replacing portions of the existing structure; cutting pipe ends on skew or slope; and equipment, labor, tools, and incidentals.

Protection methods for excavations greater than 5 ft. deep will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring." Excavation, shaping, bedding, and backfill will be paid for in accordance with Item 400, "Excavation and Backfill for Structures." When jacking, boring, or tunneling is used at the Contractor's option, payment will be made under this Item. When jacking, boring, or tunneling is required, payment will be made under Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

Item 462
Concrete Box Culverts and Drains

1. DESCRIPTION

Furnish, construct, and install concrete box culverts and drains.

2. MATERIALS

2.1. **General**. Furnish materials in accordance with the following.

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- Item 464, "Reinforced Concrete Pipe"

Provide cast-in-place or precast, formed or machine-made, box culverts, and drains. Use Class S concrete for top slabs of cast-in-place concrete culverts for culverts with overlay, a 1- to 2-course surface treatment or a top slab that is the final riding surface unless otherwise shown on the plans. Use Class C concrete for the rest of the culvert and for all other cast-in-place boxes. Culverts with fill do not require Class S concrete.

Furnish material for machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.2. **Fabrication**.

2.2.1. **Cast-in-Place**. Meet Item 420, "Concrete Substructures" and Item 422, "Concrete Superstructures."

2.2.2. **Formed Precast**. Meet Item 424, "Precast Concrete Structural Members (Fabrication)."

2.2.3. **Machine-Made Precast**. Machine-made precast box culvert fabrication plants must be approved in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification." The Department's MPL shows approved machine-made precast box culvert plants. Fabricate machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.3. **Testing**.

2.3.1. **Cast-in-Place**. Provide test specimens that meet Item 421, "Hydraulic Cement Concrete."

2.3.2. **Formed Precast**. Make, cure, and test compressive test specimens in accordance with Tex-704-I.

2.3.3. **Machine-Made Precast**. Make, cure, and test compressive test specimens in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.3.4. **Testing Equipment**. The producer must furnish all equipment required for testing concrete for boxes produced in a precasting plant.

2.4. **Lifting Holes**. Provide no more than 4 lifting holes in each section for precast boxes. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes large enough for adequate

lifting devices based on the size and weight of the box section. Use lifting holes no larger than 3 in. in diameter. Cut no more than 5 in. in any direction of reinforcement per layer for lifting holes.

2.5. **Marking**. Mark precast boxes with the following:

- name or trademark of fabricator and plant location;
- ASTM designation;
- date of manufacture;
- box size;
- minimum and maximum fill heights;
- designated fabricator's approval stamp;
- boxes to be used for jacking and boring (when applicable);
- designation "SR" for boxes meeting sulfate-resistant concrete plan requirements (when applicable); and
- match-marks for proper installation, when required under Section 462.2.6., "Tolerances."

Mark 1 end of each box section, for boxes without lifting holes, on the inside and outside walls to indicate the top or bottom as it will be installed.

Indent markings into the box section or paint them on each box with waterproof paint.

2.6. **Tolerances**. Ensure precast sections meet the permissible variations listed in ASTM C1577 and that the sides of a section at each end do not vary from being perpendicular to the top and bottom by more than 1/2 in. when measured diagonally between opposite interior corners.

Ensure wall and slab thicknesses are not less than shown on the plans except for occasional deficiencies not greater than 3/16 in. or 5%, whichever is greater. If proper jointing is not affected, thicknesses in excess of plan requirements are acceptable.

Deviations from the above tolerances will be acceptable if the sections can be fitted at the plant or jobsite and the joint opening at any point does not exceed 1 in. Use match-marks for proper installation on sections that have been accepted in this manner.

2.6.1. **Boxes for Jacking Operations**. Use boxes for jacking operations (as defined in Item 476, "Jacking, Boring, or Tunneling Pipe or Box,") meeting the following additional requirements:

- The box ends must be square such that no point deviates more than 3/8 in. from a plane placed on the end of the box that is perpendicular to the box sides, and
- The slab and wall thicknesses must not be less than specified on the plans and must not exceed the specified thickness by more than 1/2 in.

2.7. **Defects and Repair**. Fine cracks on the surface of the member that do not extend to the plane of the nearest reinforcement are acceptable unless the cracks are numerous and extensive. Repair cracks that extend into the plane of the reinforcing steel in an approved manner. Excessive damage, honeycomb, or cracking will be subject to structural review. The Engineer may accept boxes with repairs that are sound, properly finished, and cured in conformance with pertinent specifications. Discontinue further production of precast sections when fine cracks on the surface indicate poor curing practices until corrections are made and proper curing is provided.

Repair machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.8. **Storage and Shipment**. Store precast sections on a level surface. Do not place any load on the sections until design strength is reached and curing is complete. Shipment of sections is permissible when the design strength and curing requirements have been met.

Store and ship machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

3. CONSTRUCTION

3.1. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," except where jacking, boring, or tunneling methods are shown on the plans or permitted. Jack, bore, or tunnel in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box." Immediate backfilling is permitted for all box structures where joints consist of materials other than mortar. Take precautions in placing and compacting the backfill to avoid any movement of the boxes or damage to the joints. Remove and replace boxes damaged by the Contractor at no expense to the Department.

3.2. **Placement of Boxes**. Place the box sections in conformance with the plans or as directed when precast boxes are used to form multiple barrel structures. Place material to be used between barrels as shown on the plans or as directed. Start the laying of boxes on the bedding at the outlet end and proceed toward the inlet end with the abutting sections properly matched unless otherwise authorized. Fit, match, and lay the boxes to form a smooth, uniform conduit true to the established lines and grades. Lower the box sections into the trench, for trench installations, without damaging the box or disturbing the bedding and the sides of the trench. Carefully clean the ends of the box before it is placed. Prevent the earth or bedding material from entering the box as it is laid. Remove and re-lay, without extra compensation, boxes that are not in alignment or show excessive settlement after laying. Form and place cast-in-place boxes in accordance with Item 420, "Concrete Substructures."

3.3. **Jointing**. Use any of the jointing materials in accordance with the joint requirements specified in Item 464, "Reinforced Concrete Pipe," unless otherwise shown on the plans. Box joints for rubber gasketed material may be substituted for tongue and groove joints, provided they meet the requirements of ASTM C1677 for design of the joints and permissible variations in dimensions.

3.4. **Connections and Stub Ends**. Make connections of boxes to existing boxes, pipes, drains, or drain appurtenances as shown on the plans. Mortar or concrete the bottom of existing structures if necessary to eliminate any drainage pockets created by the connections. Connect boxes to any required headwalls, wingwalls, safety end treatments or riprap, or other structures as shown on the plans or as directed. Repair any damage to the existing structure resulting from making the connections. Finish stub ends for connections to future work not shown on the plans by installing watertight plugs into the free end of the box.

Fill lifting holes with mortar or concrete and cure for precast boxes. Precast concrete or mortar plugs may be used.

4. MEASUREMENT

This Item will be measured by the foot. Measurement will be made between the ends of the culvert or drain along the flow line, not including safety end treatments. Safety end treatments will be measured in accordance with Item 467, "Safety End Treatment." Measurement of spurs, branches, or new connection box section will be made from the intersection of the flow line with the outside surface of the structure into which it connects. Where inlets, headwalls, wingwalls, catch basins, manholes, junction chambers, or other structures are included in lines of culverts or drains, the length of box section tying into the structure wall will be included for measurement, but no other portion of the structure length or width will be included.

The measured length of multiple barrel structures will be the sum of the lengths of the barrels.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Box Culvert" of the size specified. This price is full compensation for constructing, furnishing, and transporting sections; preparation and shaping of the bed; backfill material between box sections; jointing of sections; jointing material; cutting of sections on skew or slope; connections to new or existing structures; breaking back, removing and disposing of portions of the existing structure and replacing portions of the existing structure as required to make connections; concrete and reinforcing steel; and equipment, labor, materials, tools, and incidentals.

Protection methods for excavations greater than 5 ft. deep will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring." Excavation, shaping, bedding, and backfill will be paid for in accordance with Item 400, "Excavation and Backfill for Structures." When jacking, boring, or tunneling is used at the Contractor's option, payment will be made under this Item. When jacking, boring, or tunneling is required, payment will be made under Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

Item 464
Reinforced Concrete Pipe

1. DESCRIPTION

Furnish and install reinforced concrete pipe, materials for precast concrete pipe culverts, or precast concrete storm drain mains, laterals, stubs, and inlet leads.

2. MATERIALS

2.1. **Fabrication**. Fabrication plants must be approved by the Construction Division in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification," before furnishing precast reinforced concrete pipe for Department projects. The Department's MPL has a list of approved reinforced concrete pipe plants.

Furnish material and fabricate reinforced concrete pipe in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.2. **Design**.

2.2.1. **General**. The class and D-load equivalents are shown in Table 1. Furnish arch pipe in accordance with ASTM C506 and the dimensions shown in Table 2. Furnish horizontal elliptical pipe in accordance with ASTM C507 and the dimensions shown in Table 3. For arch pipe and horizontal elliptical pipe the minimum height of cover required is 1 ft.

Table 1
Circular Pipe
ASTM C76 & ASTM C655

Class	D-Load
I	800
II	1,000
III	1,350
IV	2,000
V	3,000

Table 2
Arch Pipe

Design Size	Equivalent Diameter (in.)	Rise (in.)	Span (in.)
1	18	13-1/2	22
2	21	15-1/2	26
3	24	18	28-1/2
4	30	22-1/2	36-1/4
5	36	26-5/8	43-3/4
6	42	31-5/16	51-1/8
7	48	36	58-1/2
8	54	40	65
9	60	45	73
10	72	54	88

Table 3
Horizontal Elliptical Pipe

Design Size	Equivalent Diameter (in.)	Rise (in.)	Span (in.)
1	18	14	23
2	24	19	30
3	27	22	34
4	30	24	38
5	33	27	42
6	36	29	45
7	39	32	49
8	42	34	53
9	48	38	60
10	54	43	68

2.2.2. **Jacking, Boring, or Tunneling**. Design pipe for jacking, boring, or tunneling considering the specific installation conditions such as the soil conditions, installation methods, anticipated deflection angles, and jacking stresses. Provide design notes and drawings signed and sealed by a Texas licensed professional engineer when requested.

2.3. **Marking**. Furnish each section of reinforced concrete pipe marked with the following information specified in DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

- class or D-load of pipe,
- ASTM designation,
- date of manufacture,
- pipe size,
- name or trademark of fabricator and plant location,
- designated fabricator's approval stamp,
- pipe to be used for jacking and boring (when applicable), and
- designation "SR" for pipe meeting sulfate-resistant concrete plan requirements (when applicable).

Clearly mark 1 end of each section during the process of manufacture or immediately thereafter for pipe with elliptical reinforcement. Mark the pipe on the inside and outside of opposite walls to show the location of the top or bottom of the pipe as it should be installed unless the external shape of the pipe is such that the correct position of the top and bottom is obvious. Mark the pipe section by indenting or painting with waterproof paint.

2.4. **Inspection**. Provide access for inspection of the finished pipe at the project site before and during installation.

2.5. **Causes for Rejection**. Individual section of pipe may be rejected for any of the conditions stated in the Annex of DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.6. **Repairs**. Make repairs if necessary as stated in the Annex of DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.7. **Jointing Materials**. Use any of the following materials for the making of joints unless otherwise shown on the plans. Furnish a manufacturer's certificate of compliance for all jointing materials except mortar.

2.7.1. **Mortar**. Provide mortar for joints that meets the requirements of Section 464.3.3., "Jointing."

2.7.2. **Cold-Applied, Plastic Asphalt Sewer Joint Compound**. Provide a material that consists of natural or processed asphalt base, suitable volatile solvents, and inert filler. Ensure the consistency is such that the ends of the pipe can be coated with a layer of the compound up to 1/2 in. thick by means of a trowel. Provide

a joint compound that cures to a firm, stiff plastic condition after application. Provide a material of a uniform mixture. Stir any small separation found in the container into a uniform mix before using.

Provide a material that meets the requirements of Table 4 when tested in accordance with Tex-526-C.

Table 4
Cold-Applied, Plastic Asphalt Sewer Joint Compound Material Requirements

Composition	Analysis
Asphalt base, 100%–% volatiles–% ash, % by weight	28–45
Volatiles, 212°F evaporation, 24 hr., % by weight	10–26
Mineral matter, determined as ash, % by weight	30–55
Consistency, cone penetration, 150 g, 5 sec., 77°F	150–275

2.7.3. **Rubber Gaskets**. Provide gaskets that conform to ASTM C1619 Class A or C. Meet the requirements of ASTM C443 for design of the pipe joints and permissible variations in dimensions.

2.7.4. **Pre-Formed Flexible Joint Sealants**. Pre-formed flexible joint sealants may be used for sealing joints of tongue-and-groove concrete pipe. Provide flexible joint sealants that meet the requirements of ASTM C990. Use flexible joint sealants that do not depend on oxidizing, evaporating, or chemical action for its adhesive or cohesive strength. Supply in extruded rope form of suitable cross-section. Provide a size of the pre-formed flexible joint sealant in accordance with the manufacturer's recommendations and large enough to properly seal the joint. Protect flexible joint sealants with a suitable wrapper able to maintain the integrity of the jointing material when the wrapper is removed.

3. CONSTRUCTION

3.1. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," except where jacking, boring, or tunneling methods are permitted. Jack, bore, or tunnel the pipe in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box." Immediate backfilling is permitted if joints consist of materials other than mortar. Take special precautions in placing and compacting the backfill to avoid any movement of the pipe or damage to the joints. Do not use heavy earth-moving equipment to haul over the structure until a minimum of 4 ft. of permanent or temporary compacted fill has been placed over the structure unless otherwise shown on the plans or permitted in writing. Remove and replace pipe damaged by the Contractor at no expense to the Department.

3.2. **Laying Pipe**. Start the laying of pipe on the bedding at the outlet end with the spigot or tongue end pointing downstream, and proceed toward the inlet end with the abutting sections properly matched, true to the established lines and grades unless otherwise authorized. Fit, match, and lay the pipe to form a smooth, uniform conduit. Cut cross trenches in the foundation to allow the barrel of the pipe to rest firmly upon the bedding where bell-and-spigot pipe is used. Cut cross trenches no more than 2 in. larger than the bell ends of the pipe. Lower sections of pipe into the trench without damaging the pipe or disturbing the bedding and the sides of the trench. Carefully clean the ends of the pipe before the pipe is placed. Prevent the earth or bedding material from entering the pipe as it is laid. Lay the pipe in the trench, when elliptical pipe with circular reinforcing or circular pipe with elliptical reinforcing is used, so the markings for the top or bottom are not more than 5° from the vertical plane through the longitudinal axis of the pipe. Remove and re-lay, without extra compensation, pipe that is not in alignment or shows excessive settlement after laying.

Lay multiple lines of reinforced concrete pipe with the centerlines of the individual barrels parallel. Use the clear distances between outer surfaces of adjacent pipes shown in Table 5 unless otherwise shown on the plans. Use the equivalent diameter from Table 2 or Table 3 for arch pipe or horizontal elliptical pipe to determine the clear distance requirement in Table 5.

Table 5
Minimum Clear Distance between Pipes

Equivalent Diameter	Min Clear Distance
18 in.	9 in.
24 in.	11 in.
30 in.	1 ft. 1 in.
36 in.	1 ft. 3 in.
42 in.	1 ft. 5 in.
48 in.	1 ft. 7 in.
54 in.	1 ft. 11 in.
60 to 84 in.	2 ft.

3.3. **Jointing**. Make available an appropriate rolling device similar to an automobile mechanic's "creeper" for conveyance through small-size pipe structures.

3.3.1. **Joints Sealed with Hydraulic Cement Mortar**. Use Type S mortar meeting the requirements of ASTM C270. Clean and wet the pipe ends before making the joint. Plaster the lower half of the bell or groove and the upper half of the tongue or spigot with mortar. Pack mortar into the joint from both inside and outside the pipe after the pipes are tightly jointed. Finish the inside smooth and flush with adjacent joints of pipe. Form a bead of semicircular cross-section over tongue-and-groove joints outside the pipe, extending at least 1 in. on each side of the joint. Form the mortar for bell-and-spigot joints to a 45° fillet between the outer edge of the bell and the spigot. Cure mortar joints by keeping the joints wet for at least 48 hr. or until the backfill has been completed, whichever comes first. Place fill or backfill once the mortar jointing material has cured for at least 6 hr. Conduct jointing only when the atmospheric temperature is above 40°F. Protect mortared joints against freezing by backfilling or other approved methods for at least 24 hr.

Driveway culverts do not require mortar banding on the outside of the pipe.

Furnish pipes, with approval, that are large enough for a person to enter with the groove between 1/2 in. and 3/4 in. longer than the tongue. Such pipe may be laid and backfilled without mortar joints. Clean the space on the interior of the pipe between the end of the tongue and the groove of all foreign material, thoroughly wet and fill with mortar around the entire circumference of the pipe, and finish flush after the backfilling has been completed.

3.3.2. **Joints Using Cold-Applied, Plastic Asphalt Sewer Joint Compound**. Ensure both ends of the pipes are clean and dry. Trowel or otherwise place a 1/2–in. thick layer of the compound in the groove end of the pipe covering at least 2/3 of the joint face around the entire circumference. Shove home the tongue end of the next pipe with enough pressure to make a tight joint. Remove any excess mastic projecting into the pipe after the joint is made. Backfill after the joint has been inspected and approved.

3.3.3. **Joints Using Rubber Gaskets**. Make the joint assembly according to the recommendations of the gasket manufacturer. Make joints watertight when using rubber gaskets. Backfill after the joint has been inspected and approved.

3.3.4. **Joints Using Pre-Formed Flexible Joint Sealants**. Install pre-formed flexible joint sealants in accordance with the manufacturer's recommendations. Place the joint sealer so no dirt or other deleterious materials come in contact with the joint sealing material. Pull or push home the pipe with enough force to properly seal the joint. Remove any joint material pushed out into the interior of the pipe that would tend to obstruct the flow. Store pre-formed flexible joint sealants in an area warmed naturally or artificially to above 70°F in an approved manner when the atmospheric temperature is below 60°F. Apply flexible joint sealants to pipe joints immediately before placing pipe in trench, and connect pipe to previously laid pipe. Backfill after the joint has been inspected and approved.

3.4. **Connections and Stub Ends**. Make connections of concrete pipe to existing pipes, pipe storm drains, or storm drain appurtenances as shown on the plans.

Mortar or concrete the bottom of existing structures if necessary to eliminate any drainage pockets created by the connections. Repair any damage to the existing structure resulting from making the connections.

Make connections between concrete pipe and corrugated metal pipe with a suitable concrete collar and a minimum thickness of 4 in. unless otherwise shown on the plans.

Finish stub ends for connections to future work not shown on the plans by installing watertight plugs into the free end of the pipe.

Fill lift holes with concrete, mortar, or precast concrete plugs after the pipe is in place.

4. MEASUREMENT

This Item will be measured by the foot. Measurement will be made between the ends of the pipe barrel along the flow line, not including safety end treatments. Safety end treatments will be measured in accordance with Item 467, "Safety End Treatment." Pipe that will be jacked, bored, or tunneled will be measured in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box." Measurement of spurs, branches, or new connecting pipe will be made from the intersection of the flow line with the outside surface of the pipe into which it connects. Where inlets, headwalls, catch basins, manholes, junction chambers, or other structures are included in lines of pipe, the length of pipe tying into the structure wall will be included for measurement, but no other portion of the structure length or width will be included.

For multiple pipes, the measured length will be the sum of the lengths of the barrels.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Reinforced Concrete Pipe," "Reinforced Concrete Pipe (Arch)," or "Reinforced Concrete Pipe (Elliptical)" of the size and D-load specified or of the size and class specified. This price is full compensation for constructing, furnishing, transporting, placing, and joining pipes; shaping the bed; cutting pipes on skew or slope; connecting to new or existing structures; breaking back, removing, and disposing of portions of the existing structure; replacing portions of the existing structure; cutting pipe ends on skew or slope; and equipment, labor, tools, and incidentals.

Protection methods for excavations greater than 5 ft. deep will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring." Excavation, shaping, bedding, and backfill will be paid for in accordance with Item 400, "Excavation and Backfill for Structures." When jacking, boring, or tunneling is used at the Contractor's option, payment will be made under this Item. When jacking, boring or tunneling is required, payment will be made under Item 476, "Jacking, Boring or Tunneling Pipe or Box."

Item 465
Junction Boxes, Manholes, and Inlets

1. DESCRIPTION

Construct junction boxes, manholes, and inlets, complete in place or to the stage detailed, including furnishing and installing frames, grates, rings, and covers.

2. MATERIALS

Furnish materials in accordance with the following:

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- Item 471, "Frames, Grates, Rings, and Covers"

Cast-in-place junction boxes, manholes, inlets, risers, and appurtenances are acceptable unless otherwise shown. Alternate designs for cast-in-place items must be acceptable to the Engineer and must conform to functional dimensions and design loading. Alternate designs must be designed and sealed by a licensed professional engineer.

2.1. **Concrete**. Furnish Class H concrete as referenced in Item 421 "Hydraulic Cement Concrete," except that Mix Design Options 1–8 will be allowed for formed precast junction boxes, manholes, and inlets. Furnish concrete per DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification," for machine-made precast junctions boxes, manholes, and inlets. Furnish Class C concrete for cast-in-place manholes and inlets unless otherwise shown on the plans.

2.2. **Mortar**. Furnish mortar conforming to DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications."

2.3. **Timber**. Provide sound timber that is a minimum of 3 in. nominal thickness and reasonably free of knots and warps for temporary covers when used with Stage I construction (see Article 465.3., "Construction").

2.4. **Other Materials**. Use commercial-type hardware as approved.

3. CONSTRUCTION

Construct all types of junction boxes, manholes, and inlets either complete or in 2 stages, described as Stage I and Stage II.

Construct the Stage I portion of junction boxes, manholes, and inlets as shown on the plans or as specified in this Item. Furnish and install a temporary cover as approved.

Furnish and install the storm drain pipe and a temporary plug for the exposed end of the storm drain pipe from the storm drain to a point below the top of curb indicated on the plans for Stage I construction of cast iron or steel inlet units.

Construct Stage II after the pavement structure is substantially complete unless otherwise approved.

Construct the remaining wall height and top of junction box, manhole, or inlet for Stage II, and furnish and install any frames, grates, rings and covers, curb beams, or collecting basins required.

Construct cast-in-place junction boxes, manholes, and inlets in accordance with Item 420, "Concrete Substructures." Forms will be required for all concrete walls. Outside wall forms for cast-in-place concrete may be omitted with approval if the surrounding material can be trimmed to a smooth vertical face.

3.1. **Precast Junction Boxes, Manholes, and Inlets**. Construct formed precast junction boxes, manholes, and inlets in accordance with Item 420, "Concrete Substructures," except as otherwise noted in this Item. Construct machine-made precast junction boxes, manholes, and inlets in accordance with ASTM C478 except as otherwise noted in this Item. Mix and place concrete for machine-made junction boxes, manholes, and inlets per the requirements of DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification." Conform to the product permissible variations and rejection criteria stated in ASTM C478 for machine-made precast junction boxes, manholes, and inlets. Cure all precast units in accordance with Item 424, "Precast Concrete Structural Members (Fabrication)."

Multi-project fabrication plants (as defined in Item 424 "Precast Concrete Structural Members (Fabrication)," that produce manholes and inlets will be approved by the Construction Division in accordance with DMS-7340, "Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Manholes and Inlets." The Department's MPL has a list of approved multi-project plants.

3.1.1. **Lifting Holes**. Provide no more than 4 lifting holes in each section for precast units. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes large enough for adequate lifting devices based on the size and weight of the section. The maximum hole diameter is 3 in. at the inside surface of the wall and 4 in. at the outside surface. Cut no more than 5 in. in any direction of reinforcement per layer for lifting holes. Repair spalled areas around lifting holes.

3.1.2. **Marking**. Clearly mark each precast junction box, manhole, and inlet unit with the following information:

- name or trademark of fabricator and plant location;
- product designation;
- ASTM designation (if applicable);
- date of manufacture;
- designated fabricator's approval stamp; and
- designation "SR" for product meeting sulfate-resistant concrete plan requirements (when applicable).

3.1.3. **Storage and Shipment**. Store precast units on a level surface. Do not ship units until design strength requirements have been met.

3.2. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures." Immediate backfilling is permitted for all junction box, manhole, and inlet structures where joints consist of rubber boots, rubber gaskets, or bulk or preformed joint sealant. Take precautions in placing and compacting the backfill to avoid any movement of junction boxes, manholes, and inlets. Remove and replace junction boxes, manholes, and inlets damaged by the Contractor at no expense to the Department.

3.3. **Junction Boxes, Manholes, and Inlets for Precast Concrete Pipe Storm Drains**. Construct junction boxes, manholes, and inlets for precast concrete pipe storm drains before completion of storm drain lines into or through the junction box, manhole, or inlet. Neatly cut all storm drains at the inside face of the walls of the junction box, manhole, or inlet.

3.4. **Junction Boxes, Manholes, and Inlets for Box Storm Drains**. Place bases or risers of junction boxes, manholes, and inlets for box storm drains before or in conjunction with placement of the storm drain. Backfill the junction box, manhole, or inlet and storm drain as a whole.

3.5. **Inverts**. Shape and route floor inverts passing out or through the junction box, manhole, or inlet as shown on the plans. Shape by adding and shaping mortar or concrete after the base is placed or by placing the required additional material with the base.

3.6. **Finishing Complete Junction Boxes, Manholes, and Inlets**. Complete junction boxes, manholes, and inlets in accordance with the plans. Backfill to original ground elevation in accordance with Item 400, "Excavation and Backfill for Structures."

3.7. **Finishing Stage I Construction**. Complete Stage I construction by constructing the walls to the elevations shown on the plans and backfilling to required elevations in accordance with Item 400, "Excavation and Backfill for Structures."

3.8. **Stage II Construction**. Construct subgrade and base course or concrete pavement construction over Stage I junction box, manhole, or inlet construction unless otherwise approved. Excavate to expose the top of Stage I construction and complete the junction box, manhole or inlet in accordance with the plans and these Specifications, including backfill and cleaning of all debris from the bottom of the junction box, manhole, or inlet.

3.9. **Inlet Units**. Install cast iron or steel inlet units in conjunction with the construction of concrete curb and gutter. Set the inlet units securely in position before placing concrete for curb and gutter. Form openings for the inlets and recesses in curb and gutter as shown on the plans. Place and thoroughly consolidate concrete for curb and gutter adjacent to inlets and around the inlet castings and formed openings and recesses without displacing the inlet units.

4. MEASUREMENT

All junction boxes, manholes, and inlets satisfactorily completed in accordance with the plans and specifications will be measured by each junction box, manhole, or inlet, complete, or by each junction box, manhole, or inlet completed to the stage of construction required by the plans.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for as follows:

5.1. **Complete Manholes**. Payment for complete manholes will be made at the unit price bid for "Manhole (Complete)" of the type specified.

5.2. **Complete Inlets**. Payment for inlets will be made at the unit price bid for "Inlet (Complete)," of the type specified.

5.3. **Complete Junction Boxes**. Payment for junction boxes will be made at the unit price bid for "Junction Box (Complete)" of the type specified.

5.4. **Manholes Stage I**. Payment for Manholes, Stage I, will be made at the unit price bid for each "Manhole (Stage I)" of the type specified.

5.5. **Manholes Stage II**. Payment for Manholes, Stage II, will be made at the unit price bid for each "Manhole (Stage II)" of the type specified.

5.6. **Inlets Stage I**. Payment for Inlets, Stage I, will be made at the unit price bid for each "Inlet (Stage I)" of the type specified.

5.7. **Inlets Stage II**. Payment for Inlets, Stage II, will be made at the unit price bid for each "Inlet (Stage II)" of the type specified.

5.8. **Junction Boxes Stage I**. Payment for Junction Boxes, Stage I, will be made at the unit price bid for each "Junction Box (Stage I)" of the type specified.

5.9. **Junction Boxes Stage II**. Payment for Junction Boxes, Stage II, will be made at the unit price bid for each "Junction Box (Stage II)" of the type specified.

This price is full compensation for concrete, reinforcing steel, mortar, frames, grates, rings and covers, excavation, and backfill and for all other materials, tools, equipment, labor, and incidentals.

Item 467
Safety End Treatment

1. DESCRIPTION

Furnish, construct, and install safety end treatments for drainage structures, or install or replace pipe runners or pipe runner assemblies on existing drainage structures.

2. MATERIALS

2.1. **General**. Furnish materials in accordance with the following.

- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 432, "Riprap"
- Item 440, "Reinforcement for Concrete"
- Item 442, "Metal for Structures"
- Item 445, "Galvanizing"
- Item 460, "Corrugated Metal Pipe"
- Item 464, "Reinforced Concrete Pipe"

Use Class C concrete for cast-in-place and precast concrete units unless otherwise shown on the plans. Furnish cast-in-place or precast safety end treatments unless otherwise shown on the plans. Furnish Class B concrete for concrete riprap unless otherwise shown on the plans. Provide galvanized steel for prefabricated metal end sections in accordance with Item 460, "Corrugated Metal Pipe."

Furnish pipe runners in accordance with the following:

- ASTM A1085;
- ASTM A53, Type E or S, Grade B;
- ASTM A500, Grade B; or
- API 5L, Grade X42.

Furnish plates and angles in accordance with ASTM A36. Furnish nuts and bolts in accordance with ASTM A307. Galvanize pipes, plates, angles, nuts, and bolts in accordance with Item 445, "Galvanizing."

2.2. **Fabrication**. Fabricate cast-in-place concrete units and precast units in accordance with Item 420, "Concrete Substructures." Provide either prefabricated metal end sections or mitered CMP when specified for the pipe structure unless otherwise shown on the plans.

Provide one of the following when reinforced concrete pipe (RCP) is specified for the pipe structure, unless otherwise shown on the plans:

- mitered RCP or
- precast safety end treatment (SET) units. Provide riprap only if the plans specifically require it for this alternative.

2.2.1. **SET Types**.

2.2.1.1. **Type I**. Provide Type I SET consisting of reinforced concrete headwalls or wingwalls and pipe runners in accordance with the details shown on the plans when required.

2.2.1.2. **Type II**. Provide Type II SET in accordance with the details shown on the plans consisting of the following:

- CMP or RCP mitered to the proper slope, concrete riprap and pipe runners, when required;
- prefabricated metal end sections, concrete riprap and pipe runners, when required; or
- precast SET units, concrete riprap, when required, and pipe runners, when required.

2.2.2. **Lifting Holes**. Provide no more than 4 lifting holes in each section for precast units. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes large enough for adequate lifting devices based on the size and weight of the section. The maximum hole diameter is 3 in. at the inside surface of the wall and 4 in. at the outside surface. Cut no more than 1 longitudinal wire or 2 circumferential wires per layer of reinforcing steel when locating lift holes. Repair spalled areas around lifting holes.

2.2.3. **Marking**. Clearly mark the following on each precast unit, mitered CMP, mitered RCP, or metal end section before shipment from the casting or fabrication yard:

- the date of manufacture,
- the name or trademark of the manufacturer, and
- the type and size designation.

2.2.4. **Storage and Shipment**. Store precast units on a level surface. Do not place any loads on precast units until the design strength is reached. Do not ship units until design strength requirements have been met.

2.2.5. **Causes for Rejection**. Precast units may be rejected for not meeting any one of the specification requirements. Individual units may also be rejected for fractures or cracks passing through the wall or surface defects indicating honeycombed or open texture surfaces. Remove rejected units from the project and replace with acceptable units meeting the requirements of this Item.

2.2.6. **Defects and Repairs**. Occasional imperfections in manufacture or accidental damage sustained during handling may be repaired. The repaired units will be acceptable if they conform to the requirements of this Item and the repairs are sound and properly finished and cured in conformance with pertinent specifications. Repair damaged galvanizing in accordance with Section 445.3.5., "Repairs."

3. CONSTRUCTION

3.1. **General**. Remove portions of existing structures in accordance with Section 420.4.8., "Extending Existing Substructures." Drill, dowel, and grout in accordance with Item 420, "Concrete Substructures." Furnish concrete riprap in accordance with Item 432, "Riprap."

Provide riprap on all prefabricated metal end sections.

3.2. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures." Take special precautions in placing and compacting the backfill to avoid any movement or damage to the units. Bed precast units on foundations of firm and stable material accurately shaped to conform to the bases of the units.

3.3. **Placement of Precast Units**. Provide adequate means to lift and place the precast units. Fill lifting holes with mortar or concrete and cure. Precast concrete or mortar plugs may be used.

3.4. **Connections**. Make connections to new or existing structures in accordance with the details shown on the plans. Furnish jointing material in accordance with Item 464, "Reinforced Concrete Pipe."

Also remove a length of the existing pipe from the headwall to the joint when removing existing headwalls as shown on the plans or as approved. Re-lay the removed pipe if approved, or furnish and lay a length of new pipe.

3.5. **Install or Replace Pipe Runners or Assemblies**. Install or replace individual pipe runners or pipe runner assemblies on existing drainage structures as indicated on the plans.

4. MEASUREMENT

SETs of all types will be measured by each barrel of each structure end.

Pipe runners or pipe runner assemblies installed or replaced on existing structure will be measured by each installed or replaced on each structure end.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the various designations of "Safety End Treatment" specified as follows:

- SET (Type I) (Barrel Span) (Wall Height) (Slope, Horizontal:Vertical) (Orientation, Cross or Parallel)
- SET (Type I) (Pipe Diameter or Design) (Slope, Horizontal:Vertical) (Orientation, Cross or Parallel)
- SET (Type II) (Pipe Diameter or Design) (Pipe Material) (Slope, Horizontal:Vertical) (Orientation, Cross or Parallel)
- SET (Pipe Runner)
- SET (Pipe Runner Assembly)

For payment purposes, the wingwall heights of Type I SETs for box culverts will be rounded to the nearest foot.

This price is full compensation for constructing, furnishing, transporting, and installing the end treatments; pipe runners, or pipe runner assemblies, connecting to existing structure; breaking back, removing and disposing of portions of the existing structure, removing and disposing of existng pipe runner or pipe runner assemblies, and replacing portions of the existing structure as required to make connections; excavation and backfill; furnishing concrete, reinforcing steel, corrugated metal pipe or reinforced concrete pipe, and pipe runners; and concrete riprap, nuts, bolts, plates, angles, equipment, labor, tools, and incidentals.

The removal and re-laying of existing pipe or the furnishing of new pipe to replace existing pipe will not be paid for directly but will be considered subsidiary to this Item.

The mitered length of CMP or RCP that is a part of the SET (Type II) will not be paid for directly but will be considered subsidiary to this Item. The limits for payment for pipe will be as shown on the plans and paid for in accordance with the pertinent bid item.

The limits of riprap to be included in the price bid for each SET will be shown on the plans. Any riprap placed beyond the limits shown will be paid in accordance with Item 432, "Riprap." Riprap between multiple precast SET units will be required as shown on the plans and is included in the price bid for SET.

When precast SETs are provided as an option to mitered RCP, riprap aprons will not be required unless the plans specifically require riprap aprons for precast SET units. The plans will show the limits of the riprap to be included with the precast SET for payment.

Item 471
Frames, Grates, Rings, and Covers

1. DESCRIPTION

Furnish and install frames, grates, rings, and covers for inlets, manholes, and other structures.

2. MATERIALS

2.1. **Frame, Grate, Ring, and Cover Castings**. Provide clean castings conforming to the shape and dimensions shown on the plans. Ensure all gray and ductile iron castings conform to the AASHTO Designation M 306. Cast or machine the bearing surfaces for traffic service castings between manhole rings and covers and between grates and frames with such precision as to prevent rocking.

Provide gray iron castings in accordance with ASTM A48 Class 35B and AASHTO M 306 for traffic service applications unless otherwise specified. Provide gray iron castings in accordance with ASTM A48 Class 35B for sidewalk or pedestrian applications unless otherwise specified. Provide ductile iron castings in accordance with ASTM A536, Grade 70-50-05, unless otherwise specified. Provide steel castings in accordance with ASTM A27, Grade 70-36, unless otherwise specified. Ensure all traffic service castings and gratings meet or exceed the H20 proof-load requirements of AASHTO M 306. Load test results and material certifications must be made available upon request.

Ensure all traffic service (heavy duty) rated castings and grating meet the proof-load testing requirements of AASHTO M 306. Ensure all load tests are conducted with a calibrated NIST certified load cell. Ensure materials are loaded with a 9 × 9-in. load block to an applied load of 40,000 lb. for one minute without deformation or failure. Load test results and material certifications must be made available upon request.

Provide castings within ±1/16 in. per foot of plan dimensions, and within ±5% of plan weight.

2.2. **Welded Steel Grates and Frames**. Provide welded steel grates and frames as an assembly in accordance with the member size, dimensions, and details shown on the plans. Fabricate these assemblies in accordance with Item 441, "Steel Structures." Use steel that meets ASTM A36 or equivalent.

2.3. **Documentation**. Furnish a manufacturer's certification stating the casting meets the proof-load testing requirements of AASHTO M 306 for traffic service castings.

3. CONSTRUCTION

Construct and install frames, grates, rings, and covers in accordance with the details shown on the plans. Weld in accordance with Item 448, "Structural Field Welding." Tack weld grates and covers to the frame or ring when directed.

Galvanize steel castings, welded steel grates, and frames in accordance with Item 445, "Galvanizing." Galvanizing is not required for iron castings unless used in conjunction with structural steel shapes or shown on the plans.

Provide galvanized bolts and nuts in accordance with Item 445, "Galvanizing."

4. MEASUREMENT

Frames, grates, rings, and covers, when a part of the complete manhole or inlet, will not be measured for payment but will be considered subsidiary to Item 465, "Junction Boxes, Manholes, and Inlets." Frames, grates, rings, and covers, when not a part of a Manhole (complete) or Inlet (complete), will be measured by the each.

5. PAYMENT

When payment is required in accordance with "Measurement," payment for frames, grates, rings, and covers will be made at the unit price bid for "Grate," "Frame," "Grate and Frame," "Frame and Cover," or "Ring and Cover" with the type and number of grates specified, if necessary. This price is full compensation for equipment, materials, labor, tools, and incidentals.

Item 476
Jacking, Boring, or Tunneling Pipe or Box

1. DESCRIPTION

Furnish and install pipe or box by jacking, boring, or tunneling.

2. MATERIALS

Use the following types of pipe or box:

- corrugated metal pipe meeting Item 460, "Corrugated Metal Pipe," of the size, type, design, and dimension shown on the plans;
- reinforced concrete pipe meeting the special requirements for jacking, boring, or tunneling of Item 464, "Reinforced Concrete Pipe," of the size, strength, and dimension shown on the plans;
- reinforced concrete box meeting Item 462, "Concrete Box Culverts and Drains," of the size and type shown on the plans; or
- other types specified by the plans.

3. CONSTRUCTION

Excavate suitable shafts or trenches for conducting the jacking, boring, or tunneling operations and for placing end joints of the pipe or box if the grade at the jacking, boring, or tunneling end is below the ground surface. Maintain a 3:1 slope from edge of pavement on the shaft side of the road unless otherwise shown or directed. Provide a positive barrier when the shaft location is within the clear zone of the roadway. Protect excavations deeper than 5 ft. as specified in Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring."

Install pipe or box so there is no interference with the operation of street, highway, railroad, or other facility and no embankment or structure is weakened or damaged.

Repair any pipe or box damaged in jacking, boring, or tunneling. Remove and replace any pipe or box damaged beyond repair at the Contractor's expense.

Backfill shafts or trenches excavated to facilitate jacking, boring, or tunneling immediately after installation of pipe or box.

3.1. **Jacking**. Provide jacks suitable for forcing the pipe or box through the embankment. Use even pressure to all jacks during operation. Provide a suitable jacking head and suitable bracing between the jacks and the jacking head to apply uniform pressure around the ring of the pipe or circumference of the box. Use joint cushioning of plywood or other approved material. For plywood cushioning material, use 1/2-in. minimum thickness for pipe diameter 30 in. or less, and use 3/4-in. minimum thickness for pipe diameter greater than 30 in. Use 3/4-in. minimum thickness for all boxes. Use cushioning rings of single or multiple pieces. Provide a suitable jacking frame or backstop. Set the pipe or box to be jacked on guides that support the section of the pipe or box, and direct it on the proper line and grade. Place the entire jacking assembly in line with the direction and grade of the pipe or box. In general, excavate the embankment material just ahead of the pipe or box, remove the material through the pipe or box, and force the pipe or box through the embankment with jacks into the space bored or tunneled.

Furnish a plan showing the proposed method of jacking for approval. Include the design for the jacking head, jacking support or backstop (thrust block), arrangement and position of jacks, and guides in the plan.

Ensure excavation for the underside of the pipe for at least 1/3 of the circumference of the pipe conforms to the contour and grade of the pipe. Ensure the excavation for the bottom slab of the box conforms to the grade of the box. Over-excavate, if desired, to provide no more than 2 in. of clearance for the upper portion and sides of the pipe or box. Taper this clearance to zero at the point where the excavation conforms to the contour of the pipe or box. Carry out jacking without interruption to prevent the pipe from becoming firmly set in the embankment. Monitor volume of soil excavated to avoid any appreciable over excavation. Pressure-grout any over excavation of more than 1 in. Pressure-grout between the carrier pipe and casing when shown on the plans.

The distance the excavation extends beyond the end of the pipe or box must not exceed 2 ft. Decrease this distance as necessary to maintain stability of the material being excavated.

Jack the pipe or box from the low or downstream end. The final position of the pipe or box must not vary from the line and grade shown on the plans by more than 1 in. in 10 ft. Variation must be regular and in one direction, and the final flow line must be in the direction shown on the plans.

Use a shield or cutting edge of steel plate around the head end of the pipe or box extending a short distance beyond the end if desired. The minimum distance for parallel pipe or box jacking or tunneling is 3 ft. or 2 times the diameter of the pipe or width of box, whichever is greater, unless otherwise shown on the plans.

3.2. **Boring or Tunneling**. Bore from a shaft in an approved location provided for the boring equipment and workmen.

Dispose of excavated material using an approved method. Use water or other appropriate drilling fluids in connection with the boring operation only as necessary to lubricate cuttings and pipe or box; do not use jetting.

Use a gel-forming colloidal drilling fluid consisting of high-grade, carefully processed bentonite to consolidate cuttings of the bit in unconsolidated soil formations. Seal the walls of the bore hole and furnish lubrication for subsequent removal of cuttings and immediate installation of the pipe.

Allowable variations from line and grade are specified in Section 476.3.1., "Jacking." Pressure-grout any over excavation of more than 1 in.

3.2.1. **Larger Diameter Boring Methods**. Use the pilot hole or auger method for drainage and large utility borings. Pressure-grout any over excavation of more than 1 in. Pressure-grout between the carrier pipe and casing when shown on the plans.

3.2.1.1. **Pilot Hole Method**. Bore a 2-in. pilot hole the entire length of the crossing, and check it for line and grade during the boring or tunneling operation on the opposite end of the bore from the work shaft. This pilot hole will serve as centerline for the larger diameter hole to be bored.

3.2.1.2. **Auger Method**. Use a steel encasement pipe of the appropriate diameter equipped with a cutter head to mechanically perform the excavation. Use augers of large enough diameter to convey the excavated material to the work shaft.

3.2.2. **Electrical and Communication Conduit Boring**. Limit over excavation to the dimensions shown in Table 1 for electrical and communication conduit borings. Increased boring diameters will be allowed for outer diameters of casing and couplings. Pressure-grouting will not be required for electrical and communication conduit borings.

Table 1
Allowable Bore Diameter for Electrical or Communication Conduit or Casing

Single Conduit Bores		Multiple Conduit Bores	
Conduit Size (in.)	Maximum Allowable Bore (in.)	Conduit Size (in.)[1]	Maximum Allowable Bore (in.)
2	4	4	6
3	6	5	8
4	6	6	10
6	10	7	12
		8	12

1. The diameter of multiple conduits is the sum of the outside diameter of the 2 largest conduits for placement of up to 4 conduits in one bore. Submit boring diameters for the Engineer's approval when more than 4 conduits are to be placed in a bore.

3.3. **Tunneling**. Use an approved tunneling method where the characteristics of the soil, the size of the proposed pipe, or the use of monolithic pipe would make the use of tunneling more satisfactory than jacking or boring, or when shown on the plans.

Ensure the lining of the tunnel is strong enough to support the overburden when tunneling is permitted. Submit the proposed liner method for approval. Approval does not relieve the Contractor of the responsibility for the adequacy of the liner method.

Pressure-grout the space between the liner plate and the limits of excavation.

Pressure-grout between the carrier pipe and liner plate when shown on the plans.

3.4. **Joints**. Make joints by field bolting or connecting bands, whichever is feasible if corrugated metal pipe is used. Make the joints in accordance with Item 464, "Reinforced Concrete Pipe," if reinforced concrete pipe is used. Make the joints in accordance with Item 462, "Concrete Box Culverts and Drains," if reinforced concrete box is used.

4. MEASUREMENT

This Item will be measured by the foot between the ends of the pipe or box along the flow line.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Jacking, Boring, or Tunneling Pipe" of the type, size, and class specified; or "Jacking, Boring, or Tunneling Pipe" of the type, size, and design specified; or "Jacking or Tunneling Box Culvert" of the size specified.

This price is full compensation for excavation, grouting, backfilling, and disposal of surplus material; furnishing pipe, box, and pipe liner materials required for tunnel operations; preparation, hauling, and installing of pipe, box, and pipe liner materials; and materials, tools, equipment, labor, and incidentals.

Protection methods for open excavations deeper than 5 ft. will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring."

Item 502
Barricades, Signs, and Traffic Handling

1. DESCRIPTION

Provide, install, move, replace, maintain, clean, and remove all traffic control devices shown on the plans and as directed.

2. CONSTRUCTION

Implement the traffic control plan (TCP) shown on the plans.

Install traffic control devices straight and plumb. Make changes to the TCP only as approved. Minor adjustments to meet field conditions are allowed.

Submit Contractor-proposed TCP changes, signed and sealed by a licensed professional engineer, for approval. The Engineer may develop, sign, and seal Contractor-proposed changes. Changes must conform to guidelines established in the TMUTCD using approved products from the Department's Compliant Work Zone Traffic Control Device List.

Use fluorescent prismatic reflfective sheeting, meeting the requirements of DMS-8300 Type B_{FL} or C_{FL}, for all signs and traffic control devices that have an orange background and a black non-reflective legend on all work zones. Manufacture all signs with a white background and black non-reflective legend using High Specific Intensity sheeting meeting the requirements of DMS-8300 Type A. Orange and white sheeting used on channelizing devices must be manufactured using High Specific Intensity sheeting meeting the requirements of DMS-8300 Type A.

At no time will the Contractor mix Type B_{FL} or C_{FL} fluorescent orange sheeting with orange Type A High Specific Intensity sheeting on the same project. White Engineering Grade (Type A) will not be mixed with white High Specific Intensity (Type A) sheeting.

Maintain traffic control devices by taking corrective action when notified. Corrective actions include, but are not limited to, cleaning, replacing, straightening, covering, and removing devices. Maintain the devices such that they are properly positioned and spaced, legible, and have retroreflective characteristics that meet requirements day or night and in all weather conditions.

The Engineer may authorize or direct in writing the removal or relocation of project limit advance warning signs. When project limit advance warning signs are removed before final acceptance, provide traffic control in accordance with the TMUTCD for minor operations as approved.

Remove all traffic control devices upon completion of the work as shown on the plans or as directed.

3. MEASUREMENT

Barricades, Signs, and Traffic Handling will be measured by the month. Law enforcement officer and patrol vehicle will be measured by the hour.

4. PAYMENT

4.1. **Barricades, Signs, and Traffic Handling**. Except for Contracts with callout or work orders, the work performed and materials furnished in accordance with this Item and measured as provided under

"Measurement" will be paid for at the unit price bid for "Barricades, Signs, and Traffic Handling." This price is full compensation for installation, maintenance, adjustments, replacements, removal, materials, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Barricades, Signs, and Traffic Handling." This price is full compensation for installation, maintenance, adjustments, replacements, removal, materials, equipment, labor, tools, and incidentals.

When the plans establish pay items for particular work in the TCP, that work will be measured and paid under pertinent Items.

4.1.1. **Initiation of Payment**. Payment for this Item will begin on the first estimate after barricades, signs, and traffic handling devices have been installed in accordance with the TCP and construction has begun.

4.1.2. **Paid Months**. Monthly payment will be made each succeeding month for this Item provided the barricades, signs, and traffic handling devices have been installed and maintained in accordance with the TCP until the Contract amount has been paid.

If, within the time frame established by the Engineer, the Contractor fails to provide or properly maintain signs and barricades in compliance with the Contract requirements, as determined by the Engineer, the Contractor will be considered in noncompliance with this Item. No payment will be made for the months in question, and the total final payment quantity will be reduced by the number of months the Contractor was in noncompliance.

4.1.3. **Maximum Total Payment Before Acceptance**. The total payment for this Item will not exceed 10% of the total Contract amount before final acceptance in accordance with Article 5.12., "Final Acceptance." The remaining balance will be paid in accordance with Section 502.4.5., "Balance Due."

4.1.4. **Total Payment Quantity**. The quantity paid under this Item will not exceed the total quantity shown on the plans except as modified by change order and as adjusted by Section 502.4.2., "Paid Months." An overrun of the plans quantity for this Item will not be allowed for approving designs; testing; material shortages; closed construction seasons; curing periods; establishment, performance, test, and maintenance periods; failure to complete the work in the number of months allotted; nor delays caused directly or indirectly by requirements of the Contract.

4.1.5. **Balance Due**. The remaining unpaid months of barricades less non-compliance months will be paid on final acceptance of the project, if all work is complete and accepted in accordance with Article 5.12., "Final Acceptance."

4.1.6. **Contracts with Callout or Work Orders**. The work performed and the materials furnished with this Item and measured as provided under "Measurement," will be considered subsidiary to pertinent Items.

4.2. **Law Enforcement**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement," will be paid by Contractor force account for "Uniformed Police Officer." This price is full compensation for furnishing all labor, materials, supplies, equipment, patrol vehicle, fees, and incidentals necessary to complete the work as directed.

Item 504
Field Office and Laboratory

1. DESCRIPTION

Provide field offices and laboratories for exclusive use of the Engineer and inspection staff.

2. EQUIPMENT

2.1. **General**. Furnish facilities after receipt of the work order and before beginning physical work on the project. Provide field offices of the type and number specified near the worksite at an acceptable location. If desired, use permanent buildings or rental space meeting the requirements for field offices instead of portable buildings only if approved. Maintain the field office until the Department accepts the project. Furnish other equipment as required.

Provide inspection laboratories of the type specified before beginning the fabrication of products required by the Contract. Locate the building so that plant operations are visible from the building. Maintain the laboratories until the production of the associated product is complete.

Immediately repair or replace facilities if damaged in any manner. Payment for repair will not be made unless it is the result of negligence by the Department. Reimburse the Department for equipment damaged by the Contractor's operations. Remove buildings and other facilities and restore the right of way before project acceptance when facilities are allowed in the right of way.

2.1.1. **Parking and Fencing**. Provide an all-weather parking area for the sole use of at least 2 State-owned vehicles unless otherwise shown on the plans. Situate the area near the field office or laboratory at an acceptable location. Maintain the parking area until the project is completed and restore the area to a condition acceptable to the Engineer upon project completion.

Enclose the field office or laboratory and the parking area with a 6-ft. chain-link fence, a top-mounted 3-strand barbed wire, and a 12-ft. gate when shown on the plans.

2.1.2. **Buildings**.

2.1.2.1. **Field Office**. Provide field offices with roof, floor, doors, and screened windows. Ensure the floor is strong enough to support testing equipment and has an impervious floor covering. Ensure that the field office is tied down, weatherproof, piped for water and fuel, and electrically wired by personnel meeting the requirements of Article 7.19., "Electrical Requirements."

Furnish and install adequate equipment, outlets, lighting, air-conditioning, heating, and ventilation. Provide a partitioned restroom furnished with restroom supplies, a lavatory, and a flush toilet connected to a sewer or septic tank. If desired, furnish a portable toilet only when approved.

Provide secured and controlled access to the field office or laboratory through security measures such as bars, alarms, or security fencing. Furnish steps to the structures if directed.

2.1.2.2. **Laboratory**. Provide laboratories with all of the requirements described in Section 504.2.1.2.1., "Field Office." In addition, provide the following items unless otherwise directed:

- a 10 lb. ABC fire extinguisher with up-to-date inspection tag and a working smoke detector;
- laboratory equipment necessary for testing when shown on the plans;
- water (for testing purposes) from an approved source;

- an exhaust fan for concrete curing, asphalt, or other operations to meet Department and OSHA requirements (Vent all exhaust to the outside of the structure.);
- a work platform at least 18 in. long and 12 in. wide, mounted on a lumber post at least 6 × 6 in. extending through the floor and firmly fixed in the ground (The work platform support can be provided by other methods as shown on the plans or as directed.);
- a minimum of 20 ft. of total work counter length at least 3 ft. wide and 3 ft. above the floor and strong enough to support required testing equipment; and
- a laboratory sink measuring 24 × 30 in. and 12 in. deep.

2.1.3. **Field Office and Laboratory Appurtenances**. Provide workbenches and tables at least 3 ft. wide and 6 ft. long, chairs, and filing cabinets in an approved quantity. Provide solar screens, blinds, or shades if directed. Provide approved potable water, electricity, collection and disposal of trash, and janitorial services.

Provide internet connectivity, a printer/fax/scan/copier, and telephone if shown on the plans.

Provide a closet within the facility for Contracts that require a nuclear gauge for moisture or density determination, or a separate structure for storage of the gauge located as far as possible from normal office work. Provide internal keyed deadbolt locks and hinges with pins on the inside of the storage area for all doors allowing access to the nuclear gauge.

2.2. **Structure Types**.

2.2.1. **Type A Structure (Field Laboratory)**. Provide at least 200 sq. ft. of gross floor area in rooms 8 ft. high. Partition the building into at least 2 rooms, each furnished with an exterior door and at least 2 windows.

2.2.2. **Type B Structure (Field Office and Laboratory)**. Provide at least 600 sq. ft. of gross floor area in rooms 8 ft. high. Partition the floor area into at least 3 interconnected rooms with doors, 2 exterior doors, and at least 2 windows in each room.

2.2.3. **Type C Structure (Field Office)**. Provide at least 400 sq. ft. of gross floor area in rooms 8 ft. high. Partition the floor area into at least 2 interconnected rooms with doors, 2 exterior doors, and at least 2 windows in each room.

2.2.4. **Type D Structure (Asphalt Mix Control Laboratory)**. Provide at least 700 sq. ft. of gross floor area in rooms 8 ft. high. Partition the floor area into at least 2 interconnected rooms with doors, 2 exterior doors, and at least 2 windows in each room.

2.2.4.1. **Asphalt Content by Ignition Method**. Provide enough power ventilation for the room, a NEMA 6-50R (208/240 V, 50 A) outlet within 3 ft. of the ignition oven location, and an independent exhaust outlet no farther than 8 ft. from the oven when asphalt content is determined by the ignition method. Provide a surface for the ignition oven that is level, sturdy, and fireproof with at least 6 in. of clearance between the furnace and other vertical surfaces.

Vent the ignition oven to the outside.

2.2.5. **Type E Structure**. Provide building as shown on the plans.

3. MEASUREMENT AND PAYMENT

The work performed, materials furnished, utilities and utility service (including phone if required), appurtenances (including office equipment and Internet service), testing equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 520
Weighing and Measuring Equipment

1. DESCRIPTION

Provide weighing and measuring equipment for materials measured or proportioned by weight or volume.

2. EQUIPMENT

Provide certified scales, scale installations, and measuring equipment meeting the requirements of *NIST Handbook 44*, except that the required accuracy must be 0.4% of the material being weighed or measured.

Provide personnel, facilities, and equipment for checking the scales as approved. Check all weighing and measuring equipment after each move and at least once each 6 mo. or when requested.

Calibrate all scales using weights certified by the Texas Department of Agriculture (TDA) or an equivalent agency as approved. Provide a written calibration report from a scale mechanic for all calibrations. Cease plant operations during the checking operation. Do not use inaccurate or inadequate scales. Bring performance errors as close to zero as practicable when adjusting equipment.

Furnish enough certified weights to check the accuracy and sensitivity of the scales. Insulate scales against shock, vibrations, or movement of other operating equipment. Provide an automated ticket printout for each truckload of material on a daily basis where payment is determined by weight. Each loading ticket must show the ticket number, truck number, gross weight, tare weight, and net weight.

Provide a summary spreadsheet that lists separately the ticket number, truck number, gross weight, tare weight, net weight, overload weight, and payment weight amounts as shown in Table 1 if required on the plans for materials paid by the ton. Provide this spreadsheet:

- for each lot when materials are paid for in increments of sublots or lots, and
- daily for other materials.

Provide the totals for net weight and overload amounts to be deducted for all summary sheets within 2 days of delivery of materials. Include the overload deduction in the total amount reported for payment. Submissions are subject to verification.

Table 1
Example Spreadsheet

Ticket No.	Truck No.	Gross Wt.	Tare Wt.	Net Wt.	Overload Wt.	Payment Wt.
				Totals	Totals	Totals

Furnish leak-free weighing containers large enough to hold a complete batch of the material being measured.

2.1. **Truck Scales**. Furnish platform truck scales capable of weighing the entire truck or truck–trailer combination in a single draft.

2.2. **Aggregate Batching Scales**. Equip scales used for weighing aggregate with a quick adjustment at zero that provides for any change in tare. Provide a visual means that indicates the required weight for each aggregate.

2.3. **Suspended Hopper**. Provide a means for the addition or the removal of small amounts of material to adjust the quantity to the exact weight per batch. Ensure the scale equipment is level.

2.4. **Belt Scales**. Use belt scales for proportioning aggregate that are accurate to within 1.0% based on the average of 3 test runs, where no individual test run exceeds 2.0% when checked in accordance with Tex-920-K.

2.5. **Asphalt Material Meter**. Provide an asphalt material meter with an automatic digital display of the volume or weight of asphalt material. Verify the accuracy of the meter in accordance with Tex-921-K. Ensure the accuracy of the meter is within 0.4% when using the asphalt meter for payment purposes. Ensure the accuracy of the meter is within 1.0% when used to measure component materials only and not for payment.

2.6. **Liquid Asphalt Additive Meters**. Provide a means to check the accuracy of meter output for asphalt primer, fluxing material, and liquid additives. Furnish a meter that reads in increments of 0.1 gal. or less. Verify accuracy of the meter in accordance with Tex-923-K. Ensure the accuracy of the meter within 5.0%.

2.7. **Particulate Solid and Slurry Additive Meters**. Provide a means to check the accuracy of meter output for particulate solids (such as hydrated lime or mineral filler) and slurries (such as hydrated lime slurry). Ensure the accuracy of the meter within 5.0%.

3. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 529

Concrete Curb, Gutter, and Combined Curb and Gutter

1. DESCRIPTION

Construct hydraulic cement concrete curb, gutter, and combined curb and gutter.

2. MATERIALS

Furnish materials conforming to:

- Item 360, "Concrete Pavement"
- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"

Use Class A concrete or material specified on the plans. Use Grade 8 coarse aggregate for extruded Class A concrete. Use other grades if approved.

When approved, use fibers meeting the requirements of DMS-4550, "Fibers for Concrete," to replace reinforcing steel in Class A concrete. Dose fibers in accordance with the Department's MPL of pre-qualified fibers for concrete.

3. CONSTRUCTION

Provide finished work with a well-compacted mass and a surface free from voids and honeycomb, in the required shape, line, and grade. Round exposed edges with an edging tool of the radius shown on the plans. Mix, place, and cure concrete in accordance with Item 420, "Concrete Substructures." Construct joints at locations shown on the plans. Cure for at least 72 hr.

Furnish and place reinforcing steel in accordance with Item 440, "Reinforcement for Concrete."

Set and maintain a guideline that conforms to alignment data shown on the plans, with an outline that conforms to the details shown on the plans. Ensure that changes in curb grade and alignment do not exceed 1/4 in. between any 2 contacts on a 10-ft. straightedge.

3.1. **Conventionally Formed Concrete**. Shape and compact subgrade, foundation, or pavement surface to the line, grade, and cross-section shown on the plans. Lightly sprinkle subgrade or foundation material immediately before concrete placement.

Pour concrete into forms, and strike off with a template 1/4 to 3/8 in. less than the dimensions of the finished curb unless otherwise approved. After initial set, plaster surface with mortar consisting of 1 part hydraulic cement and 2 parts fine aggregate. Brush exposed surfaces to a uniform texture.

Place curbs, gutters, and combined curb and gutters in 50-ft. maximum sections unless otherwise approved.

3.2. **Extruded or Slipformed Concrete**. Hand-tamp and sprinkle subgrade or foundation material before concrete placement. Provide clean surfaces for concrete placement. Coat cleaned surfaces, if required, with approved adhesive or coating at the rate of application shown on the plans or as directed. Place concrete with approved self-propelled equipment.

The forming tube of the extrusion machine or the form of the slipform machine must be easily adjustable vertically during the forward motion of the machine to provide variable heights necessary to conform to the established gradeline.

Attach a pointer or gauge to the machine so that a continual comparison can be made between the extruded or slipform work and the grade guideline. Other methods may be used when approved.

Finish surfaces immediately after extrusion or slipforming.

4. MEASUREMENT

This Item will be measured by the foot.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Curb," "Concrete Curb (Mono)," or "Concrete Curb and Gutter" of the type specified. This price is full compensation for surface preparation of curb foundation, equipment, labor, materials, tools, and incidentals.

Item 530
Intersections, Driveways, and Turnouts

1. DESCRIPTION

Construct and pave intersections, driveways, and turnouts. Pave existing intersections, driveways, and turnouts.

Intersections are considered to be areas off the travel lanes and shoulders of the Contract highway on the intersecting highway on the state system. The intersecting on-system highway work will be paid for under this Item only when shown on the plans.

Driveways are defined as private (residential or commercial) and public (county road and city street) access areas off the travel lanes and shoulders.

Turnouts include but are not limited to mailbox and litter barrel widenings.

2. MATERIALS

Furnish materials that meet the following:

- Item 247, "Flexible Base"
- Item 260, "Lime Treatment (Road-Mixed)"
- Item 263, "Lime Treatment (Plant-Mixed)"
- Item 275, "Cement Treatment (Road-Mixed)"
- Item 276, "Cement Treatment (Plant-Mixed)"
- Item 292, "Asphalt Treatment (Plant-Mixed)"
- Item 316, "Seal Coat"
- Item 330, "Limestone Rock Asphalt Pavement"
- Item 334, "Hot-Mix Cold-Laid Asphalt Concrete Pavement"
- Item 340, "Dense-Graded Hot-Mix Asphalt (Small Quantity)"
- Item 360, "Concrete Pavement"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"

3. CONSTRUCTION

Construct and pave intersections, driveways, and turnouts, and pave existing intersections, driveways, and turnouts as shown on the plans or as directed. Place materials in accordance with construction Articles of pertinent Items. Provide uninterrupted access to adjacent property unless otherwise directed. Ensure that abrupt elevation changes in driveway or turnout areas that serve as sidewalks do not exceed 1/4 in. and that the sidewalk area cross slope does not exceed 2%. Ready-mix concrete and hand finishing will be permitted when concrete pavement is specified unless otherwise shown on the plans for intersections.

4. MEASUREMENT

This Item will be measured by the square yard of the final pavement surface.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Intersections," "Driveways," "Turnouts," "Intersections, Driveways, and Turnouts," or "Driveways and Turnouts" of the surface specified.

This price is full compensation for furnishing and operating equipment; excavation and embankment; base and pavement materials; and labor, materials, tools and incidentals. Drainage structures will be measured and paid for in accordance with the pertinent bid items.

Item 531
Sidewalks

1. DESCRIPTION

Construct hydraulic cement concrete sidewalks.

2. MATERIALS

Furnish materials conforming to the following:

- Item 360, "Concrete Pavement"
- Item 420, "Concrete Substructures"
- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"

Use Class A concrete unless otherwise shown on the plans. Use Grade 8 course aggregate for extruded Class A concrete. Use other grades if approved.

3. CONSTRUCTION

Shape and compact subgrade, foundation, or pavement surface to the line, grade, and cross-section shown on the plans. Lightly sprinkle subgrade or foundation material immediately before concrete placement. Hand-tamp and sprinkle foundation when placement is directly on subgrade or foundation materials. Remove and dispose of existing concrete in accordance with Item 104, "Removing Concrete." Provide a clean surface for concrete placement directly on the surface material or pavement.

Mix and place concrete in accordance with the pertinent Items. Hand-finishing is allowed for any method of construction. Finish exposed surfaces to a uniform transverse broom finish surface. Curb ramps must include a detectable warning surface and conform to details shown on the plans. Install joints as shown on the plans. Ensure that abrupt changes in sidewalk elevation do not exceed 1/4 in., sidewalk cross slope does not exceed 2%, curb ramp grade does not exceed 8.3%, and flares adjacent to the ramp do not exceed 10% slope. Ensure that the sidewalk depth and reinforcement are not less than the driveway cross-sectional details shown on the plans where a sidewalk crosses a concrete driveway.

Provide finished work with a well-compacted mass, a surface free from voids and honeycomb, and the required true-to-line shape and grade. Cure for at least 72 hr. in accordance with Item 420, "Concrete Substructures."

3.1. **Conventionally Formed Concrete**. Provide pre-molded or board expansion joints of the thickness shown on the plans for sidewalk section lengths greater than 8 ft. but less than 40 ft., unless otherwise directed. Terminate workday production at an expansion joint.

3.2. **Extruded or Slipformed Concrete**. Provide any additional surface finishing immediately after extrusion or slipforming as required on the plans. Construct joints at locations as shown on the plans or as directed.

4. MEASUREMENT

Sidewalks will be measured by the square yard of surface area. Curb ramps will be measured by the square yard of surface area or by each. A curb ramp consists of the ramp, landing, adjacent flares or side curb, and detectable warning surface as shown on the plans.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Sidewalks" of the depth specified and "Curb Ramps" of the type specified. This price is full compensation for surface preparation of sidewalk foundation; materials; removal and disposal of existing concrete; excavation, hauling and disposal of excavated material; drilling and doweling into existing concrete curb, sidewalk, and pavement; repair of adjacent street or pavement structure damaged by these operations; and equipment, labor, materials, tools, and incidentals.

Sidewalks that cross and connect to concrete driveways or turnouts will be measured and paid for in accordance with Item 530, "Intersections, Driveways, and Turnouts."

Item 556
Pipe Underdrains

1. DESCRIPTION

Install pipe underdrains.

2. MATERIALS

2.1. **Pipe**. Furnish the types and sizes of pipe specified on the plans. Use only one type of pipe for any underdrain system on the project. Use perforated pipe in areas to be drained, and use non-perforated pipe between the perforated pipe and the outfall.

2.1.1. **Type 1**. Corrugated steel pipe (CSP) conforming to any type specified in AASHTO M 36, fabricated from corrugated galvanized sheet.

2.1.2. **Type 2**. Corrugated aluminum pipe conforming to AASHTO M 196, Type I or IA, fabricated from corrugated sheet.

2.1.3. **Type 3**. Bituminous-coated corrugated steel pipe conforming to the requirements of Type 1 and uniformly coated inside and out with a minimum thickness of 0.05 in. of bituminous material meeting the requirements of Table 1 when tested in accordance with ASTM A849, Material Class A or Material Class PA.

Table 1
Requirements of Bituminous Material

Test	Requirements
Solubility, % by wt., in trichloroethylene	99.5 Min
Brittleness	Pass
Flow, in.	0.25 Max

2.1.4. **Type 4**. Bituminous-coated corrugated aluminum pipe conforming to the requirement of Type 2 and uniformly coated inside and out with a minimum thickness of 0.05 in. of bituminous material meeting the requirements of Table 1 when tested in accordance with ASTM A849, Material Class A or Material Class PA.

2.1.5. **Type 5**. Acrylonitrile-butadiene-styrene (ABS) pipe conforming to ASTM D2751, SDR-35. Perforations must meet the requirements of AASHTO M 278.

2.1.6. **Type 6**. Corrugated polyethylene plastic tubing conforming to AASHTO M 252.

2.1.7. **Type 7**. Corrugated polyvinyl chloride (PVC) pipe conforming to ASTM F949.

2.1.8. **Type 8**. Smooth-wall PVC pipe conforming to AASHTO M 278, Class PS 46.

2.1.9. **Type 9**. As shown on the plans.

2.2. **Filter Material**. Furnish hard, durable, and clean sand, gravel, crushed stone, or crushed shell meeting the gradation by percent weight specified in Table 2 unless otherwise shown on the plans. Filter material must be free of clay balls or other organic or deleterious matter as determined by Tex-413-A. Do not furnish crushed limestone unless shown on the plans. Use only one type of filter material for any underdrain system on a project.

Table 2
Percent Retained on Sieve (Tex-401-A)

Sieve Size	Type A	Type B	Type C	Type D
1-1/2"	–	–	0–10	
3/4"	–	0–10	20–40	
3/8"	–	15–35	–	–
#4	0–10	35–55	40–60	0–5
#8				0–20
#16				15–50
#20	35–65[1]	35–65[1]	35–65[1]	
#30				40–75
#50	75–100[1]	75–100[1]	75–100[1]	70–90
#100				90–100

1. Of the portion finer than No. 4 sieve.

Loss by decantation as determined by Tex-406-A must not exceed 1% of the material retained on a No. 4 sieve or 4% of the material passing a No. 4 sieve. Use Type B or Type C filter material around the underdrains unless otherwise shown on the plans. Do not place Type A or Type D filter material within 6 in. of perforations.

2.3. **Filter Fabric**. Meet DMS-6200, "Filter Fabric," Type 1.

2.4. **Riprap**. Provide concrete riprap in accordance with Item 432, "Riprap," when required.

3. CONSTRUCTION

Begin excavation of the trench at the outfall and proceed toward its upper end, following the lines and grades shown on the plans or as directed. Hold the minimum horizontal limits of excavation for filter material to the dimensions shown in Table 3 or as shown on the plans.

Table 3
Minimum Horizontal Limits of Excavation for Filler Material

Depth of Trench (ft.)	Distance Outside Neat Lines of Pipe Underdrains (ft.)
0 to 6	1.00
Over 6 to 10	1.50
Over 10 to 15	2.00
Over 15	2.50

Place filter fabric in the bottom and sides of the trench in areas to be drained before placing pipe or filter material, as shown in Figure 1. Provide enough width of fabric to overlap on top of the filter material. Center perforated pipe in the excavated ditch with the perforations below the horizontal axis. Join the pipe with appropriate couplers if required. Join plastic pipe in accordance with the manufacturer's recommendations. Do not use tarpaper strips. Obtain approval for pipe placement before placing filter material.

Place filter material at least 12 in. above the bottom of the pipe or as shown on the plans. Do not allow filter material to displace the pipe.

Lap filter fabric over the top of the filter material after placing pipe and filter material according to the manufacturer's recommendation or as shown on the plans.

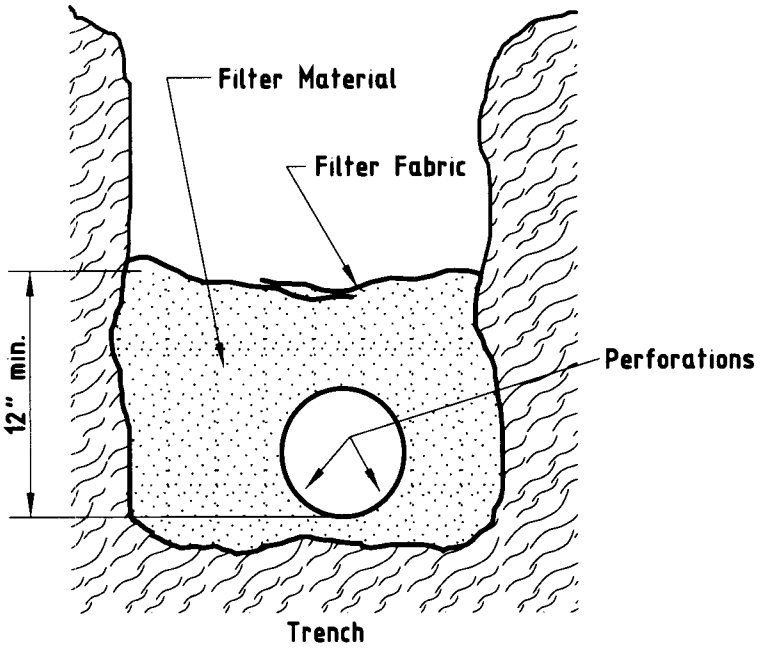


Figure 1
Installation Process

Install non-perforated pipe sections between the perforated pipe and the outfall. The sections of non-perforated pipe do not require filter fabric or filter material.

Place approved plugs in the upper ends of all pipe. Cover exposed outfall ends with 1/2-in. galvanized hardware cloth as directed. Provide Class B concrete riprap, when required, in accordance with Item 432, "Riprap," and details shown on the plans. Place the riprap to the contour and grade of the embankment slope. Cut the pipe to the slope of the riprap.

Backfill the remainder of the trench with suitable material in layers not to exceed 6 in.

4. MEASUREMENT

This Item will be measured by the foot along the top of the pipe and will include the length of elbows, Y's, T's, and other branches.

5. PAYMENT

The work performed and material furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pipe Underdrains" of the pipe type and size specified. This price is full compensation for pipe, couplers, plugs, screens, filter material, filter fabric, riprap, excavation, backfill, equipment, labor, materials, tools, and incidentals.

Protection methods for excavations deeper than 5 ft. will be measured and paid for in accordance with Item 402, "Trench Excavation Protection."

Item 560
Mailbox Assemblies

1. DESCRIPTION

Install, remove, temporarily relocate, or replace mailbox assemblies of the type specified.

2. MATERIAL

Furnish mailbox assemblies in accordance with the plans. An assembly does not include the mailbox unless shown otherwise on the plans. Provide new mailbox assemblies for permanent installations.

3. CONSTRUCTION

Temporarily relocate mailbox assemblies as shown on the plans or as directed. Furnish and install approved mailbox assemblies and mount mailboxes on those assemblies. Maintain mailbox assemblies in a serviceable condition. Furnish and install additional mailbox assemblies as directed. Relocate mailbox and assemblies to permanent locations upon completion of construction work.

4. MEASUREMENT

This Item will be measured by each permanent mailbox assembly installed.

5. PAYMENT

The work performed, materials furnished, and measured according to "Measurement" will be paid at the unit price bid for "Mailbox Installation (Single)," of the type specified; "Mailbox Installation (Double)," of the type specified; or "Mailbox Installation (Multiple)," of the type specified. This price is full compensation for installing mailboxes and reflectors in permanent locations, materials, equipment, labor, tools, and incidentals. Removing existing or installing and moving temporary mailbox assemblies will not be paid directly but will be subsidiary to pertinent Items.

Item 585
Ride Quality for Pavement Surfaces

1. DESCRIPTION

Measure and evaluate the ride quality of pavement surfaces.

2. EQUIPMENT

2.1. **Surface Test Type A**. Provide a 10-ft. straightedge or where allowed, a high-speed or lightweight inertial profiler, certified at the Texas A&M Transportation Institute.

2.2. **Surface Test Type B**. Provide a high-speed or lightweight inertial profiler, certified at the Texas A&M Transportation Institute. Provide equipment certification documentation. Display a current decal on the equipment indicating the certification expiration date.

Use a certified profiler operator from the Department's MPL. When requested, furnish documentation for the person certified to operate the profiler.

2.3. **Diamond Grinding Equipment**. Provide self-propelled powered grinding equipment specifically designed to smooth and texture pavements using circular diamond blades when grinding is required. Provide equipment with automatic grade control capable of grinding at least 3 ft. of width longitudinally in each pass without damaging the pavement.

3. WORK METHODS

Measure and evaluate profiles using Surface Test Types A and B on surfaces as described below unless otherwise shown on the plans.

3.1. **Transverse Profile**. Measure the transverse profile of the finished riding surface in accordance with Surface Test Type A.

3.2. **Longitudinal Profile**. Measure the longitudinal profile of the surface, including horizontal curves.

3.2.1. **Travel Lanes**. Use Surface Test Type B on the final riding surface of all travel lanes except as follows unless otherwise shown on the plans.

3.2.1.1. **Service Roads and Ramps**. Use Surface Test Type A on service roads and ramps unless Surface Test Type B is shown on the plans.

3.2.1.2. **Short Projects**. Use Surface Test Type A when project pavement length is less than 2,500 ft. unless otherwise shown on the plans.

3.2.1.3. **Bridge Structures**. Measure the profile in accordance with the pertinent item or use Surface Test Type A for span type bridge structures, approach slabs, and the 100 ft. leading into and away from such structures.

3.2.1.4. **Leave-Out Sections**. Use Surface Test Type A for leave-out sections and areas between leave-out sections that are less than 100 ft.

3.2.1.5. **Ends**. Use Surface Test Type A on the first and last 100 ft. of the project pavement length.

3.2.2. **Shoulders and Other Areas**. Use Surface Test Type A for shoulders and all other areas including intermediate pavement layers.

3.3. **Profile Measurements**. Measure the finished surface in accordance with Surface Test Type A or B in accordance with Section 585.3.1., "Transverse Profile," Section 585.3.2., "Longitudinal Profile," and the plans.

3.3.1. **Surface Test Type A**. Test the surface with a 10-ft. straightedge as directed. Use an inertial profiler to measure the surface when allowed. The Engineer will use Department software to evaluate the surface.

3.3.2. **Surface Test Type B**.

3.3.2.1. **QC Testing**. Perform QC tests on a daily basis throughout the duration of the project. Use a 10-ft. straightedge, inertial profiler, profilograph, or any other means to perform QC tests.

3.3.2.2. **QA Testing**. Perform QA tests using either a high-speed or lightweight inertial profiler. Coordinate with and obtain authorization from the Engineer before starting QA testing. Perform QA tests on the finished surface of the completed project or at the completion of a major stage of construction, as approved. Perform QA tests within 7 days after receiving authorization.

The Engineer may require QA testing to be performed at times of off-peak traffic flow. Operate the inertial profiler in a manner that does not unduly disrupt traffic flow as directed. When using a lightweight inertial profiler to measure a surface that is open to traffic, use a moving traffic control plan in accordance with Part 6 of the TMUTCD and the plans.

In accordance with Tex-1001-S, operate the inertial profiler and deliver test results within 24 hr. of testing. Provide all profile measurements in electronic data files using the format specified in Tex-1001-S.

3.3.2.2.1. **Verification Testing**. The Engineer may perform ride quality verification testing within 10 working days after the Contractor's QA testing is complete for the project or major stage of construction. When the Department's profiler produces an overall average international roughness index (IRI) value over 3.0 in. per mile higher than the value calculated using Contractor data, the Engineer will decide whether to accept the Contractor's data, use the Department's data, use an average of both parties' data, or request a referee test. Referee testing is mandatory if the difference is greater than 6.0 in. per mile.

3.3.2.2.2. **Referee Testing**. The Construction Division will conduct referee testing, and the results are final. The Construction Division may require recertification for the Contractor's or Department's inertial profiler.

3.4. **Acceptance Plan and Pay Adjustments**. The Engineer will evaluate profiles for determining acceptance, bonus, penalty, and corrective action.

3.4.1. **Surface Test Type A**. Use diamond grinding or other approved work methods to correct surface areas that have more than 1/8-in. variation between any 2 contacts on a 10-ft. straightedge. For asphalt concrete pavements, fog seal the aggregate exposed from diamond grinding. Following corrective action, retest the area to verify compliance with this Item.

3.4.2. **Surface Test Type B**. The Engineer will use the QA test results to determine pay adjustments for ride quality using Department software. IRI values will be calculated using the average of both wheel paths. When taking corrective actions to improve a deficient 0.1-mi. section, pay adjustments will be based on the data obtained from reprofiling the corrected area.

3.4.2.1. **IRI Pay Adjustment for 0.1-mi. Sections**. Unless pay adjustment Schedule 1 or 2 is shown on the plans, Schedule 3 from Table 1 and Table 2 will be used to determine the level of pay adjustment for each 0.1-mi. section on the project.

No bonus will be paid for any 0.1-mi. section that contains localized roughness.

3.4.2.2. **IRI Deficient 0.1-mi. Sections**. When pay adjustment Schedule 1 or 2 is specified, correct any 0.1-mi. section with an average IRI over 95.0 in. per mile. Correct the deficient section to an IRI of 65 in. per mile or less when Schedule 1 is specified or correct to an IRI of 75 in. per mile or less when Schedule 2 is specified. No corrective action is required for Schedule 3. After making corrections, reprofile the pavement section to verify that corrections have produced the required improvements.

The associated bonus shown in Table 1 applies when successful corrective action improves the IRI of a deficient 0.1-mi. section.

If corrective action does not produce the required improvement, the Engineer may require:

- continued corrective action, or
- apply the pertinent schedule penalty shown in Table 2 if the reprofiled IRI is greater than 65 in. per mile.

3.4.2.2.1. **Corrective Action**. Use diamond grinding or other approved work methods to correct any deficient 0.1-mi. section. For asphalt concrete pavements, fog seal the aggregate exposed from diamond grinding or other approved work methods allowed.

3.4.2.3. **Localized Roughness**. Measure localized roughness using an inertial profiler in accordance with Tex-1001-S. The Engineer will determine areas of localized roughness using the individual profile from each wheel path.

Use a 10-ft. straightedge, when allowed, to locate areas that have more than 1/8-in. variation between any 2 contacts on the straightedge when Schedule 3 is specified.

The Engineer may waive localized roughness requirements for deficiencies resulting from manholes or other similar appurtenances near the wheel paths.

3.4.2.3.1. **Corrective Action**. Use diamond grinding or other approved work methods to correct localized roughness. For asphalt concrete pavements, fog seal the aggregate exposed from diamond grinding or other approved work methods allowed. Reprofile the corrected area, and provide results that show the corrective action was successful. If the corrective action is not successful, the Engineer will require continued corrective action or apply a localized roughness penalty.

3.4.2.3.2. **Localized Roughness Penalty**. Instead of continued corrective action, the Engineer may assess a penalty for each occurrence of localized roughness. No more than one penalty will be applied for any 5 ft. of longitudinal distance. For Schedule 1, a localized roughness penalty of $500 per occurrence will be applied. For Schedule 2, a localized roughness penalty of $250 per occurrence will be applied. For Schedule 3, localized roughness penalties will not be applied.

Localized roughness penalties will be evaluated within 0.1-mi. sections and applied unless the IRI deficient 0.1-mi. section penalty is greater. When the IRI deficient penalty is greater, the pay adjustment in Table 2 will be applied.

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, certification and recertification, traffic control for all testing, materials and work needed for corrective action, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items. Sections shorter than 0.1 mi. and longer than 50 ft. will be prorated in accordance with Tex-1001-S.

Table 1
Bonus Pay Adjustments for Ride Quality

Average IRI for each 0.10 mi. of Traffic Lane	Pay Adjustment $/0.10 mi. of Traffic Lane	
(in./mi.)	Schedule 1 and Schedule 2	Schedule 3
≤ 30	600	300
31	580	290
32	560	280
33	540	270
34	520	260
35	500	250
36	480	240
37	460	230
38	440	220
39	420	210
40	400	200
41	380	190
42	360	180
43	340	170
44	320	160
45	300	150
46	280	140
47	260	130
48	240	120
49	220	110
50	200	100
51	180	90
52	160	80
53	140	70
54	120	60
55	100	50
56	80	40
57	60	30
58	40	20
59	20	10
60 to 65	0	0

Table 2
Penalty Pay Adjustments for Ride Quality

Average IRI for each 0.10 mi. of Traffic Lane	**Pay Adjustment** $/0.10 mi. of Traffic Lane	
(in./mi.)	**Schedule 1**	**Schedule 2**
66	-20	0
67	-40	0
68	-60	0
69	-80	0
70	-100	0
71	-120	0
72	-140	0
73	-160	0
74	-180	0
75	-200	0
76	-220	-20
77	-240	-40
78	-260	-60
79	-280	-80
80	-300	-100
81	-320	-120
82	-340	-140
83	-360	-160
84	-380	-180
85	-400	-200
86	-420	-220
87	-440	-240
88	-460	-260
89	-480	-280
90	-500	-300
91	-520	-320
92	-540	-340
93	-560	-360
94	-580	-380
95	-600	-400
> 95	-3,000	

Item 780
Concrete Crack Repair

1. DESCRIPTION

Repair cracks in concrete members by epoxy injection, gravity filling, routing and sealing, or surface sealing.

2. MATERIALS

Provide materials in accordance with the TxDOT *Concrete Repair Manual*. Select a pre-approved material meeting the requirements of the applicable DMS when available.

3. WORK METHODS

Follow the procedures outlined in the Department's *Concrete Repair Manual*. Submit alternate procedures to the Engineer for approval before proceeding with repair work.

The manual includes the following categories of concrete crack repair:

- Pressure-Injected Epoxy
- Gravity-Fed Epoxy
- Routing and Sealing
- Surface Sealing

4. MEASUREMENT

This Item will be measured by the foot of exterior crack length, injected gallon, square footage for flood coats, or lump sum.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Crack Repair" of the type specified. This price is full compensation for furnishing and installing all repair materials, equipment, labor, and incidentals.

Item 785
Bridge Joint Repair or Replacement

1. DESCRIPTION

Repair or replace damaged bridge joint as shown on the plans.

2. MATERIALS

Provide materials conforming to the pertinent requirements of the following Items except as shown on the plans.

- Item 429, "Concrete Structure Repair"
- Item 449, "Anchor Bolts"
- Item 454, "Bridge Expansion Joints"
- DMS-6100, "Epoxies and Adhesives"

Submit information on pre-packaged repair materials and concrete mix design a minimum of 10 days before beginning work.

3. EQUIPMENT

Provide equipment in accordance with Item 429, "Concrete Structure Repair," and Item 448, "Structural Field Welding."

4. WORK METHODS

Obtain approval for all materials and work methods before beginning work.

Repair damaged bridge joints as shown on the plans. Perform the work in accordance with Item 429, "Concrete Structure Repair," Item 438, "Cleaning and Sealing Joints," Item 448, "Structural Field Welding," and Item 454, "Bridge Expansion Joints," as directed. Provide certified welder when shown on the plans.

Remove concrete and steel sections to limits shown on the plans and as approved when damage extends past specified regions. Repair concrete and steel members damaged by the Contractor beyond limits shown at no additional cost. Contain concrete during removal from falling onto lower roadway or into waterway. Remove existing joint and seal. Ensure prestressed concrete deck panel is not damaged during concrete removal. Clean and extend existing reinforcing steel and replace any damaged steel or add additional steel as shown on the plans.

Examine existing steel joint, finger plate, armor plate, or sliding plate to determine if the items are salvageable. Reinstall anchor bolts, anchor studs, and other steel attachments if loose and in accordance with the plans.

Install replacement joint system as shown on the plans. Set joint opening as shown on the plans and as directed. Restore concrete under and around joint flush with top of riding surface. Cure repaired concrete a minimum of 4 days, unless directed otherwise.

Prepare and seal joint opening. Match existing joint seal type unless shown otherwise. Splice new joint seal to existing joint seal when required in accordance with manufacturer's recommended practices to obtain adequate bond between existing seal and new seal.

5. MEASUREMENT

This Item will be measured by the foot of joint repaired, per side of joint opening, and by the foot of joint replaced.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Bridge Joint Repair" and "Bridge Joint Replacement" of the type identified. This price is full compensation for removing existing joint and seal; breaking back and repairing concrete damaged for joint removal and replacement; removing and replacing additional concrete as shown on the plans; furnishing and placing all materials, cleaning and sealing the joints, disposal of all materials removed, additional sealant required to extend into concrete rail or curb, additional material that may be required due to existing asphalt and concrete removal being more than estimate on the plans; and for all labor, tools, equipment, and incidentals necessary to complete the work.

Item 7000

Surface Water Pollution Prevention Plan (SW3P)

1. DESCRIPTION

The Contractor will provide the following for this item:

- An SW3P plan that is approved by the Engineer/Owner
- Necessary permits and associated fees
- All BMPs as indicated on the approved SW3P plan
- Maintenance and inspection of the SW3P upon its implementation and until a NOT (Notice of Termination) has been filed and accepted by the TCEQ

2. MATERIALS

Furnish materials shown in the contractor provided SW3P and as approved by the engineer/owner.

3. CONSTRUCTION

The Contractor will maintain the SW3P in accordance with TCEQ requirements throughout construction and until the NOT has been filed with the TCEQ.

4. MEASUREMENT

This Item will be paid as a Lump Sum Item

5. PAYMENT

Payment for Storm Water Pollution Prevention Plan will include all labor, equipment and materials to complete the work as described in the approved SW3P plan and any necessary permits and associated fees.

ADS HP STORM 12"- 60" PIPE SPECIFICATION

Scope

This specification describes 12- through 60-inch (300 to 1500 mm) ADS HP Storm pipe for use in gravity-flow storm drainage applications.

Pipe Requirements

- 12- through 60-inch (300 to 1500 mm) pipe shall have a smooth interior and annular exterior corrugations and meet or exceed ASTM F2881 and AASHTO M330
- Manning's "n" value for use in design shall be 0.012

Joint Performance

Pipe shall be joined with a gasketed integral bell & spigot joint meeting the requirements of F2881.

12- through 60-inch (300 to 1500 mm) shall be watertight according to the requirements of ASTM D3212. Spigots shall have gaskets meeting the requirements of ASTM F477. Gasket shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

12- through 60-inch (300 to 1500 mm) diameters shall have an exterior bell wrap installed by the manufacturer.

Fittings

Fittings shall conform to ASTM F2881 and AASHTO M330. Bell & spigot connections shall utilize a spun-on, welded or integral bell and spigots with gaskets meeting ASTM F477. Bell & spigot fittings joint shall meet the watertight joint performance requirements of ASTM D3212. Corrugated couplings shall be split collar, engaging at least 2 full corrugations.

Field Pipe and Joint Performance

To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F1417 or ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material. Contact the manufacturer for recommended leakage rates.

Material Properties

Polypropylene compound for pipe and fitting production shall be impact modified copolymer meeting the material requirements of ASTM F2881, Section 5 and AASHTO M330, Section 6.1.

Installation

Installation shall be in accordance with ASTM D2321 and ADS recommended installation guidelines, with the exception that minimum cover in traffic areas for 12- through 48-inch (300 to 1200 mm) diameters shall be one foot. (0.3 m) and for 60-inch (1500 mm) diameters, the minimum cover shall be 2 ft. (0.6 m) in single run applications. Backfill for minimum cover situations shall consist of Class 1, Class 2 (minimum 90% SPD) or Class 3 (minimum 95%) material. Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.04. Contact your local ADS representative or visit our website at www.ads-pipe.com for a copy of the latest installation guidelines.

Pipe Dimensions

Nominal Pipe I.D.	12	15	18	24	30	36	42	48	60
in (mm)	(300)	(375)	(450)	(600)	(750)	(900)	(1050)	(1200)	(1500)
Average Pipe I.D.	12.2	15.1	18.2	24.1	30.2	36.0	42.0	47.9	59.9
In (mm)	(310)	(384)	(462)	(612)	(767)	(914)	(1067)	(1217)	(1521)
Average Pipe O.D.	14.5	17.7	21.4	28.0	35.5	41.5	47.4	54.1	67.1
in (mm)	(368)	(450)	(544)	(711)	(902)	(1054)	(1204)	(1374)	(1704)
Minimum Pipe Stiffness *	75	60	56	50	46	40	35	35	30
@ 5% Deflection #/in./in. (kN/m^2)	(517)	(414)	(386)	(345)	(317)	(276)	(241)	(241)	(207)

* Minimum pipe stiffness values listed; contact a representative for maximum values

MEASUREMENT
This Item will be measured by the Linear Foot

PAYMENT
Payment for this item will include all labor, equipment and materials to complete the work.

SPECIAL PROVISIONS

The following special provisions to the standard specifications are enclosed herewith, and are listed as follows:

SPECIAL SPECIFICATIONS

The following special specifications are listed as follows, and enclosed herewith:

II.4 GENERAL NOTES

The general notes for this Contract are located on plan sheet no. **4** of the Contract Drawings.

PART III

CONSTRUCTION DRAWINGS